SAKURA®
Air Conditioner

Sakura Air Conditioner
User-friendly, Earth-friendly

SAKURA Steam Driven Absorption Chiller

SW Series [SW 100 (352kw) – SW 1500 (5.274kw)]

Manual for Operation / Installation / Service

Ref, S- 157-2 / 12 / 11

Content

1. General Information

1-1. General

This manual provides information and instructions for installation, operation and maintenance. For the details and further precautions, please read carefully each relevant section in this manual and the supporting documents provided by the manufacturer.

1-2. Warranty

For the quick solution, please report any damage immediately to the seller or the manufacturer with detail symptoms and through the following address. Please be sure that no warranty can be given in case of improper use contrary to the instruction in this manual or poor workmanship of user.

Manufacturer **SAKURA CORPORATION**
Tel: +81-45-949-8550 Fax: +81-45-949-8551
2-17-1, Eda-minami, Tsuzuki-ku, Yokohama, Kanagawa,
224-0007, Japan
E-mail: mail@sakura-aircon.com
Web: www.sakura-aircon.com

It is essential for the safety and long-life of the Machine that the maintenance and repair works are performed by the manufacturers or by the authorized service person. Only use the original spare parts or the equivalents authorized by the manufacturer. Needless to say, it is the best that the user can service and maintain the Machine in accordance with the instructions of this manual and the supports provided by the manufacturer.

The seller or the manufacturer warrants that the equipment is free from defects in material and workmanship at the time of delivery. The seller's obligations under this warranty expire on the earlier to occur of twelve (12) months from start-up and commissioning, or eighteen (18) months after delivery of such equipment or twenty first (21) months after the manufacturer shipping. The seller does not agree under this warranty to bear the cost of repairs or replacements due to vandalism, abuse, misuse, normal wear and tear, or improper maintenance. For the extension of the warranty, the details can be made with separate contract.

1-3. Spare Parts

For the maintenance, the spare part below will be supplied together with the Machine as standard of the manufacturer's. When the Machine received, please check if there is a shortage.

Purge pump Oil (ULTRA VAC 100) : 2 Liter

1-4. Safety Guards

This guide explains precautions and prohibitions on the Machine. Make sure to understand all of the items explained in this guide before operation.

1-4-1. Important Notices

1) Qualified Personnel

Persons who are not qualified should not be allowed to handle the Absorption chiller. Non-compliance with the warnings contained in this document or appearing on the machine itself can result in severe personal injury or damage to property. Only qualified personnel should be allowed to work on Absorption chiller.

Qualified persons as referred to the safety guidelines in this document as well as on the Absorption chiller itself are defined as follows;

- Operating personnel who have been trained to work with Absorption chiller and are conversant with the contents of the documents as far as it is connected with the actual operation of the plant.

- Commissioning service personnel who are trained to repair such Absorption chiller and who are authorized to energize, enervate, clear, ground and tag circuits, equipment and systems in accordance with established safety practices.

2) Danger Notices

The safety notices and warnings for protection against loss of life (the users or service personnel) or for protection against damage to property are highlighted in this document by the terms and pictograms defined here. The terms and pictograms used in this document and marked on the equipment itself have the following significance;

DANGER
Indicates that death, severe personal or substantial property damage will result if proper precautions are not taken.

WARNING
Indicates that death, severe personal injection or substantial property damage can result if proper precautions are not taken.

CAUTION
Indicates that minor personal injury or property damage can result if proper precautions are not taken.

IMPORTANT
If “IMPORTAMT” should appear in this document, draw attention to any particular information described.

3) Principle Safety Objective

(1) The principal safety objective is to remove the possibility of any hazard or risk to the health or safety of the machine operator or service personnel.

(2) Extreme caution must be exercised while servicing or installing the machine. Do not manually actuate any safety switches, particularly with the guards removed, as this may cause unexpected machine response.

(3) The only safe policy when working or inspecting the machine is to follow the instructions in this manual. Wherever possible shut off all electrical power and follow the procedures outlined in this manual.

(4) Accident prevention should become part of the standard working, operating and maintenance procedures, and training should be provided to ensure safety standards are understood. Part of the safety training should include the instructions detailed in this manual.

(5) Certain processed polymer materials may give off harmful or irritation gases. This must be taken into account when designing the installation area and adequate provision should be included for removal of any gases.

(6) If ancillary equipment is to be fitted ensure this is done in accordance with the relevant standards or EU Directives, and that all requirements for safety are fully met.

(7) Always ensure servicing and maintenance tasks are carried out by suitable qualified personnel. The operator should understand the limits of their responsibility, and the training should reinforce the importance of not exceeding them.

(8) The essential routine safety checks have an important function in ensuring the machine continues to run in a safe manner. These checks must be carried out in accordance with the instructions and at the recommended intervals.

(9) If there are any questions or doubts regarding any aspect of machine safety or operation or maintenance, please contact the manufacturer or his sales representative shown on this manual.

4) General Safety Rules

GOOD PRACTICE

(1) Ensure all personnel who work on the Absorption chillers are familiar with the safety features and have read and understood the contents of this manual.

(2) Maintain a constant training program to ensure operator and service personnel keep a high level of safety awareness.

(3) Initiate a planned maintenance program which must include the essential safety checks as detailed in this manual.

(4) Report any machine fault quickly, particularly those directly safety related such as loose guarding, exposed electrical wiring or circuits, etc.

(5) In case of accident, or to stop the machine quickly in an emergency, turn off the factory electrical supply and the machine electrical isolator.

(6) When changing consumable parts such as filter media, bulbs, fan belts, and etc., where directed, turn off the factory electrical supply and the machine electrical isolator.

(7) After working on the machine reassemble all guards and complete the essential safety checks before operating.

(8) Keep the machine and working area clear and clean at all times. Clear up any oil spillage's so there is no possibility of personnel slipping.

BAD PRACTICE

(1) Do not remove any safety devices. This may cause a serious accident and may result in prosecution.

(2) Do not clean, lubricate or service any parts on the machine while it is running unless it is specifically intended to be done. Follow the instructions in this manual.

(3) Do not manually actuate any switches during serving or maintenance operations. This may cause unexpected machine movements.

(4) Do not operate the machine unless you are sure that it is safe to do so, and that no danger exists to other personnel.

(5) Do not place any materials such as tools or other equipment on and inside of the machine while it is running.

(6) Do not leave the machine in an unsafe condition, or in a condition which will allow it to operate in an unsafe manner.

(7) Do not allow unauthorized or untrained personnel to operate or maintenance or inspect the machine or to replace consumable parts.

1-4-2. Safety Features and Devices

1) Safety Signs and Warnings

Fig. 1-1. Symbol of Safety and Warning

2) Location of Safety Label

(1) Machine Body

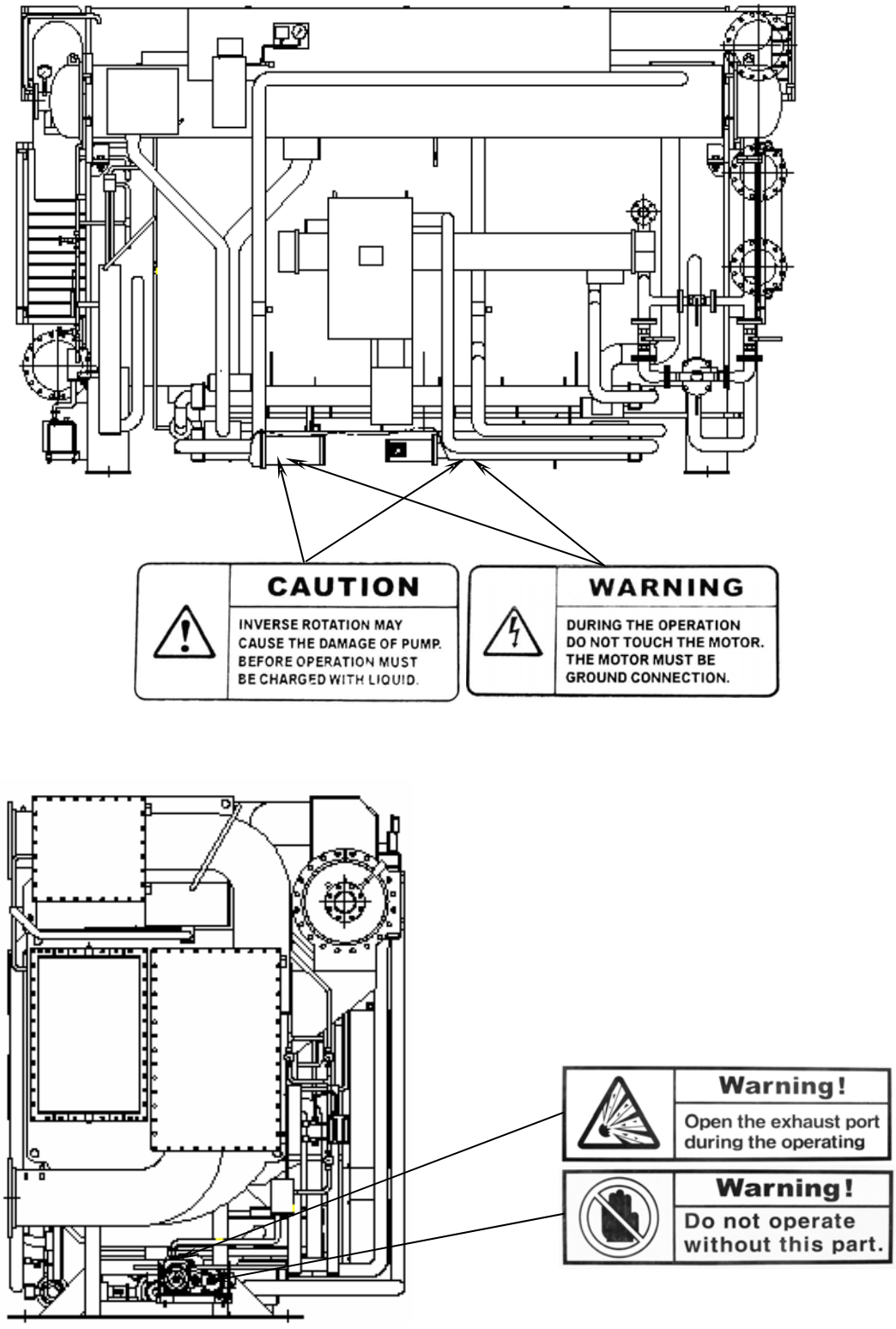


Fig.1-2. Safety Sign on Machine Body

(2) Control Panel

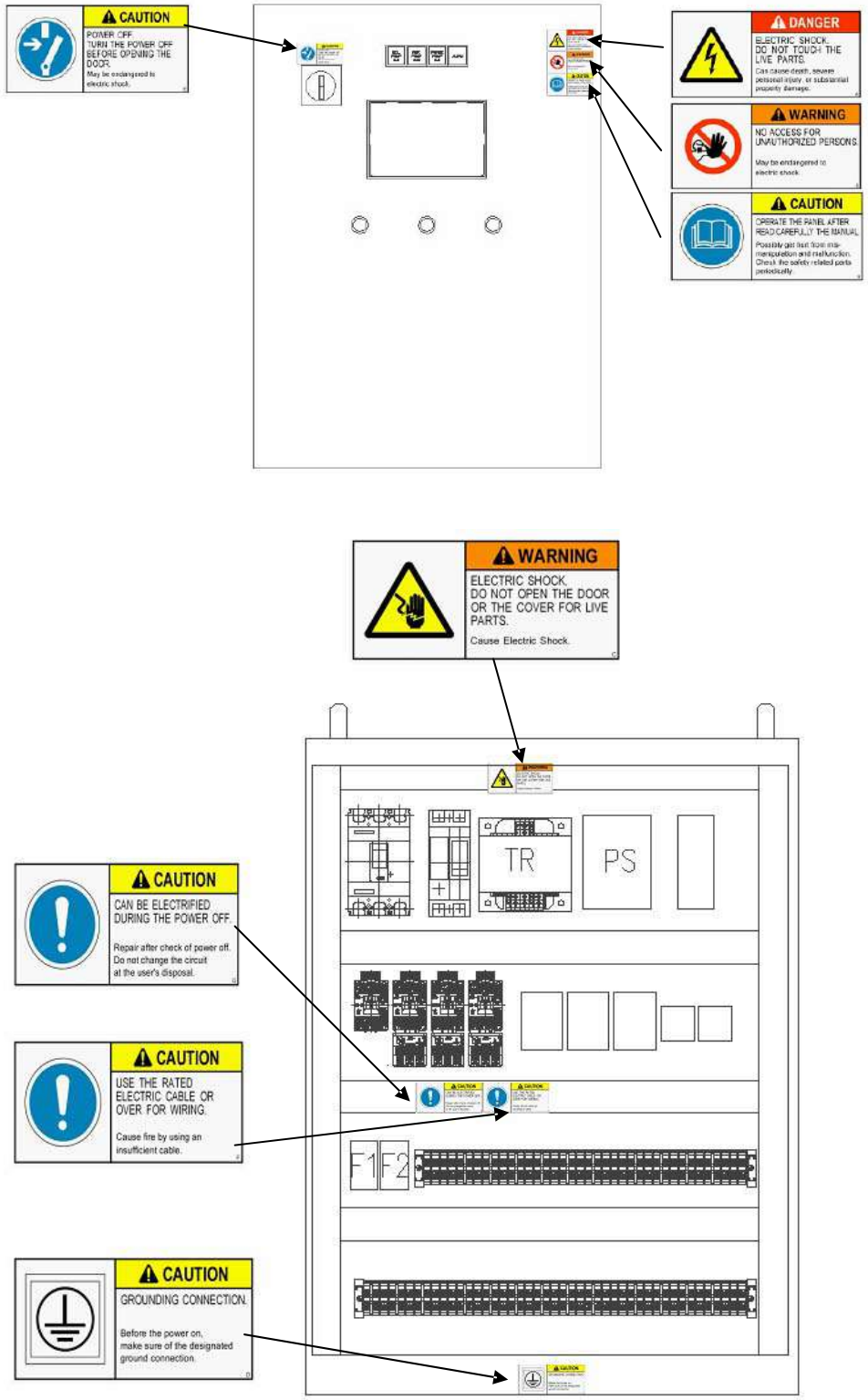


Fig.1-3. Safety Sign on Control Panel

3) Safety Devices & Program logic for Safe operation

Function		Working Condition
Anti-Water Freezing	Chilled water Low flow	Chilled water is not circulated or chilled water flow decreases less than 50% of rated value
	Refrigerant pump Stop @ Low chilled water temperature	Chilled water temperature decreases below the chilled water set point -1.5 ℃ (-2.7 °F)
	Low temperature Cut out of Chilled water	Chilled water temperature decreases lower than 3.0 ℃ (37 °F)
	Low temperature Cut out of Refrigerant	Refrigerant temperature decreases lower than 1 ℃ (34 °F)
Anti Crystallization & Generator High Temperature	Cooling water Low flow	Cooling water is not circulated or cooling water flow decreases less than 50% of rated value (Option)
	Steam control valve stops or closes or bypasses the steam	Cooling water inlet temperature is higher than 32 ℃ (89.6 °F)
		1st Generator solution temperature increases higher than 160 ℃ (320 °F)
		High concentrated solution concentration increases higher than 64 %
	High Temperature Cut out of Generator absorbent	1st Generator solution temperature increases higher than 165 ℃ (329°F)
	High Generator pressure	1st Generator pressure increases higher than 0 bar.
	Low temperature Cut out of Cooling water Inlet	Chiller is continuously operated over 30 minutes under low cooling water temperature less than 15 ℃ (59 °F)
Motor Protector	Absorbent pump motor over-load or high temperature	Motor current is over each rated value or the motor coil temperature is higher than 150 ℃ (302 °F)
	Refrigerant pump motor over-load or high temperature	
	Purge pump motor over-load	

4) Safety device for Control Panel

This safety device is designed to shut off the electrical Circuit when the panel door is opened

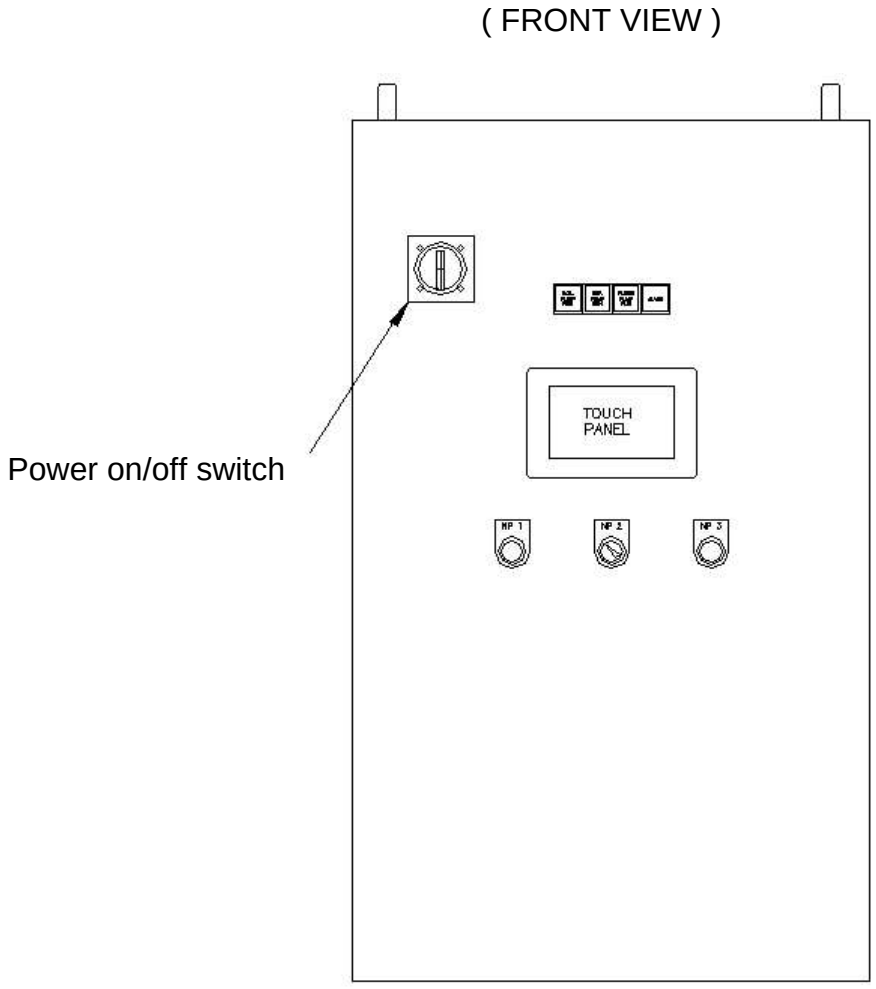


Fig.1-4. Power on/off Switch on Control Panel

NOTE: When the machine has been stopped by turning off Power on/off switch and opening panel door, follow the procedure below to restart the machine.

(1) Close the panel door
(2) Turn on the Power on/off switch
(3) Start the machine

5) Electric Enclosure

All electrical controls are enclosed in a separate cabinet and boxes complying with the IP (Ingress of Protection) requirements of EN60 529. Access to the electrical equipment enclosed by the electromagnetic control cabinet is gained by opening the door interlocked with a supply disconnecting device and other live parts are located inside enclosures which can be accessed by the use of a key or tool that is required for skilled or instructed person to carry out operations. This is to ensure that the electrical cabinet or boxes can only be accessed while the electrical supply has been disconnected.

6) Operating the Machine

GENERAL

(1) Read and fully understand all aspects of the safety systems employed on the machine. Do not attempt to short cut any of the safety procedures or instructions.
(2) Ensure you are fully aware of all operating functions, particularly with the machine setting parameters.
(3) Maintain the machine in a clean condition. Do not leave tools or other equipment on / in the machine while it is in operation.
(4) Do not stand food or drinks on the machine while in operation.
(5) Do not access inside of the machine during operation.
(6) Do not touch the surface of hot water box and generator section.
(7) Regularly inspect the machine for loosened fixings, guards and other assemblies. Report any machine fault immediately.
(8) Regularly check the tightness of access door handle during normal operation.
(9) Do not turn on motor switch on while maintenance or replacing any parts.

7) Essential Safety Checks (ESC's)

The essential safety checks are the most important part of the operator's responsibility. The purpose of the ESC's is to ensure the safety features of the machine are functioning properly, and thus the machine is in a safe condition for use.

In addition to the operator it is recommended that regular additional ESC's are carried out by the responsible person and that a record is maintained.

If any of the ESC's is in the "fail" condition, do not operate the machine, immediately notify the responsible person within the company and contact the manufacturer as soon as possible.

1-5. Daily Inspection Prior to Machine Operation

The structure, functions and safety devices of the Machine must be thoroughly understood prior to machine operation, maintenance and handling. These instructions are in regards to safe operation and its device.

Confirm following points. And, correct them if the abnormal condition is found.

1) Whether Abnormal noise occurs or not, when absorbent pump or refrigerant pump runs.
2) Whether Cooling water temperature is properly controlled or not.
3) Whether Chilled water and cooling water flow or not.

1-6. Training

Contact the manufacturer specified on cover page for information on training courses to aid you in becoming familiar with this equipment / system.

1-7. Dealing and Disposal of Non-Environmental Materials

The user or service personnel should treat following non-environmental materials with special care and handle them based on local regulations.

1-7-1. Absorbent Solution

In order to prevent corrosion inside of the Machine, Absorption chiller uses Lithium Molybdate (Li_2MoO_4) as its corrosion inhibitor. This material is not so critical to the health, but should be treated with special care when they are analyzed, added and disposed.

- Do not drink and smell the solutions.
- Avoid any physical contacts with the body and cloths of users.
- Do not mix them with others such as water, and etc.
- Treat them under sufficient ventilation.
- After treatment, please wash hands of the users.
- Keep the solutions in clean and ventilated area after stored in sealed containers.

If there is any physical contact, please do following fist-aid treatment and then discuss with your doctor in order to prevent further troubles.

- Take off the cloths or shoes or other polluted sections immediately.
- Rinse skin or eyes or other polluted sections with soap or the equivalent and sufficient clean water. And, confirm there is no remainder of solution.
- In case of drinking of solutions, immediately call a doctor.

In case of disposal of solutions, please follow the relevant local regulations not to affect environmental conditions.

1-7-2. Mercury in Manometer

When the mercury manometer is mounted on the machine.

The inside vacuum condition of the Machine is measured with the mercury manometer. So, please pay attention not to break the manometer where is located on purge unit, and not to spill the mercury from the manometer.

If it is necessary to replace the manometer, please follow local regulation for the disposal of mercury.

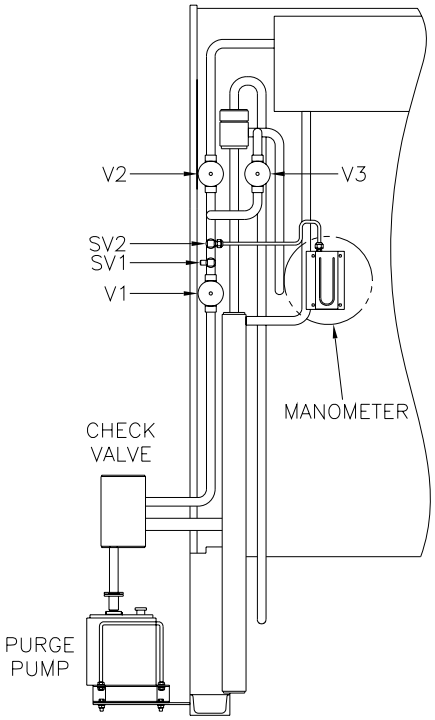


Fig.1-5. Manometer

1-7-3. Lubricant Oil in Purge pump

For the lubrication of purge pump, ISO viscosity grade 56, 68 grade lubricant oil is used. When the oil is need to be replaced or disposed, please follow local regulation for the disposal of the used oil not to affect environmental conditions.

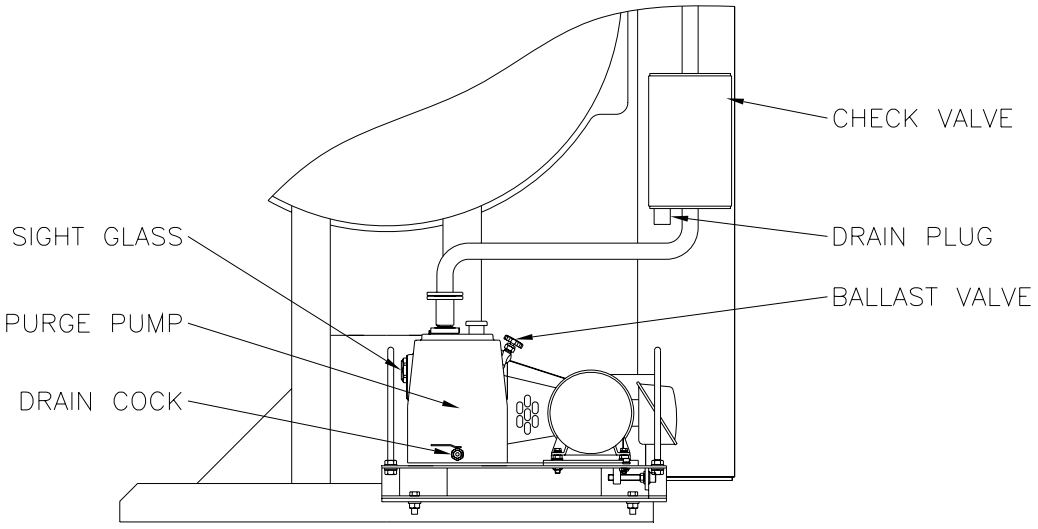


Fig.1-6. Purge Pump

1-8. Important to User

1) Be sure not to leak the air into the Absorption Machine at any cases.
(Be sure that the manual purge valves and the service valves are fully closed.)

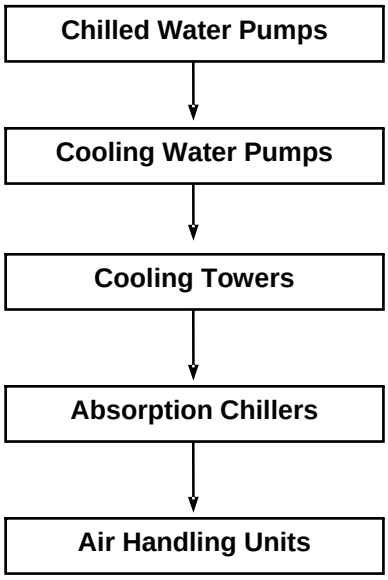
2) Do not turn off the main supply power to the Absorption Machine during the purging work.
If it is turned off the breaker, purge unit of the Absorption Machine does not work.

3) Operate the chilled water pumps and the air handling units during diluted cycle operation of the Absorption Machine. The Absorption Machine has a few cooling capacity during diluted cycle operation.

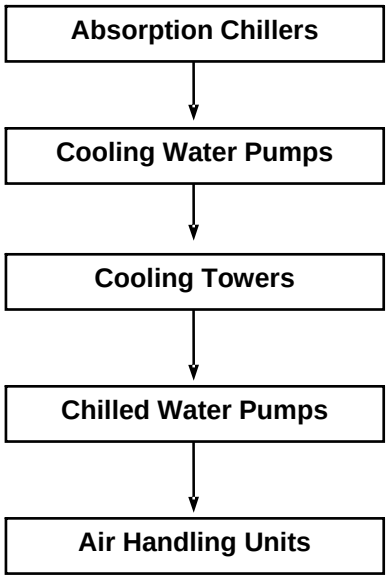
4) Do not apply megger-test on the controller circuit of micro-processor.

5) Control the start and stop operation of auxiliary equipment based on the following interlock circuit which protect the chilled water from being frozen and provide the chilled water pumps and the cooling water pumps with automatic operation. If the interlock is not made, the Absorption Machine may be damaged.

< START Procedure >



< STOP Procedure >



2. Absorption System

2-1. The Principle of Absorption Machine

2-1-1. How to be chilled with heating?

The cooling means keeping the room temperature lower than outside temperature. As shown Fig. 2-1, operate to carry the heat from the room with a lower temperature (28°C / 83°F) to the open air with a higher temperature is required. But, in the nature, the heat can not move from a low temperature side to a high temperature side. So, to transmit the heat as opposed to this law (principle), some way (apparatus) is needed. That is, a heat pump (Chiller) is used to pump out the heat from a low temperature as if a water pump is used to pump out the water from a deep well.

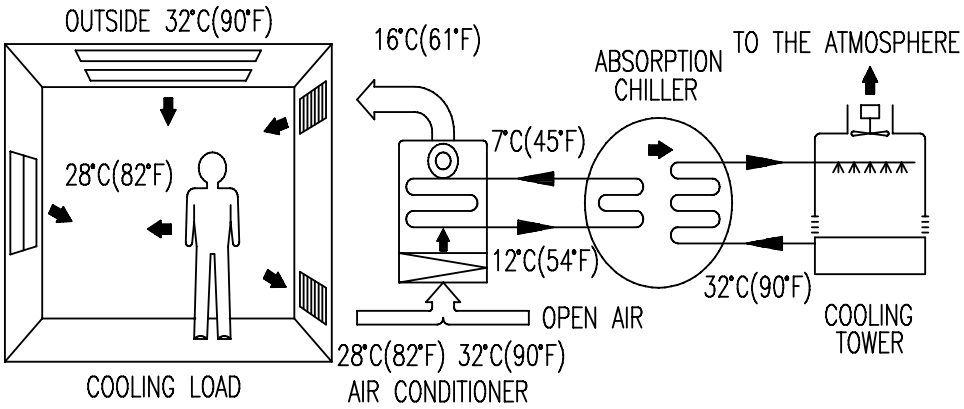


Fig. 2-1. Heat Flow

The typical Chiller using an electric as an operation power source and a compressor as a conveyer to carry the heat as seen in Fig. 2-2 is an electric Centrifugal Chiller (Turbo Chiller) and the typical chiller using heat energy is an Absorption Machine. Chilled water is made by using the latent heat released by a liquid as it evaporates. We can find this principle through our experience in a daily life. For example, when having an injection, after applying an alcohol for disinfection on the arm, we feel the arm cooled. Because, the alcohol is heated by body's temperature, took the heat from the arm when it evaporates. And another example is that we feel cool when we sweat in a hot day or by taking exercise because the sweet is evaporated from the body and it takes the heat from the body. Also, a chiller uses the latent heat of evaporation. But in a chiller, it is necessary to return the vaporized liquid to the liquid. For this purpose, the compressor is used in an electric Centrifugal Chiller (Turbo Chiller) and the absorbent is used in an Absorption Machine. The absorbent decreases the absorbent power when it is diluted by absorbing the vaporized liquid. So, the heating and concentrating process of the absorbent is required to recover the absorbent power. As a heat source, the natural gas, steam or heat water is used.

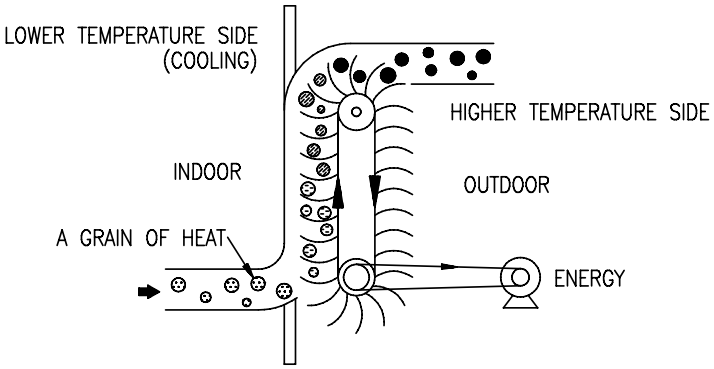


Fig. 2-2. Heat Flow at Cooling Cycle

2-1-2. The principle of Absorption

The heat transfer tubes are installed in a closed vessel and a dry silica-gel (Silica-gel is high quality absorbent material) is inserted into it as shown on Fig. 2-3. The air is taken out from the vessel and the vessel is vacuumed to pressure of approx. 6.5mmHg (1/4inchHg). Drops of water are allowed to fall on the heat transfer tubes (Evaporator). The water in the vacuum vessel evaporates at 5°C (41°F). The water takes an evaporation heat from the chilled water flowing in the heat transfer tubes when it is vaporized. Such the water is called a refrigerant and the refrigerant vapor is absorbed immediately to a silica-gel. And, a vacuum is kept inside the vessel. The water is chilled in the heat transfer tubes because the heat equivalent to the evaporation heat is taken. But, when the silica-gel reaches the limit of absorbent, it is impossible to keep a vacuum in the vessel and chilled water can not be obtained.

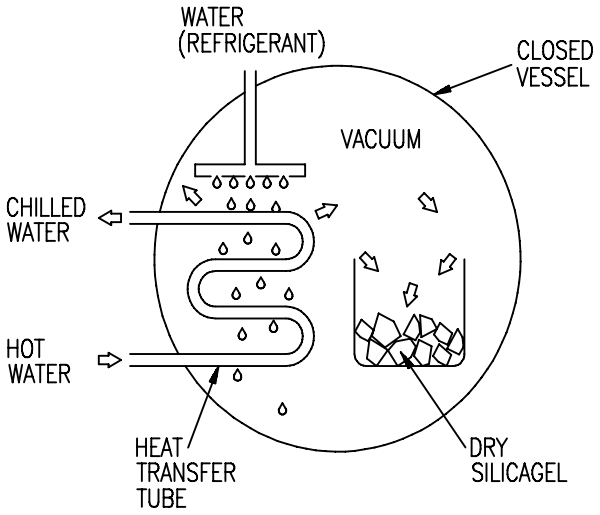


Fig. 2-3. Absorption Action of Silicagel

Therefore, it is necessary to replace this silica-gel in the vessel with new one so that the vessel is always vacuumed and be permited to get chilled water continuously. For this purpose, instead of this solid absorbent, a silica-gel, a liquid absorbent, Lithium Bromide ($LiBr$) solution is used (Such liquid is called an absorbent). This case is shown on Fig. 2-4.

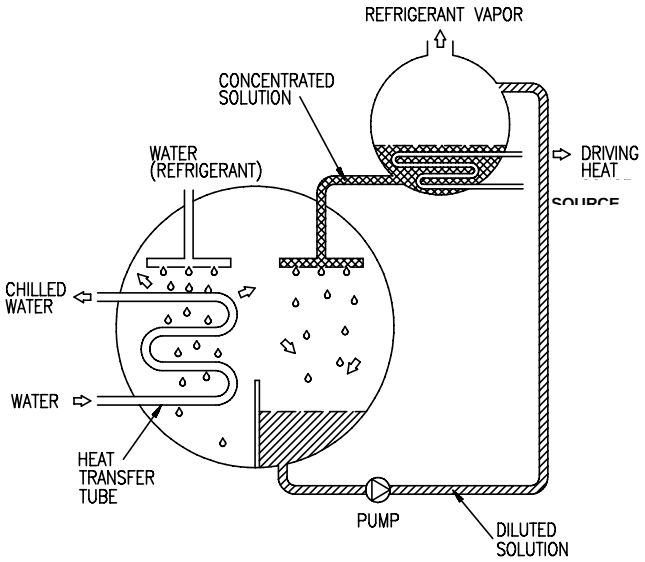


Fig. 2-4. Absorption Action of *LiBr*

Drops of the *LiBr* solution are allowed to fall (Absorber) inside the vessel. The *LiBr* solution absorbs the refrigerant vapor. But, when the absorbent once absorbs the refrigerant vapor, it is diluted and the ability to absorb the refrigerant vapor is decreased. As a result, the chilled water can be obtained no more. This means that the concentrated solution must be fed in continuously. So, the diluted solution is heated by driving heat source (natural gas, steam or hot water : generator). The heat causes the solution to release the absorbed refrigerant and also re-concentrates the solution.

The refrigerant vapor which is released from the solution when the solution is heated, is cooled in a separate vessel (Condenser) to become liquid refrigerant. Drops of this water are again introduced into the vacuum vessel (Evaporator) and recycled. This is shown Fig. 2-5.

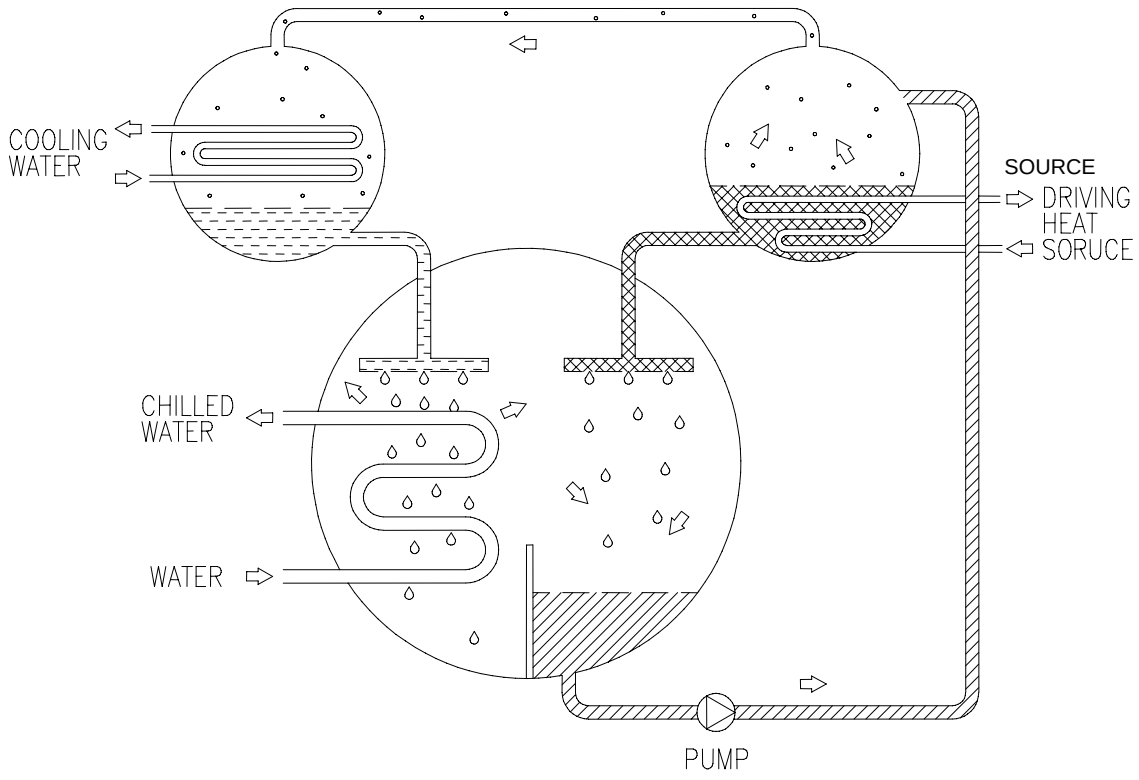


Fig. 2-5. Refrigerant Generation of *LiBr* solution

2-1-3. Basic Cycle of Single Effect Type

As shown on Fig. 2-6, this is the basic operational cycle of the single effect type Absorption Machine. Part ①

shows a Generator, part ② shows a Condenser, part ③ shows an Evaporator and part ④ shows an Absorber.

Cooling water flows through an Absorber and a Condenser. The cooling water flowing in the Condenser cools the refrigerant vapor coming from the Generator so that the refrigerant vapor comes back into refrigerant. The cooling water in the Absorber absorbs the heat generated when the refrigerant vapor is absorbed by the absorbent.

The Generator ① heats the diluted solution with the driving heat source. The diluted solution releases the refrigerant vapor and becomes the concentrated solution.

At the Condenser ②, the refrigerant vapor which come from the Generator is condensed with cooling water.

The condensed refrigerant drops on the heat transfer tubes of Evaporator ③. Drops of the refrigerant evaporate on the tubes. The water flowing through the heat transfer tubes of evaporator is cooled by the latent heat of vaporized refrigerant.

The refrigerant vapor is absorbed into the absorbent returning from the Generator and sprayed on the heat transfer tubes ④. The absorbent diluted by refrigerant vapor goes to the Generator.

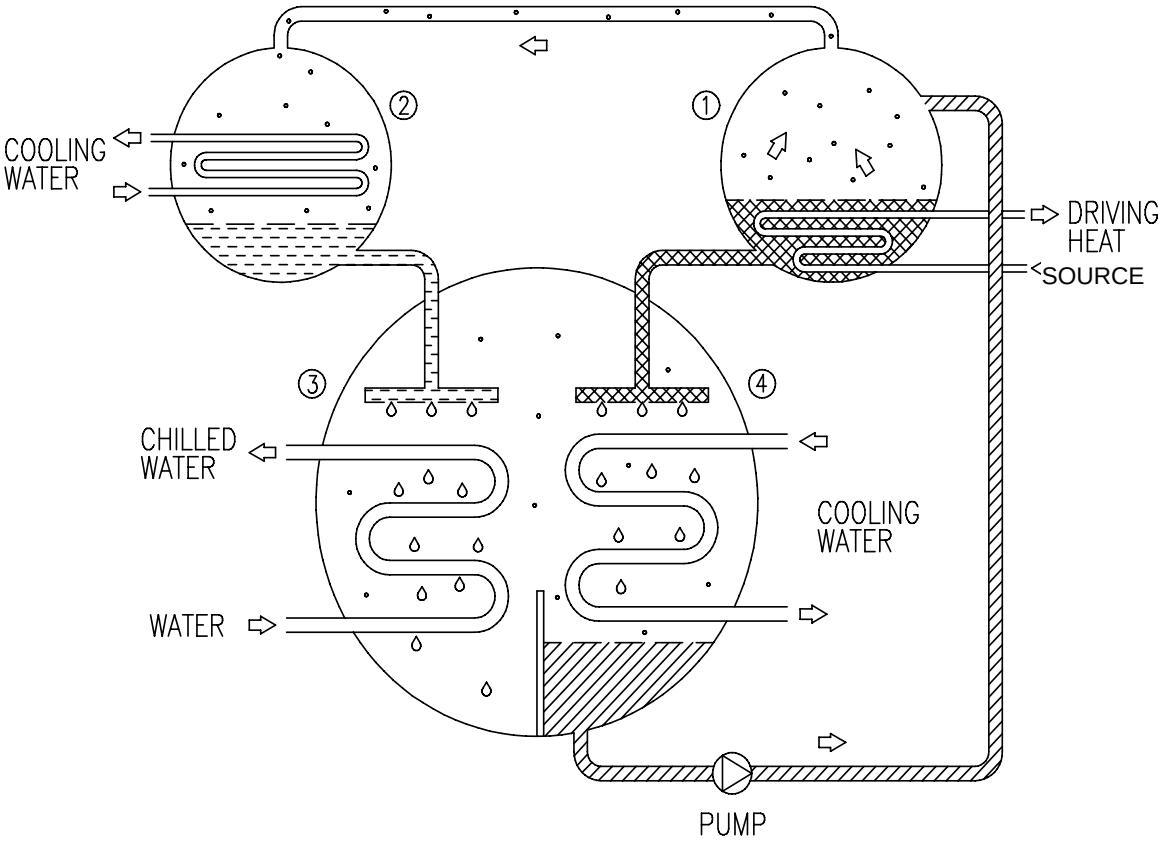


Fig. 2-6. Basic Cycle of Single Effect Type

2-1-4. Basic Cycle of Double Effect Type

In Single Effect Type Absorption Machine, all condensation heat exhausted when the refrigerant vapor coming from Generator is cooled and condensed at the Condenser, is absorbed into the cooling water.

In Double Effect Type Absorption Machine, this condensation heat is used effectively. The Generator section is divided into a High Temperature Generator and a Low Temperature Generator. The refrigerant vapor produced by the High Temperature generator is used to heat the $LiBr$ solution in the Low Temperature Generator in which the pressure (hence the boiling point) is lower.

As mentioned in the Single Effect Type Machine, the refrigerant vapor produced by the Low Temperature Generator is sent to the Condenser and becomes liquid refrigerant. On the other hand, the refrigerant vapor produced by the High Temperature Generator turns to water as it released heat to the intermediate $LiBr$ solution. This occurs at the inside of the heat transfer tubes in the Low Temperature Generator. The refrigerant vapor produced by both Low and High temperature Generator returns to liquid refrigerant and is mixed in the Condenser before returning to the Evaporator.

In this step, the diluted solution is heated by the driving heat source and by the latent heat in the refrigerant vapor which otherwise would be released into the cooling water. This combination means a lower energy consumption of driving heat source. Moreover, because the heat discarded into the cooling water is reduced, the cooling load is decreased in cooling tower. As shown Fig. 2-7.

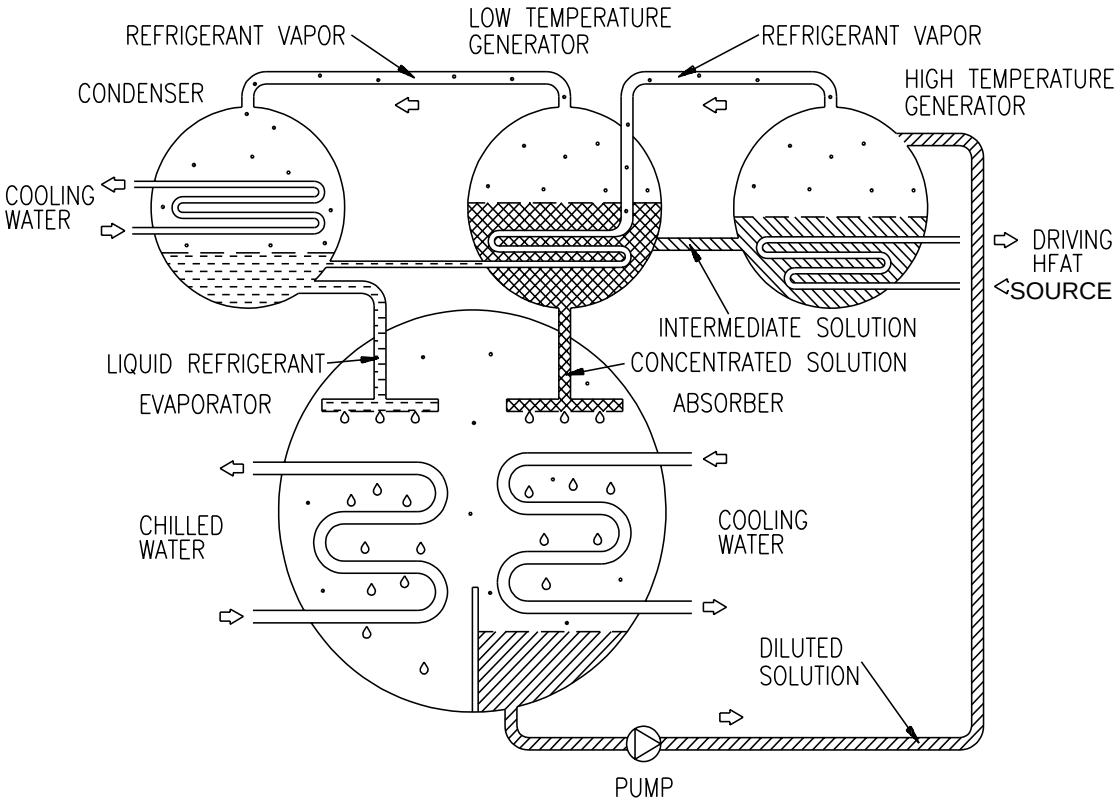


Fig. 2-7. Basic Cycle of Double Effect Type

2-1-5. Cooling Water

Cooling water flows through an Absorber and Condenser. The cooling water takes the heat which the *LiBr* solution absorbs the refrigerant vapor at Absorber. This means the absorbent is cooled by cooling water. The refrigerant vapor coming from Low Temp. Generator is cooled by cooling water.

1) **The lower temperature of cooling water.**
The absorption power of *LiBr* solution is strong at the lower temperature of the cooling water. When the temperature of cooling water in the Condenser is low, condensed temperature of refrigerant downs. Therefore condensed pressure becomes low. As the boiling temperature(Generator temperature) of the *LiBr* solution downs when the condensed pressure is low, calorific value of driving heat source can decrease. This means the energy saving.

2) **It is not acceptable that the temperature of cooling water is too low.**
As shown Fig. 2-8., a few *LiBr* dissolves with water at low temperature. That is, the *LiBr* solution of high concentration becomes crystallization under the lower temperature. For example, it is crystallized with concentration of 65% at the temperature lower than 42°C(108°F), with concentration of 60% at the temperature lower than 17°C(63°F).

3) **The Machine has some problems when cooling water temperature becomes too high.**
When the temperature of the cooling water becomes high, the absorption power of the *LiBr* solution decreases. The Machine can not get the normal chilled water temperature and wastes much fuel. Therefore, to prevent this, the maintenance for cooling water system (equipment and control) and water treatment are required.

4) **Water treatment of cooling water.**
The water treatment of cooling water is an important factor for the Machine. If the water quality is not good, the scale adheres to the inside of the heat transfer tubes, resulting in the decrease of the heat transfer effect and the excessive fuel consumption. As the heat transfer tubes may become corroded, it is required to fully take care of the water treatment.

2-1-6. Vacuum

The earth we live is pressed by the weight of air layer of thickness of approx. 10km which is surrounding the earth and this pressure is called the atmospheric pressure.

When the pressure is lower than this atmospheric pressure, it is called the vacuum. When explaining the vacuum for the Absorption Machine, it is required to know the relation between the pressure and the evaporation temperature of the water. It is experienced in a daily life that the water is boiled (evaporated) at 100°C (212°F) in the atmospheric pressure. When the pressure is higher than the atmospheric pressure, it is boiled at the temperature higher 100°C (212°F) while when the pressure is lower(vacuum), it is boiled at the temperature lower than 100°C (212°F). Table 2-1 shows the relation between the pressure and the evaporation temperature.

Table 2-1. The Relation Between The Pressure and The Evaporation Temperature

	Gauge Pressure (kg/cm^2G)	Absolute Pressure (kg/cm^2G)	Temp. (°C)	Remarks
Atmospheric Pressure	10	11	183.2	
	8	9	174.5	Driving pressure for double effect type
	5	6	158.1	
	1	2	119.6	Driving pressure for single effect type
	0.5	1.5	110.8	
1 atm.		760mmHg	100	Atmospheric Pressure
Vacuum		650.0	95.5	Pressure in the high temp. generator
		525.9	90.0	
		167.6	62.6	
		92.5	50.0	
		61.0	41.5	
		31.8	30.0	Pressure in the condenser
		29.4	28.6	
		9.2	10.0	
		6.54	5.0	Pressure in the evaporator
		5.68	3.0	

The pressure higher than the atmospheric pressure can be experienced with a boiler. When we climb a mountain, we can experience that the pressure becomes low. On high mountains, as the air layer becomes weak by its height, the pressure becomes low. For this reason, the water boils at 89°C at the summit of 2,750m mountain and rice of a canteen cannot be well boiled. Like this, the lower the pressure, that is, the closer the atmospheric to the vacuum, the lower the temperature at which the water is evaporated. Therefore, the inside of the absorption machine should be always kept in high vacuum. Since a refrigerant is evaporated at 5°C to get the chilled water of 7°C by an Absorption Machine, it is required to keep a high-vacuum condition with pressure of 6.54mmHg in the Evaporator.

2-1-7. Lithium Bromide (LiBr : Absorbent)

Lithium Bromide ($LiBr$) is a chemical made from lithium obtained from lithium ore and bromide obtained from the sea water. This chemical is not familiar to us. But we can guess easily that the lithium bromide and the sodium chloride has the similar characteristics because they are of the same element, that is, lithium(Li) and sodium(Na) are alkali while bromine(Br) and chlorine(Cl) are halogen. If it is said that the sodium chloride is salt, you will feel the lithium bromide more familiar. It is well known that when salt is left in a high-humidity atmosphere, it becomes sticky. This is because it absorbs moisture in the atmosphere. The lithium bromide has the same characteristics and its absorption power is stronger than that of salt. The higher its concentration and the lower its temperature of liquid, the stronger the absorption power.

Chemical Formula	: $LiBr$
Molecular Weight	: 86.856
Component	: Li = 7.99% / Br = 92.01%
Specific Gravity	: 3.464 at 25°C (77°F)
Melting Point	: 549°C (1,020.2°F)
Boiling Point	: 1,265°C (2,309°F)

Fig. 2-8. shows the Lithium Bromide ($LiBr$) Equilibrium Diagram
Fig. 2-9. shows the Lithium Bromide ($LiBr$) Concentration Diagram
Fig. 2-10. shows the Lithium Bromide ($LiBr$) DURING Diagram
This chart is convenient to show the condition of the cooling cycle of Lithium Bromide solution.
Fig. 2-11. shows the Lithium Bromide ($LiBr$) Enthalpy Diagram

2-1-8. Inhibitor

Lithium Bromide ($LiBr$) has a corrosive action to metals under existing oxygen. But, as the Absorption Machine is a vacuum vessel, almost no oxygen is in a vessel. However, to make complete, corrosion inhibitor is added in the absorbent and alkalinity is adjusted. So, attention should be taken to handle the absorbent and it is necessary to keep the amount of inhibitor by performing the chemical analysis for the absorbent.

2-1-9. Refrigerant

Absorption chiller uses distilled water as its refrigerant.

2-1-10. Octyl Alcohol

In order to increase absorption effect of absorbent solution, octyl alcohol is added into the Absorption Machine.

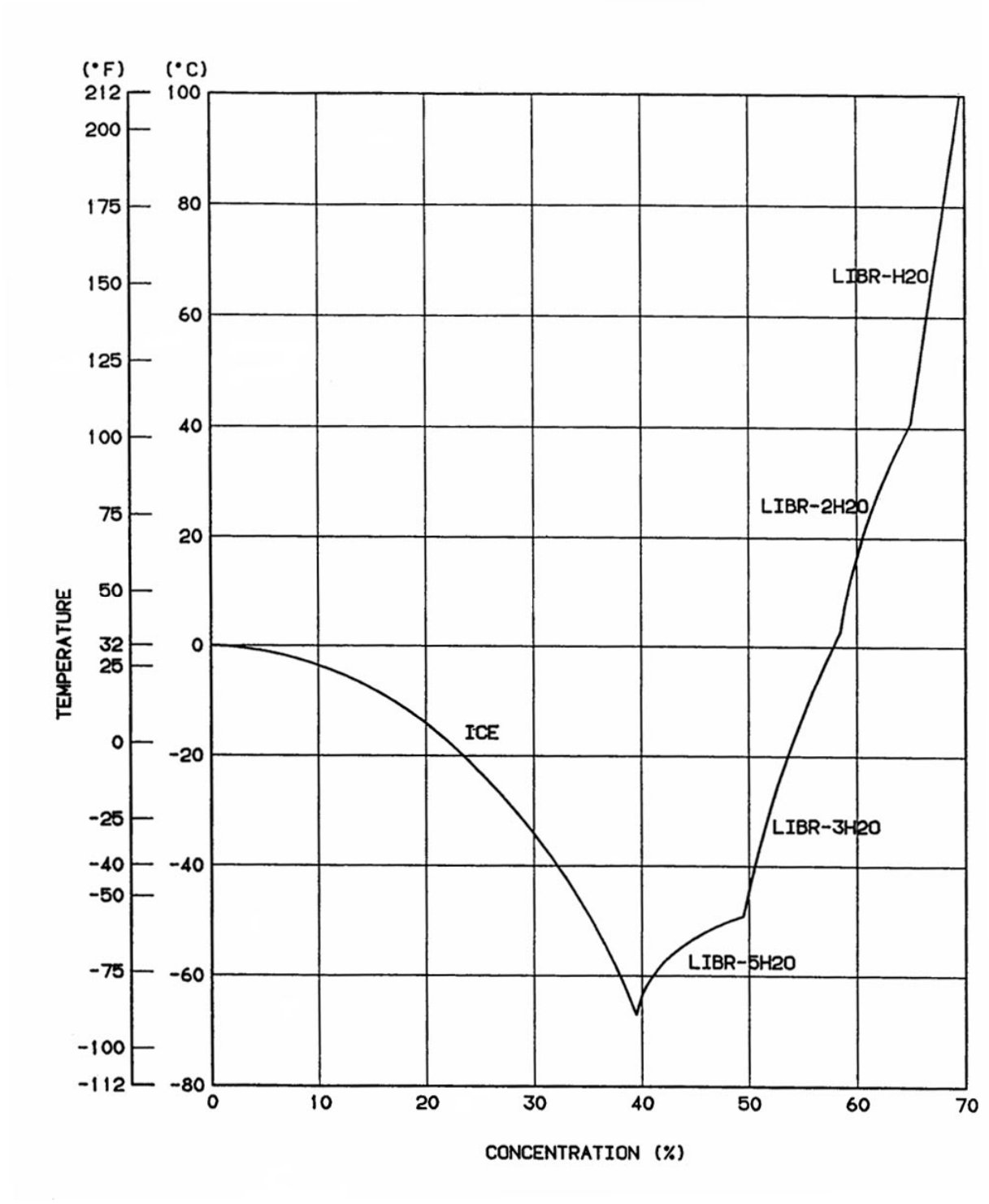


Fig. 2-8. *LiBr* Equilibrium Diagram

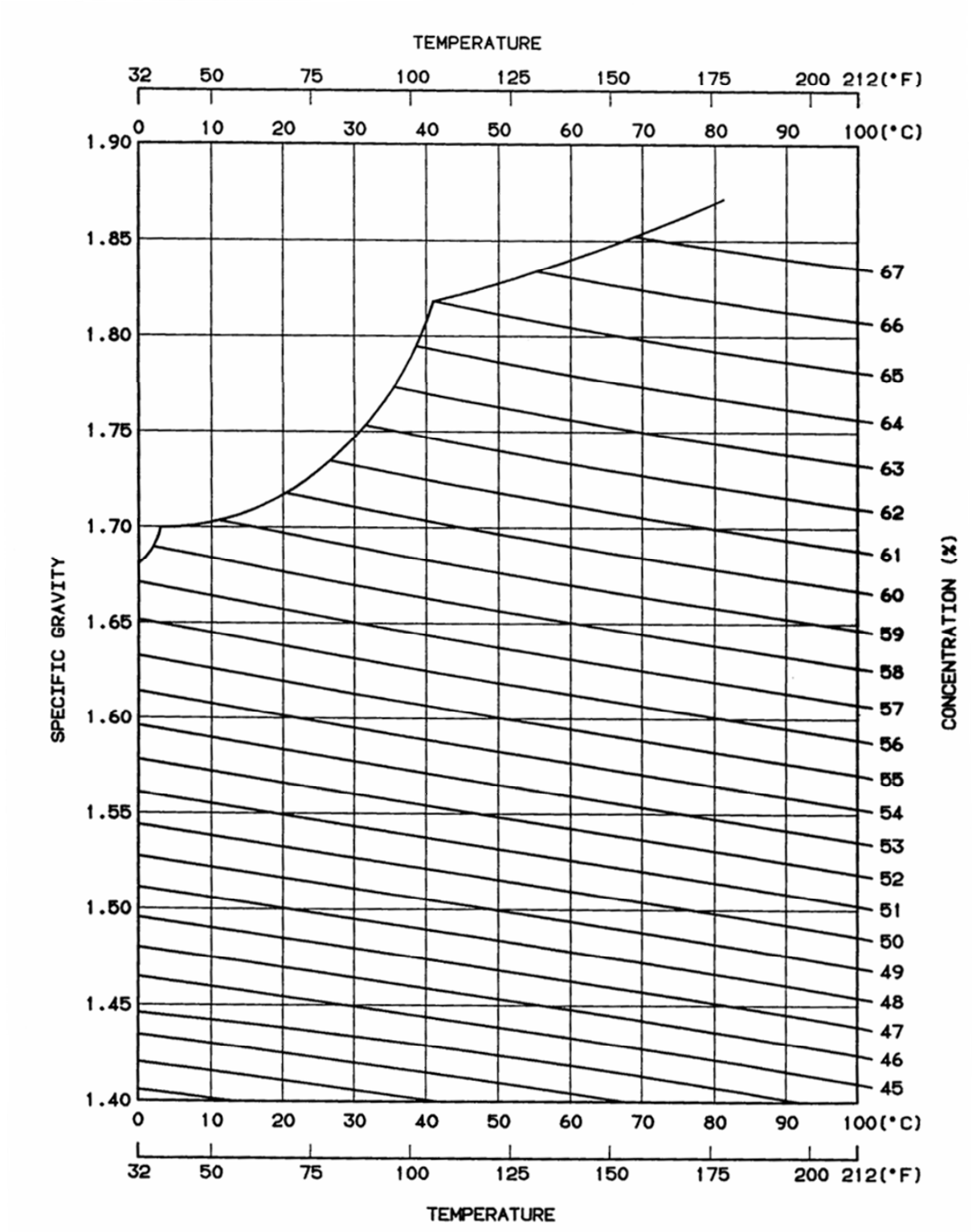


Fig. 2-9. *LiBr* Concentration Diagram

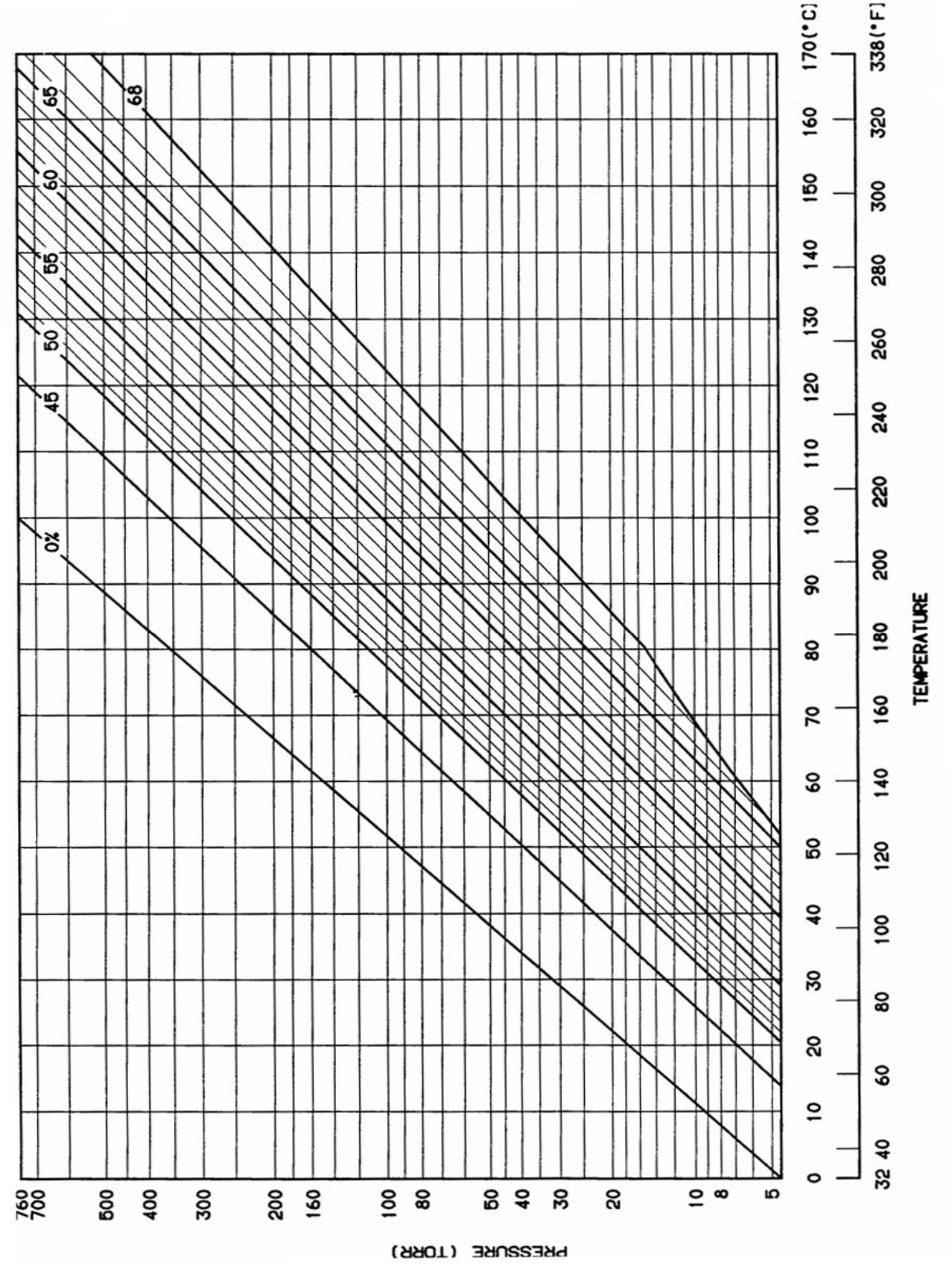


Fig. 2-10. *LiBr* DURING Diagram

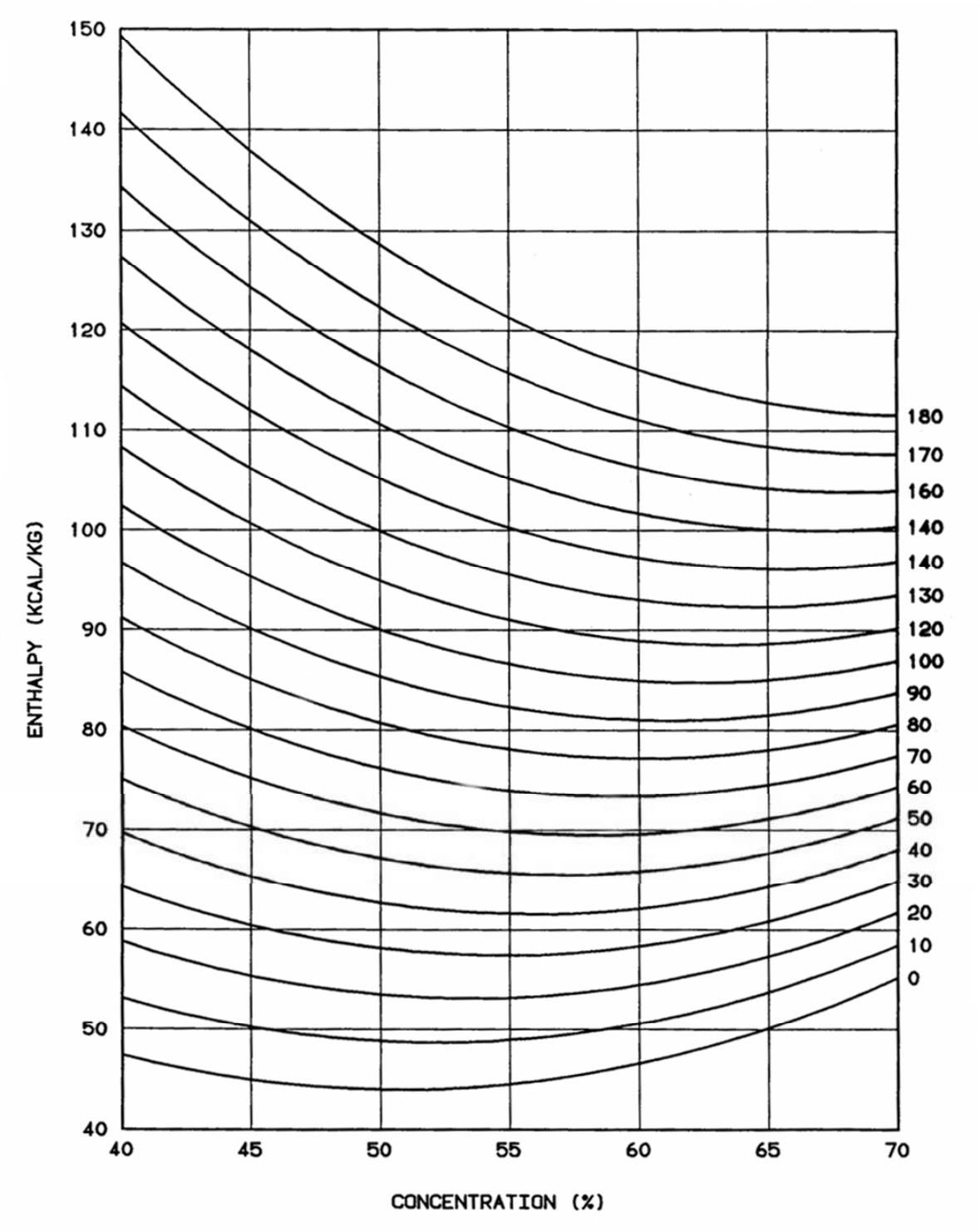


Fig. 2-11. *LiBr* Enthalpy Diagram

2-1-11. Standard Cooling Cycle

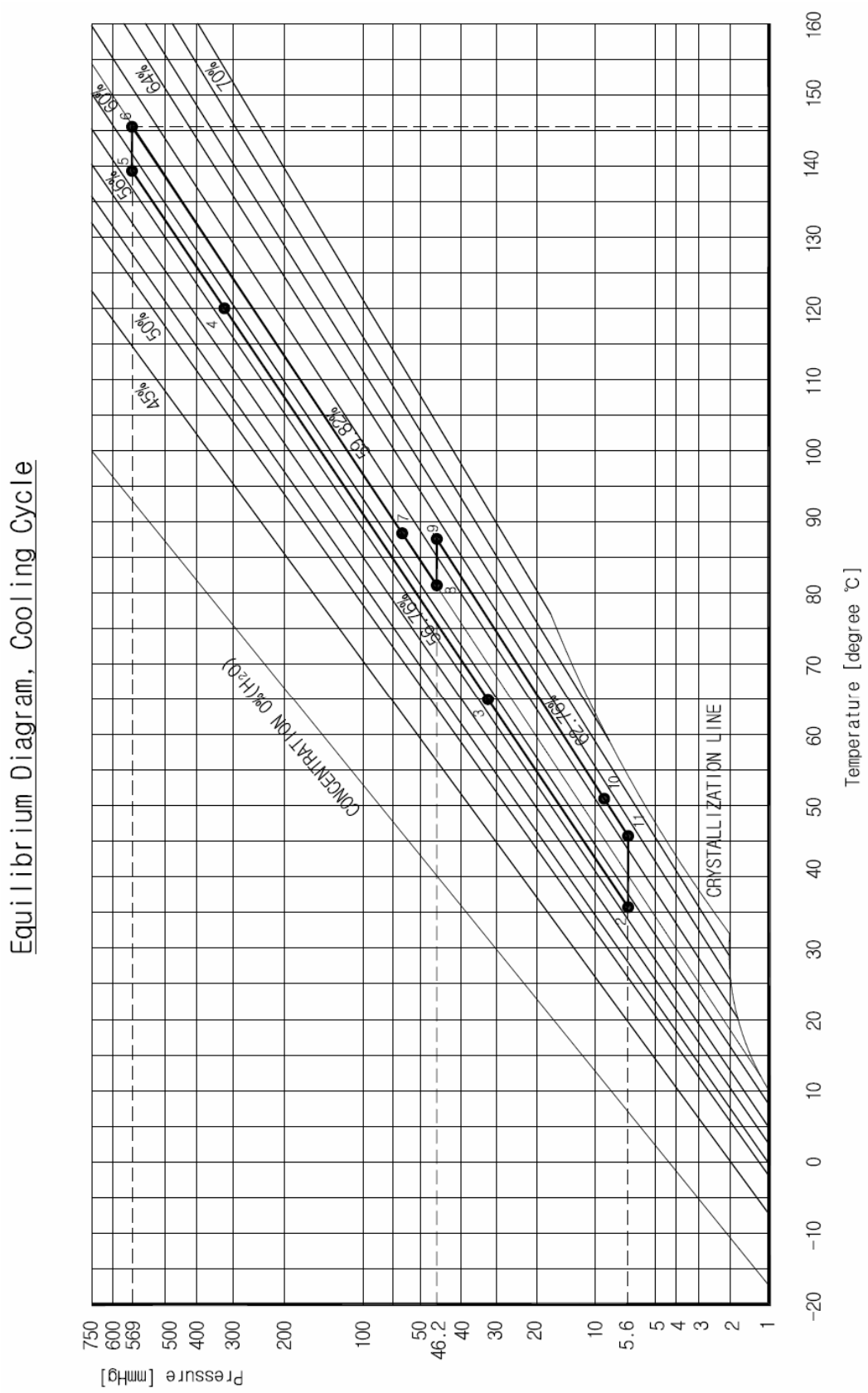


Fig. 2-12. Basic cooling cycle of the SW series Absorption Chiller

The chilled water is passed through the evaporator tube bundle and is cooled by the evaporation of refrigerant sprayed over the outer surface of the tubes by the re-circulating refrigerant pump. The refrigerant vapors are drawn into the absorber section and are absorbed by the LiBr-water solution sprayed over the absorber tubes. The heat picked up from the chilled water is transferred from the absorbed vapor to the cooling water flowing through the absorber tubes.
The solution in the absorber becomes diluted as it absorbs water and loses its ability to continue the absorption process. It is then transferred by the solution pump to the high temp. generator to be concentrated. All of the weak solution goes to the high temp. generator where it is heated by high temperature exhaust gas from micro-turbine. This boils out its absorbed refrigerant. This vapor passes to the low temp. generator tubes. Concentrated solution in the high temp. generator passes to the shell side of low temp. generator. In the shell side of the low temp. generator, the strong solution is heated by the high temperature refrigerant vapor from the high temp. generator. This boils out its absorbed water.
The refrigerant vapor is boiled from the low temp. generator solution passes into condenser section condenses on tubes containing cooling water inside. This is the same cooling water which had just flowed through the absorber tubes. On the tube side of the low temp. generator, the condensed refrigerant passes into the condenser, where it is cooled to the condenser temperature. The combined condensed refrigerant from the two generators now flows back to the evaporator to begin a new refrigerant cycle.

The strong solution, which is concentrated twice in passing two generators, flows back to the absorber spray headers to begin a new solution cycle. On the way, it passes through solution heat exchangers where heat is transferred from the hot, strong solution to the cooler, weak solution being pumped from absorber to high temp. generator. This heat transfer improves solution cycle efficiency by preheating the relatively cool, weak solution before it enters the high temp. generator and pre-cooling the hotter, strong solution before it enters the absorber.
The weak solution flowing to the high temp. generator is controlled by variable frequency drive driven solution pump. The controller calculates VFD speed to maintain optimum solution flow to the high–stage generator at all operating conditions for maximum efficiency.

Point 1. Point 1 is the same as Point 11. And it represents the strong solution in the absorber, as it begins to absorb water vapor after being sprayed on tubes from the trays. This condition is internal and can't be measured.

Point 2. Represents the diluted (weak) solution after it leaves the absorber and before it enters the low temperature heat exchanger. This includes its flow through the solution pump. This point can be measured with a solution sample from the pump discharge.

Point 3. Represents the weak solution leaving the low temperature heat exchanger. It is at the same concentration as Point 2 but at a higher temperature after gaining heat from the strong solution. This temperature can be measured.

Point 4. Represents the weak solution leaving the high temperature heat exchanger and entering the high temp. generator. It is at the same concentration as Point 2 and Point 3, but at a higher temperature after gaining heat from the intermediate solution. This temperature can be measured.

Point 5. Represents the weak solution in the high temp. generator after being preheated to the boiling temperature. The solution will boil at temperatures and concentrations corresponding to a saturated temperature established by the vapor condensing temperature in the low temp. generator tubes. This condition is internal and cannot be measured.

Point 6. Represents the intermediate solution leaving the high temp. generator and entering the high

temperature heat exchanger after being re-concentrated by boiling out refrigerant. It can be plotted approximately by measuring the temperatures of the leaving intermediate solution and the condensed vapor leaving the low temp. generator tubes (saturation temperature).

Point 7. Represents the intermediate solution from the high temperature heat exchanger as it flows into the low temp. generator. It is the same concentration as Point 6 but at a cooler temperature after giving up heat to the weak solution.

Point 8. Represents the intermediate solution in the low temp. generator. The solution will boil at temperatures and re-concentrations corresponding to saturation temperature in condenser. This condition is internal and cannot be measured.

Point 9. Represents the strong solution leaving the low temp. generator and entering the low temperature heat exchanger. It can be plotted approximately by measuring the temperatures of the leaving strong solution.

Point 10. Represents the strong solution leaving the low temperature heat exchanger. It is same concentration as Point 9 but cooler temperature after giving up heat to the weak solution. The temperature can be measured.

Point 11. Represents the strong solution entering the absorber distributors and the spray trays. This condition is internal and the temperature can't be measured. After leaving the distributors, the solution is somewhat cooled and a little concentrated as it flashes to the lower pressure of the absorber.

POINT	SOLUTION TEMPERATURE	VAPOR PRESSURE	SOLUTION CONCENTRATION
	°C	mm Hg	%
2	35.5	5.6	56.8
3	65.3	-	56.8
4	120.1	-	56.8
5	137.2	569	56.8
6	145.5	569	59.8
7	87.8	-	59.8
8	79.9	46.2	59.8
9	87.6	46.2	62.8
10	51.0	-	62.8
11	47.2	5.6	62.8

Table 2-2. Cooling Cycle Data

2-2. The Description of Cooling Cycle

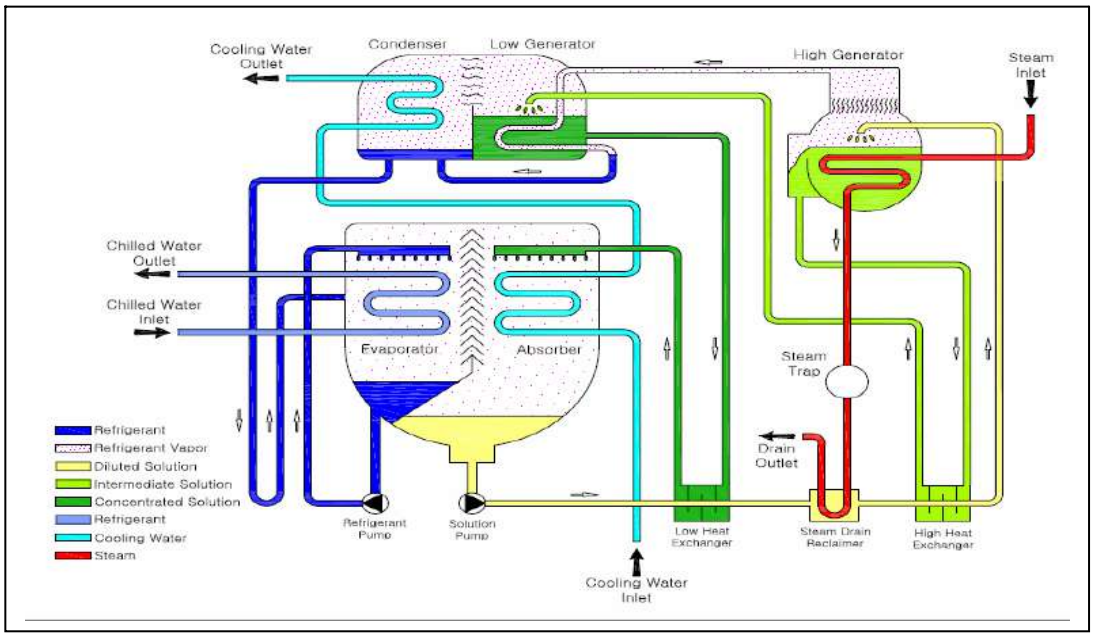


Fig. 2-13. Cooling cycle of the SW series Absorption Chiller

The double-effect, steam fired absorption machine consists of an evaporator, absorber, condenser, high-temperature and low-temperature generators, solution heat exchangers, refrigerant and solution pumps , purge system, controls and accessories. During the cooling mode, the machine operates at the condition that under vacuum, water boils at a low temperature. Under typical operating conditions, this occurs at approximately 4.4℃(40°F), thereby cooling the chilled water that circulates through the evaporator tubes. A refrigerant pump is used to spray the refrigerant(water) over the evaporator tubes to improve heat transfer.

To make the cooling process continuous, the refrigerant (water) vapor must be removed as it is produced. To accomplish this, a lithium bromide solution (which has a high affinity for water) is used to absorb the water vapor. As this process continues, the lithium bromide becomes diluted, reducing its absorption capacity. A solution pump then transfers this diluted solution to the generators where it is re-concentrated in two stages (double-effect) to boil off the previously absorbed water. A variable frequency drive on the solution pump automatically maintains optimum solution flow to the generators at all operating conditions for maximum efficiency. The diluted solution is pumped to the high-temperature generator where it is heated and re-concentrated to a medium concentration solution by the driving steam. The medium concentration solution from the high-temperature generator flows to the low-temperature generator where it is heated and re-concentrated to a strong solution by the high temperature water vapor released from the solution in the high-temperature generator. Since the low temp. generator acts as the condenser for the high temp. generator, the heat energy first applied in the high temp. generator is used again in the low temp. generator, thus reducing the heat input by approximately 45% as compared to an absorption chiller with a single-stage of re-concentration. The water vapor released in the shell side of the low temp. generator, in addition to the now condensed water vapor from the tube side of the low temp. generator, enters the condenser to be cooled and returned to a liquid state. The refrigerant water then returns to the evaporator to begin a new cycle.

To remove heat from the machine, cooling water from a cooling tower is first circulated through the tubes of the absorber to remove the heat of vaporization. The water is then circulated through the tubes of the condenser. The re-concentrated (strong) solution from the low temp. generator flows back to the absorber to begin a new cycle.
For efficiency purposes, the medium concentration solution from the high temp. generator is passed through the high-temperature solution heat exchanger to pre-heat the diluted (weak) solution, while pre-cooling the medium concentration solution. The re-concentrated (strong) solution from the low temp. generator is passed through the

low-temperature solution heat exchanger to pre-heat/pre-cool the solution before being returned to the absorber.

2-3. Machine Overview

2-3-1. Major Specification

Table 2-3. Specification Data Sheet

Item		Unit		Remarks
Nominal Capacity	Cooling	usRT		
Chilled Water System	Inlet temp. Outlet temp. Flow rate Pressure drop Design pressure Fouling factor Nozzle size	℃ ℃ m^3/h mH_2O bar $m^2.C / W$ mm		
Cooling Water System	Inlet temp. Outlet temp. Flow rate Pressure drop Design pressure Fouling factor Nozzle size	℃ ℃ m^3/h mH_2O bar $m^2.C / W$ mm		
Steam side	Inlet pressure. Drain Outlet temp. Flow rate Design pressure Fouling factor Steam Nozzle size Drain Nozzle size	bar ℃ kg/h MPa $m^2.C / W$ mm mm		
Steam control valve	Operating Pressure Flow rate Pressure drop Design Pressure Connection size	bar kg/h mH_2O bar mm		
Power Supply	Phase/Volts/Hz Absorbent pump Refrigerant pump Purge pump Control circuit Total ampere	 kW kW kW kVA A		
Dimension	Length Width Height	mm mm mm		
Weight	Operating weight Rigging weight	ton ton		

2-3-2. Main Components Description

(1) Evaporator
The refrigerant is dispersed on the heat transfer tubes of Evaporator. The chilled water through the heat transfer tubes of Evaporator is cooled by the latent heat of vaporized refrigerant.

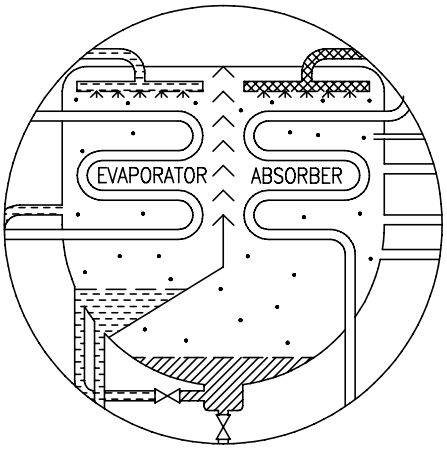


Fig. 2-15. Evaporator & Absorber

(2) Absorber
The concentrated solution is dispersed on the heat transfer tubes of Absorber. The refrigerant vapor from Evaporator is absorbed on the heat transfer tubes of Absorber by absorbent. Cooling water through the heat transfer tubes of Absorber is heated by absorption heat.

(3) Low Temp. Sol. Heat Exchanger
The diluted solution from the Absorber passes through the Low Temp. Sol. Heat Exchanger, where it is heated by concentrated solution. The diluted solution after leaving the Low Temp. Sol. Heat Exchanger flows to the High Temp. Sol. Heat Exchanger.

(4) High Temp. Sol. Heat Exchanger
The diluted solution from the Low Temp. Sol. Heat Exchanger passes through the High Temp. Sol. Heat Exchanger, where it is heated by intermediate solution. The diluted solution after leaving the High Temp. Sol. Heat Exchanger flows to 1st Generator.

(5) High Temp. Generator
The diluted solution from the High Temp. Sol. Heat Exchanger is heated in the 1st Generator. It releases the refrigerant vapor and is concentrated. It becomes intermediate solution and flows to the High Temp. Sol. Heat Exchanger.

(6) Low Temp. Generator
The intermediate solution from the High Temp. Sol. Heat Exchanger is heated in the 2nd Generator. It releases the refrigerant vapor and is concentrated. It becomes concentrated solution and flows to the Low Temp. Sol. Heat Exchanger, where it becomes low temp. Concentrated Solution and flows to Absorber.

(7) Condenser
The refrigerant vapor from the High Temp. Generator is condensed on the heat transfer tubes of Condenser. Cooling water is heated by condensation heat.
The refrigerant vapor from Low temp.Generator is fed to the condenser through the eliminators, and
It is cooled and condensed by the Cooling water

(8) Purge Unit
This is a device intended to discharge non-condensable gas and air generated inside. It consists of

purge pump, purge separator, and storage tank.

(9) Refrigerant Pump and Absorbent Pumps
These pumps are designed to circulate the internal refrigerant and absorbent.

(10) Capacity Control Unit
It detects the temperature of chilled water and sends the signals to the Steam Control Valve so as to regulate the flow rate of driving Steam.

(11) Operating Devices and Gauges
The operation panel comprises electrical parts necessary for safe operation, including lamps, operation switch, circuit breakers, power on/off switch, magnetic switches for pumps, alarm bell and auxiliary relays, if an abnormal state or trouble in the operation of the Absorption Chiller occurs, an alarm is issued, and the operation is stopped to protect the Absorption Chiller.

(12) Chilled Water Freeze Prevention Unit
When the flow of chilled water decreases, flow switch operates. When the temperature of chilled water is less than 3.0 ℃ (37 °F) etc. If an abnormal state or trouble in the operation of the absorption chiller occurs, an alarm is issued, and the operation is stopped to protect the absorption chiller.

(13) Absorbent Crystallization Prevention Unit
If the generator solution temperature is very high, the driving steam flow rate is decreased at first and the machine is finally stopped to prevent the absorbent from being crystallized. In order to prevent crystallization of the absorbent during shutdown of operation, when stopping the operation, first the heating to generation is stopped, then the absorbent pump is operated for a certain while to make uniform the concentration in all parts, only then the operation is completely stopped.

(14) Over-current thermal relay
Over-current thermal relays for absorbent pumps, refrigerant pump and purge pump are provided in control panel in order to stop the machine when overloaded.

(15) Pump motor high temperature switches
Motor coil high temperature switches are provided in the motor stator coils of absorbent pumps and refrigerant pump. So, if the motor stator coil is very high, the machine is alarm-stopped.

Table 2-4. Sensor Detail

Symbol	Item	Remarks
TH1	Chilled Water Inlet Temperature Sensor	
TH2	Chilled Water Outlet Temperature Sensor	
TH3	Cooling Water Inlet Temperature Sensor	
TH4	Cooling Water Outlet Temperature Sensor	
TH5	Evaporator Refrigerant Temperature Sensor	
TH6	Condenser Refrigerant Temperature Sensor	
TH7	High Temp. Generator Solution Temperature Sensor	
TH8	Drain Water outlet temperature Sensor	
TH9	Low Temp. Generator Solution Temperature Sensor	
TH10	High Temp. Generator Pressure Switch	

2-3-3. Outline of Machine Body

1) Typical External Schematic (Front View)

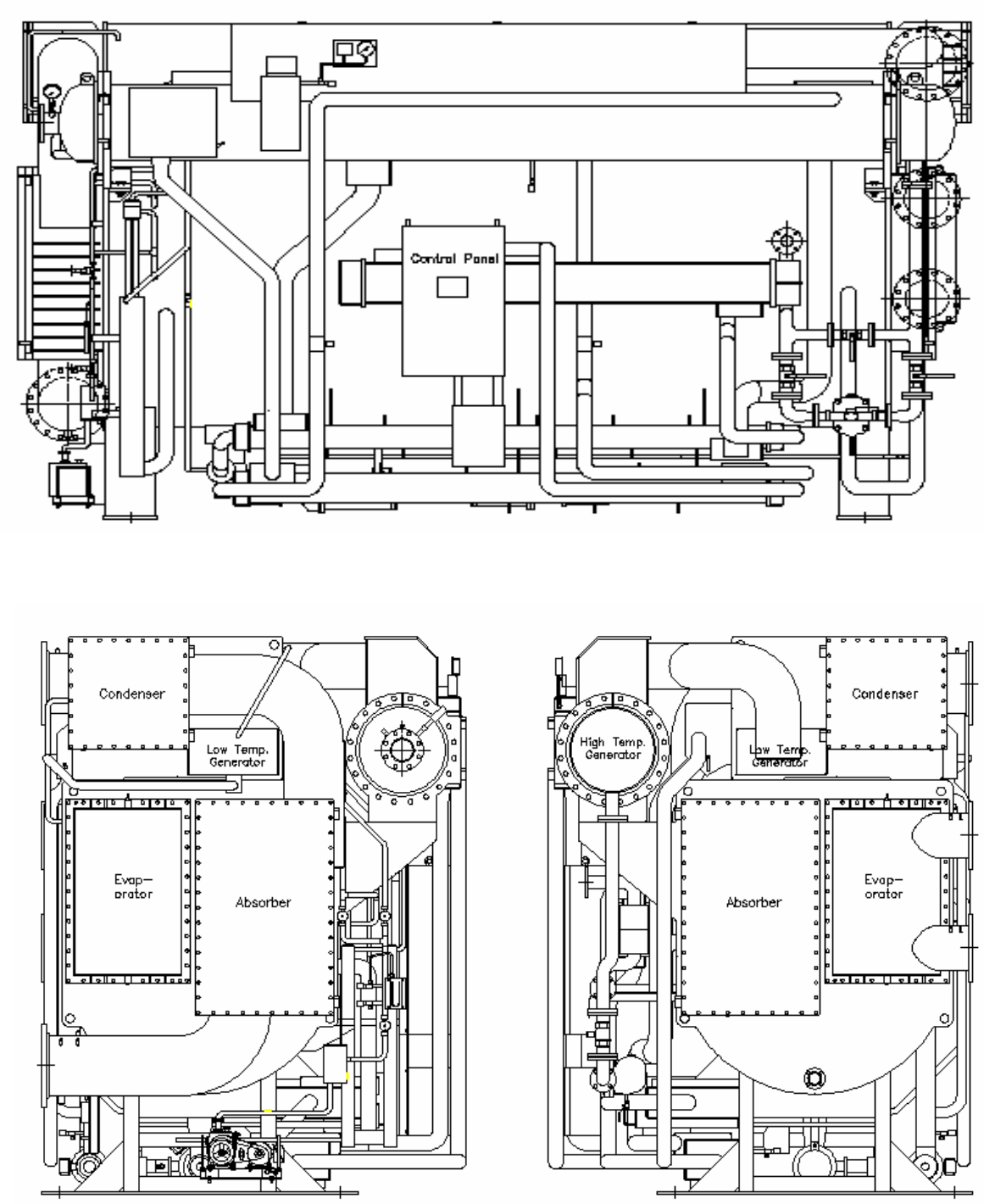
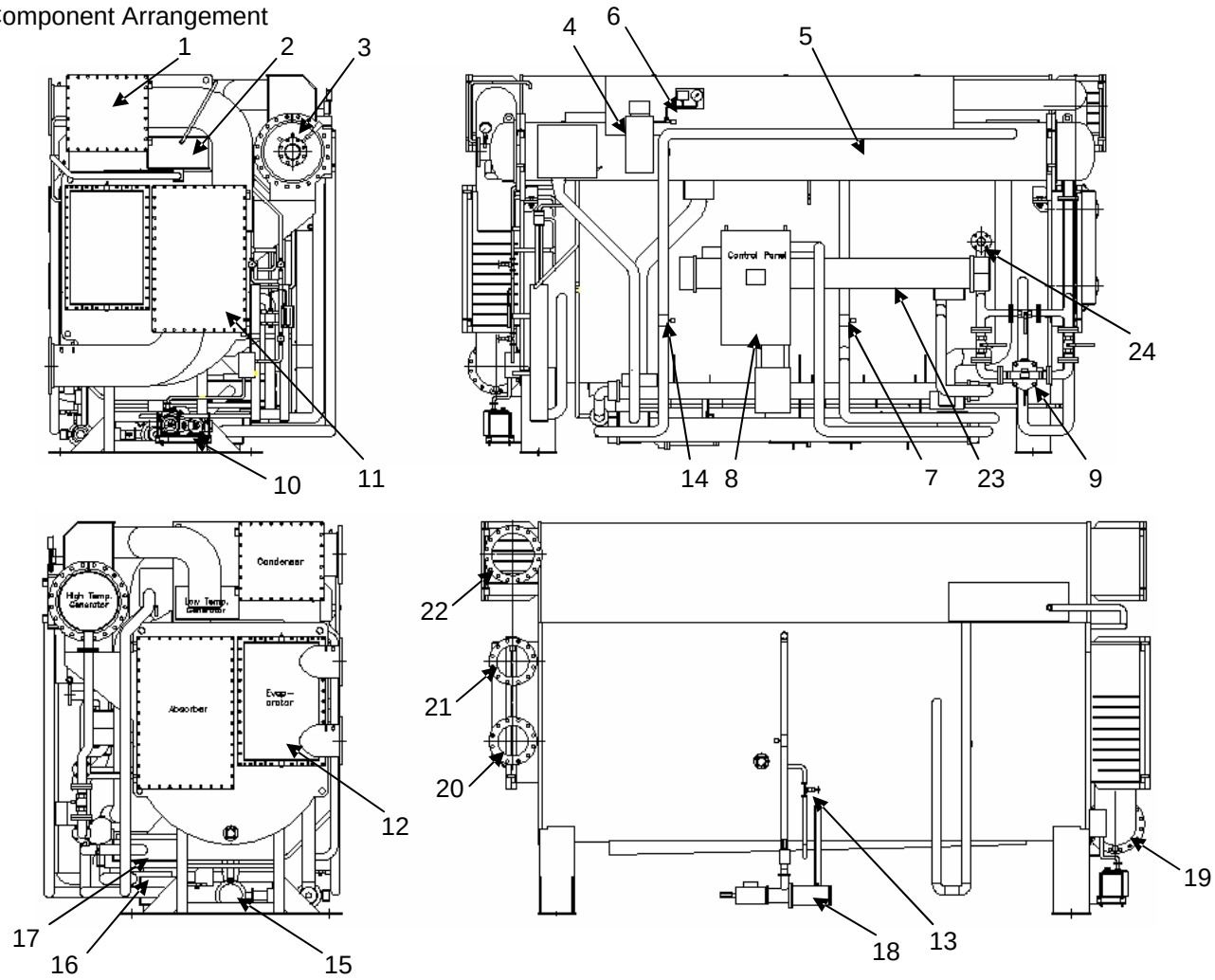


Fig. 2-16 External View of SW Absorption chiller

2) Component Arrangement

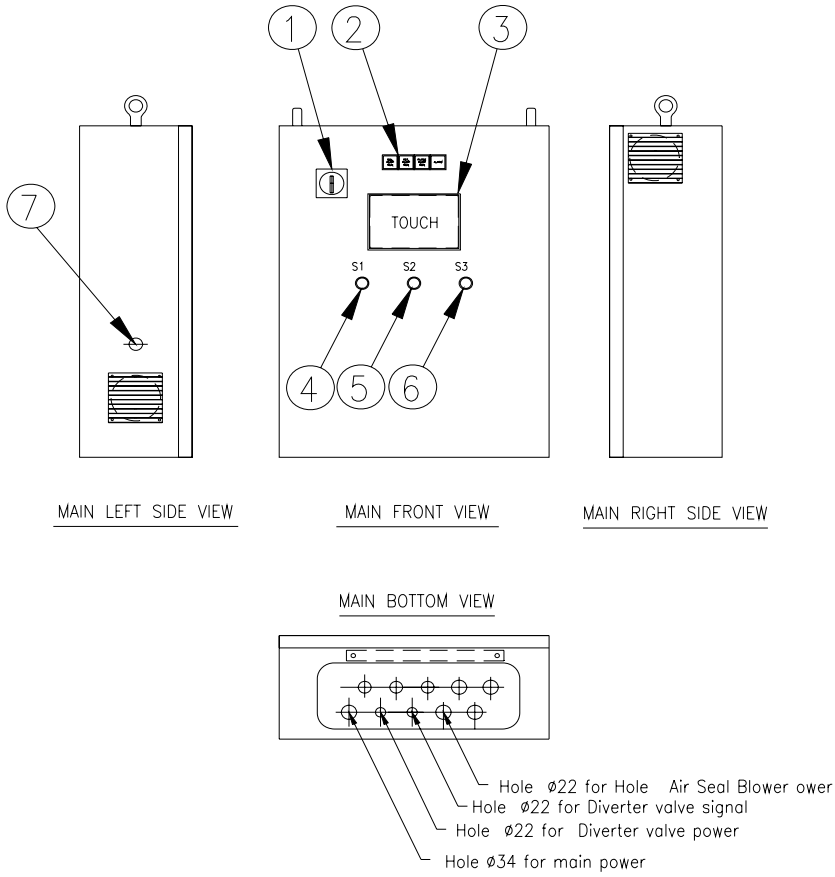


1 – Condenser
2 – Low temp. Generator (G2)
3 – Steam inlet
4 – G1 Level Control Box
5 – High temp. Generator (G1)
6 – Pressure gage & switch
7 – Absorbent Flow Adjust Valve (G1 to G2)
8 – Control panel
9 – Steam Trap
10 – Purge (Vacuum) Pump
11 – Absorber
12 – Evaporator
13 – Blow Down Valve
14 – Absorbent Flow Adjust Valve (A to G1)
15 – Absorbent Pump
16 – High-Temperature Heat Exchanger (H1)
17 – Low-Temperature Heat Exchanger (H2)
18 – Refrigerant Pump
19 – Cooling Water Inlet
20 – Chilled Water Inlet
21 – Chilled Water Outlet
22 – Cooling Water Outlet
23 – Drain Heat Reclaimer
24_ Drain outlet

Fig. 2-17. Components Arrangement

2-3-4. Outline of Control Panel

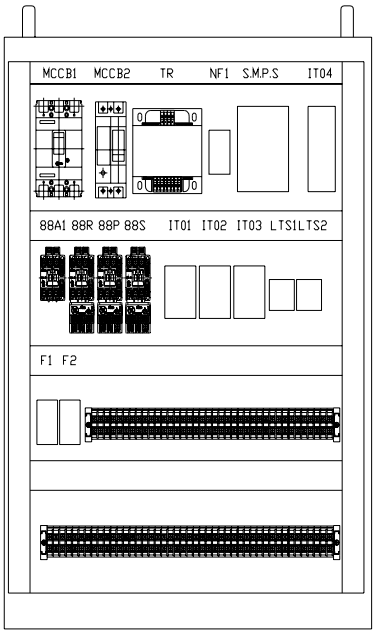
1) Outside View

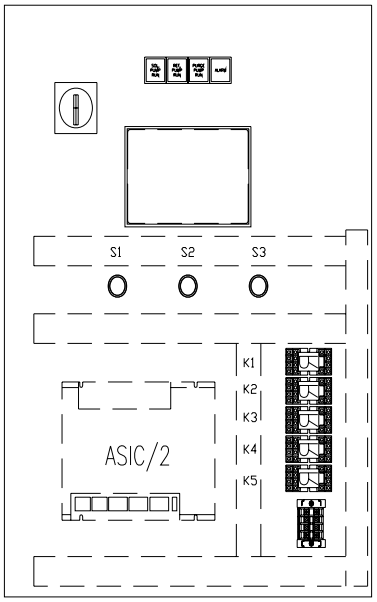


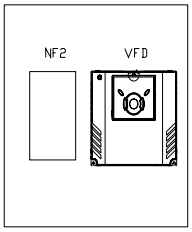
No. 1: Power On/Off Switch
No. 2: Pilot Lamp
No. 3: Touch Screen Board
No. 4: Buzzer Stop Switch
No. 5: Purge Pump Start / Stop Switch
No. 6: Emergency Stop Switch
No. 7: Buzzer

Fig. 2-18. Outline of Microprocessor Controller Cabinet

2) Inside View (Components Arrangement)







MCCB1	CIRCUIT BREAKER
MCCB2	CIRCUIT BREAKER
88R	REFRIGERANT PUMP CONTACTOR
88P	PURGE PUMP CONTACTOR
88A1	ABSORBENT PUMP CONTACTOR
88S1	AIR SEAL BLOWER CONTACTOR
51R	REFRIGERANT PUMP OVERLOAD RELAY
51P	PURGE PUMP OVERLOAD RELAY
51A1	ABSORBENT PUMP OVERLOAD RELAY
TR1	TRANSFORMER
F1~F2	FUSE
S.M.P.S	DC POWER SUPPLY
NF1	NOISE FILTER
NF2	NOISE FILTER
K1~K5	AUX RELAY
LT1~LT3	PILOT LAMP
LT4	PILOT LAMP
TS1	TEMPERATURE SWITCH SOLUTION PUMP
TS2	TEMPERATURE SWITCH REFRIGERANT PUMP
52CH	CHILLED WATER PUMP INTERLOCK
52CO	COOLING WATER PUMP INTERLOCK
AX1	REMOTE START/STOP
BZ	BUZZER
S1	BUZZER STOP PUSH BUTTON SWITCH
S2	PURGE PUMP START /STOP SWITCH

S3	EMERGENCY STOP
FA1	CHILLED WATER FLOW SWITCH
FA2	COOLING WATER FLOW SWITCH (OPTION)
V0,V1	Varister(ZNR)
VFD	INVERTER
LS1	HIGH TEMPERATURE SOLUTION LEVEL SWITCH
PS1	High Pressure Switch
LTS1	G1 LEVEL CONTROL RELAY HIGH
LTS2	G1 LEVEL CONTROL RELAY LOW
IT01~4	SIGNAL CONVERTER

Fig. 2-19. Inside of Microprocessor Control Panel

3. Installation

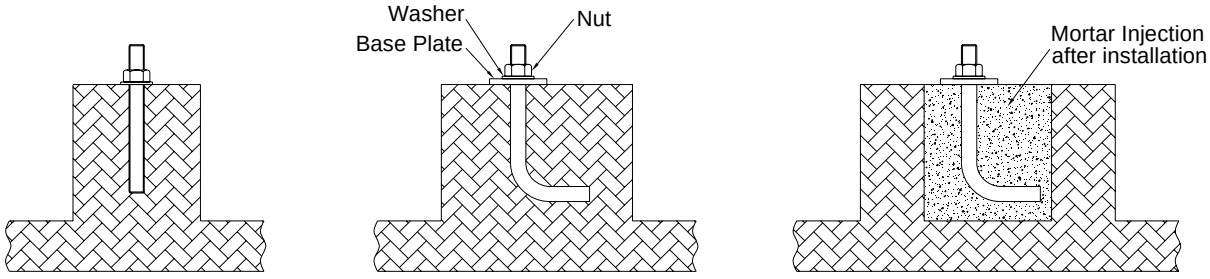
3-1. Machine Room Condition

To operate the Machine with optional efficiency and allow easy maintenance, it is necessary to find a suitable area for the Machine and its related equipment. Avoid placing the Machine in a narrow space where user movement and the maintenance such as tube cleaning, absorbent charging, and etc. are inhibited, and non-ventilated area where could generate gas explosion problem.
Select proper area as stated below;

1) The machine room must be considered to have sufficient ventilation system and 5°C ~ 45°C of ambient temperature.
2) Please avoid such area where is humid and dusty. The electric failure of the Absorption Machine may occur under the humid and dusty circumference.
   For optimum operation, it is recommended to operate the Machine in the area where the relative humidity 20 ~ 80 %RH.
3) The machine room must be considered to have sufficient service space for tube-cleaning and future maintenance. The service clearance is stated in the relevant catalogue or documents which will be provided separately.

3-2. Foundation

1) The foundation concrete must be built in the consideration of the both end levels of the Absorption Machine.
2) The foundation must be developed to support the load of the Machine and not to make unbalanced-depression of the Machine in any cases. In case of roof-top installation, the vibration and the noise must be considered as well.
3) Basically the Absorption Machine do not need special foundation plan because of the machine weight itself. But where the necessary, one of the following methods is recommended before the Machine installation.



Chemical Anchor Type **Foundation Fix Type** **Mortar Mold Type**

Fig. 3-1. Foundation Consideration

3-3. Moving the Machine

1) Determine the size and weight of the Machine from the machine specification and check that the entrance and pathway to the installation site area of adequate size.

2) Hang the shackles and wire rope as illustrated in Fig. 3-2. and Fig. 3-3. Lifting holes are furnished in the each top corners of the machine lower shell. The shackle size and the wire diameter shall be selected per the machine weight.

3) When offloading and carrying the Machine, use a crane or rollers or proper devices that can take the weight of the Machine, and the Machine must be maintained horizontal. While using a crane, attach cables to pints indicated balance the load to prevent excessive mechanical stress.

4) To prevent any damage, it is recommended that the receipt obtains expert advice from a carrage specialist and the Machine should be handled properly depending on the site condition.

5) Where cables come in contact with the Machine, place a mat (linen) or wooden piece to prevent any damages to the Machine.

6) Never remove packing materials of the Machine until the moving is completed.

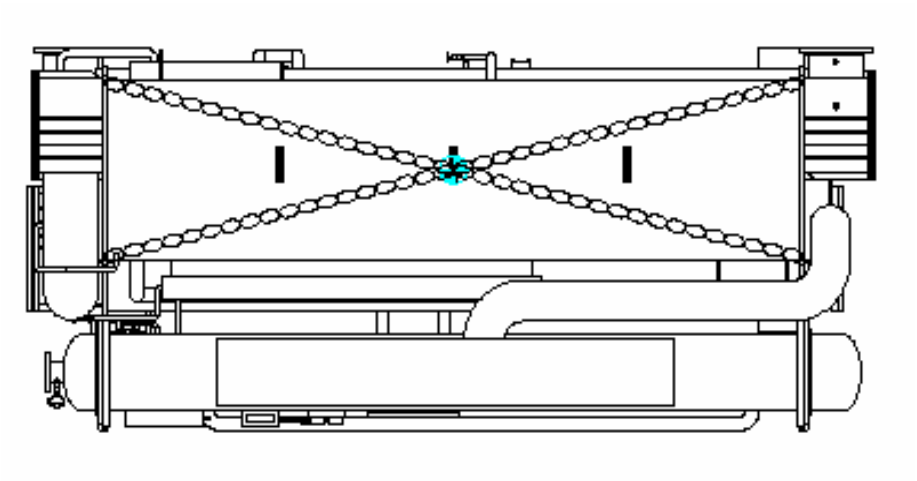


Fig. 3-2. Rigging The Unit, Typical, Top View

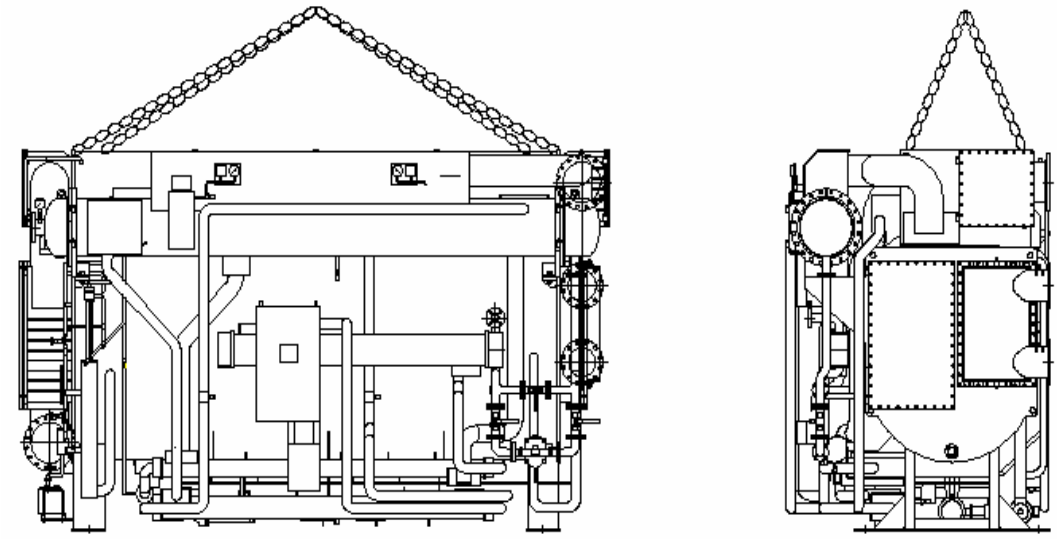


Fig. 3-3. Rigging The Unit, Typical, Side and End Views

This illustration only shows example of handling the Machine.
The shape of the Machine including control panel location may differ from this illustration due to its specifications and machine type.

3-4. Positioning and Leveling

1) The strict leveling tolerances must be adhered for trouble-free operation.

2) The leveling check points are marked on each corner of the tube sheet of lower shell of the Machine. When checks the horizontality of the Machine after positioning, fill a clear vinyl hose with water and measure the water heads difference between 1(one) point and other 3(three) points as illustrated in Fig. 3-4.

3) Make sure that 1*mm* can be allowed as the tolerance from end-to-end and side-to-side for each 1*m* length between points. When the Machine does not meet the requirement, the Machine must be shimmed with liner plate in order to meet the leveling tolerance.

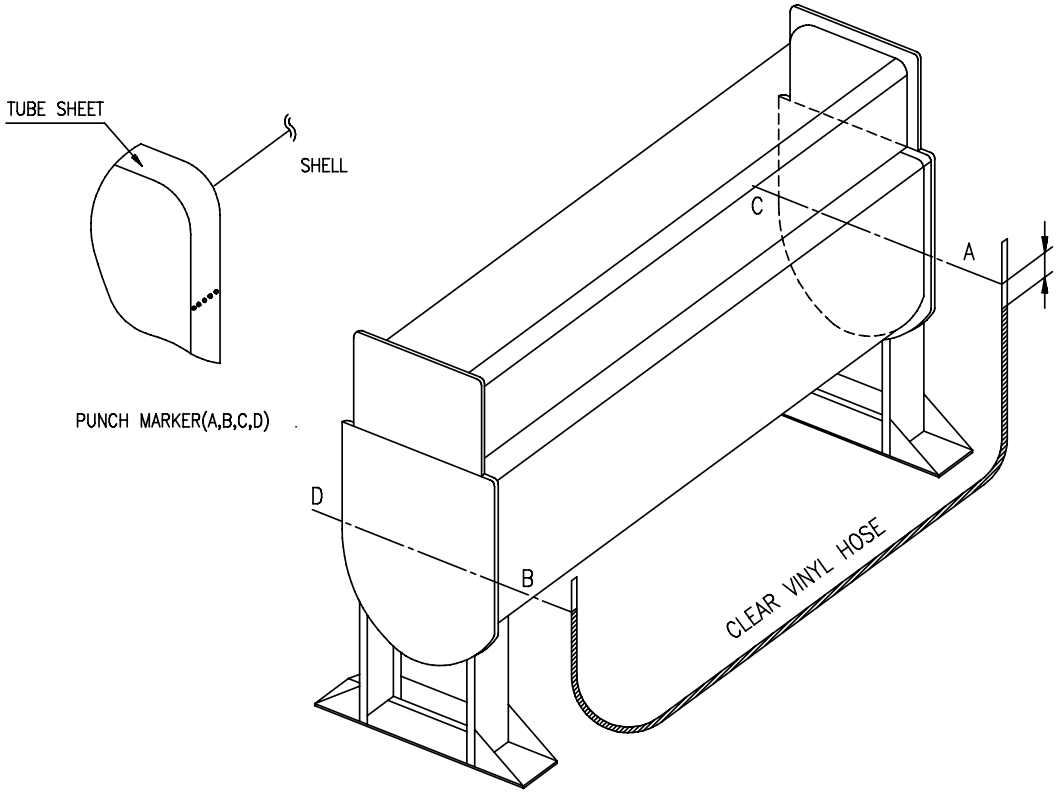


Fig. 3-4. Leveling of the Machine

3-5. Water Side Piping

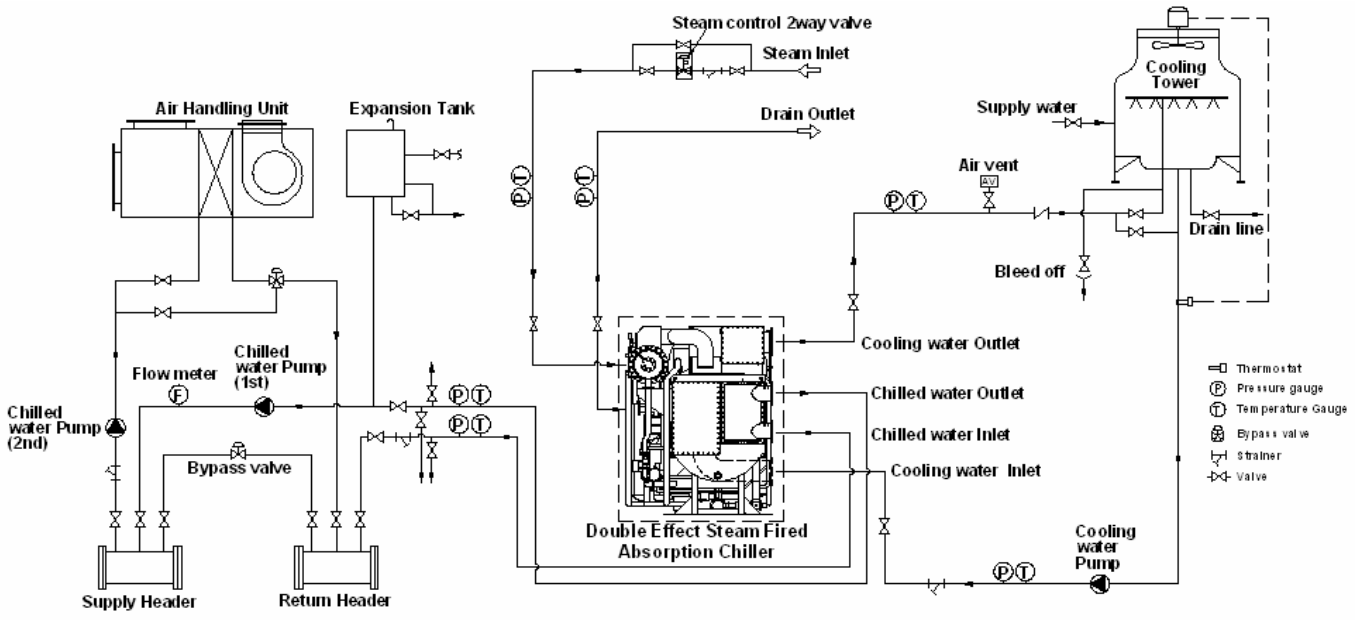


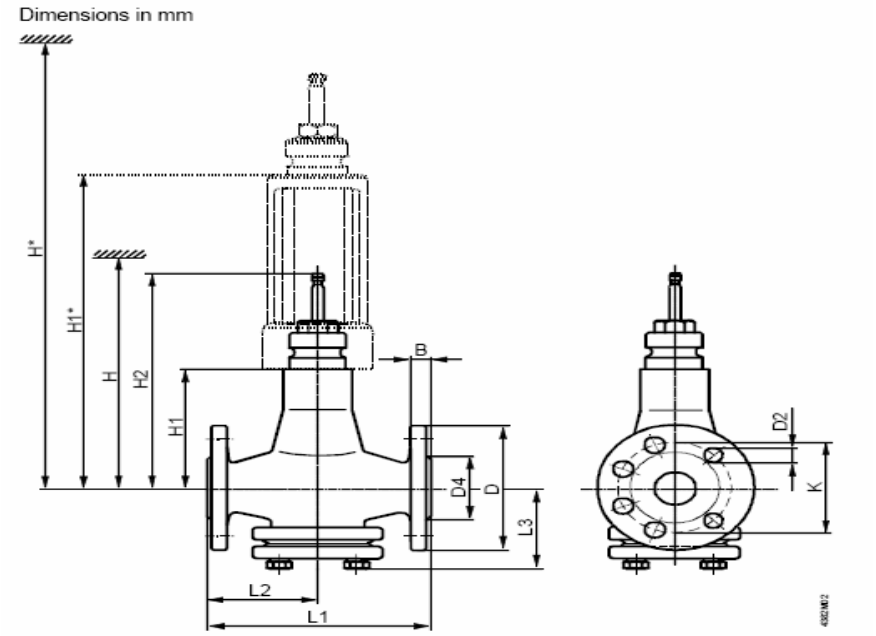
Fig. 3-5. Typical Piping Diagram

1) All external equipment out of dotted line is scope of customer's.
2) Refer to outline drawing and specification data sheet for the external dimensions of the machine, the location & the diameter of water pipe and steam pipe connections.
3) The locations of chilled water pumps, cooling water pumps and expansion tanks shall be determined in consideration of the hydrostatic head of pumps and the height of building. And the Machine shall not be subject to a pressure higher than the designed pressure at any water header.
4) The stop valves at Steam inlet and steam drain outlet pipe shall be installed.
5) For cooling water quality control, it is recommended to install cooling water bleed-off device on the inlet pipe line of cooling towers.
6) Around 10 meshes of strainers are recommended to be installed in the cooling water line.
7) For the maintenance and the inspection of the Machine, the following equipment shall be installed on each chilled water and cooling water inlet/outlet lines as well as stop valve.
   - Thermometers and pressure gauges shall be installed at chilled and cooling water inlet/outlet.
   - Air relief valves shall be installed on each chilled and cooling water lines at higher points than each water headers.
   - Drain valves shall be installed at the lowest position between the stop valves of chilled and cooling water and the Machine and the drain valve shall be piped to the drain ditch.
8) There shall be a sufficient clearance for access to the absorber, evaporator, condenser, and generator to facilitate inspection and cleaning work.

3-6.Steam control valve

1) Steam control valve (with electro-hydraulic actuator) is factory-supplied. But, it shall be intended for installation at the jobsite.
   - The standard valve provided is typically a two-way type(Fig. 3-5 is on the basis of PN40)
   - The actuator drives the valve to modulate the flow of steam to meet the required cooling load, and requires 24Vac ±20% (50 or 60 Hz) operating voltage wiring, DC 0…10V control signal and feedback signal wiring, supplied from control panel.

   (Adjust DIP switch of the actuator to proper control signal type.)



unit : mm

DN	B	D	D2	D4	K	L1	L2	L3	H1	H2	H			H1*	H*			kg	
		Ø	Ø	Ø							SKD…	SKB…	SKC…		SKD…	SKB…	SKC…	VVF61…	VVF61…2
15	16	95	14 (4x)	46	65	130	65	90	96	192.5	>596	>671		276	>776	>851		7.4	10.7
25	18	115		67	85	160	80	107	111	207.5	>611	>686		291	>791	>866		10	13.3
40		150	18 (4x)	84	110	200	100	102	136	232.5	>636	>711		316	>816	>891		16	19.5
50	20	165		99	125	230	115	107										18	21.5
65	22	185	18 (8x)	118	145	290	145	138	162	278.5			>737	342			>917	29	32.5
80	24	200		132	160	310	155	150	170	286.5			>745	350			>925	35	38.5
100		235	22 (8x)	156	190	350	175	173	180	296.5			>755	360			>935	52	55.5
125	26	270	26 (8x)	184	220	400	200	195	200	316.5			>775	380			>955	74.5	78
150	28	300		211	250	480	240	219	225	341.5			>800	405			>980	110	113.5

DN : Nominal size

H : Total actuator height plus minimum distance to the wall or the ceiling for mounting, connection, operation, maintenance etc.

H1 : Dimension from the pipe center to install the actuator(upper edge)

H2 : Valve in the “closed” position means that the valve stem is fully extended

Fig. 3-5. Steam Control Valve

3-7. Electric Works

Only qualified personnel should interface this Machine to electrical power system after becoming thoroughly familiar with all warnings, safety notices in the manual. Should you are competent to do this, process as instructed below. If you are in doubt, contact the manufacturer or a qualified electrician immediately.

IMPORTANT !

Before attempting to interface power system, read all instructions in the manual.

FOR SAFE OPERATION;

- **KEEP THE WORK AREA CLEAN.** Cluttered areas and benches invite injuries.
- **CONSIDER WORK AREA ENVIRONMENT.** Do not expose the tool to rain. Keep work area well lit. Do not use power tools in the presence of flammable liquid or gases.
- **KEEP VISITORS AWAY.** Do not let visitors touch the system or tool. All visitors should be kept away from work.
- **USE THE RIGHT TOOL.** It will do the job better and safer at the rate for which it was intended.
- **USE PROTECTIVE EQUIPMENT.** Use safety glasses and if the cutting operation is dusty, a face or dust mask
- **DO NOT ABUSE THE CORD(IF FITTED).** Never carry the tool by its cord or yank it to disconnect it from the socket. Keep the cord away from heat, oil and sharp edges.
- **SECURE YOUR WORK.** Use clamps or a vice to hold your work. It is safer than using your hand and it frees both hands to operate the tool.
- **DO NO OVERREACH.** Keep proper footing and balance at all times.
- **AVOID UNINTENTIONAL STARTING.** Do not carry the tool with a finger on the switch.
- **STAY ALERT.** Watch what you doing. Use common sense. Do not operate when you are tired.

3-7-1. Power System

This system designed for three(3) phase power distribution system having separate protective earth (1) conductors.

Ensure that the supply voltage and frequency are correct before power cables are connected. If you have any questions on the electrical ratings, see each nameplate located on the surface of Control Panel. Power service cable is required for the electrical power system interface with suitable conductor size as explained on the drawings enclosed in Section 5. Micro-processor Controller in this manual.

3-7-2. Preparing Cable

1) The insulation must be removed with the wire stripper at the end of Connection Cable. The trimmed edge of the insulation on stripped wires shall be neat, smooth and uniform. The insulation must be complete and intact with no cut, or tears.
2) The cable connection ends shall have no broken strands or no damaged insulation. The wire stripper should be properly used to remove the insulation from conductors. The wire should be placed in the correct stripping hole for the corresponding wire size to avoid cutting wire strands.
3) To maintain the lay of the wires in its original form, the strands should be twisted after the insulation is removed.
4) Shielding braid, if any, should not be cut, frayed or nicked, and should be neatly tapered.

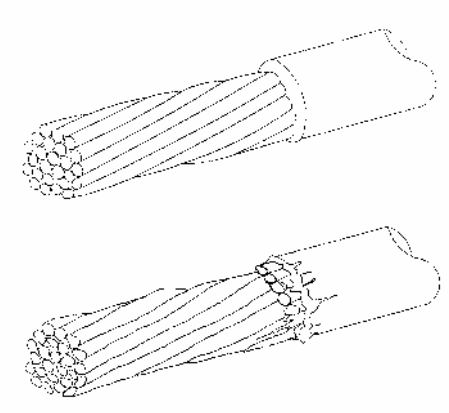


Fig. 3-10. Electric Cables

PREFERRED

Insulation does not have frayed edges.
Wire strands not cut or damaged

UNACCEPTABLE

Insulation damaged.
Wire stands cut.

3-7-3. Solderless Terminations

1) Terminal lugs of ring type are required for the connection
2) All mechanically crimped terminals shall be capable of withstanding minimum tensile strength requirements on force gauge. The tensile strength requirement is minimum 60 pounds.
3) Crimp shall be clearly evident in the barrel of the lug, but shall not damage the conductor.
4) Crimp in the insulation of the lug shall not damage the insulation of the wire.
5) Broken, nicked or loose strands of wire shall be avoided. Bent or damaged connectors are unacceptable.

(Example of solderless termination)
PREFERRED
Insulation crimp and conductor crimp in proper location on lugs.
Conductor extends less than 1/16 inch beyond conductor portion of crimp.
Insulation is fully inserted.

UNACCEPTABLE

Conductor exceeds maximum dimension of 1/16 inch beyond conductor portion of crimp.

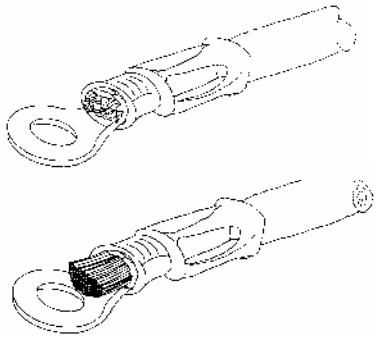


Fig. 3-11. Terminal Lugs

3-7-4. Electric Wiring

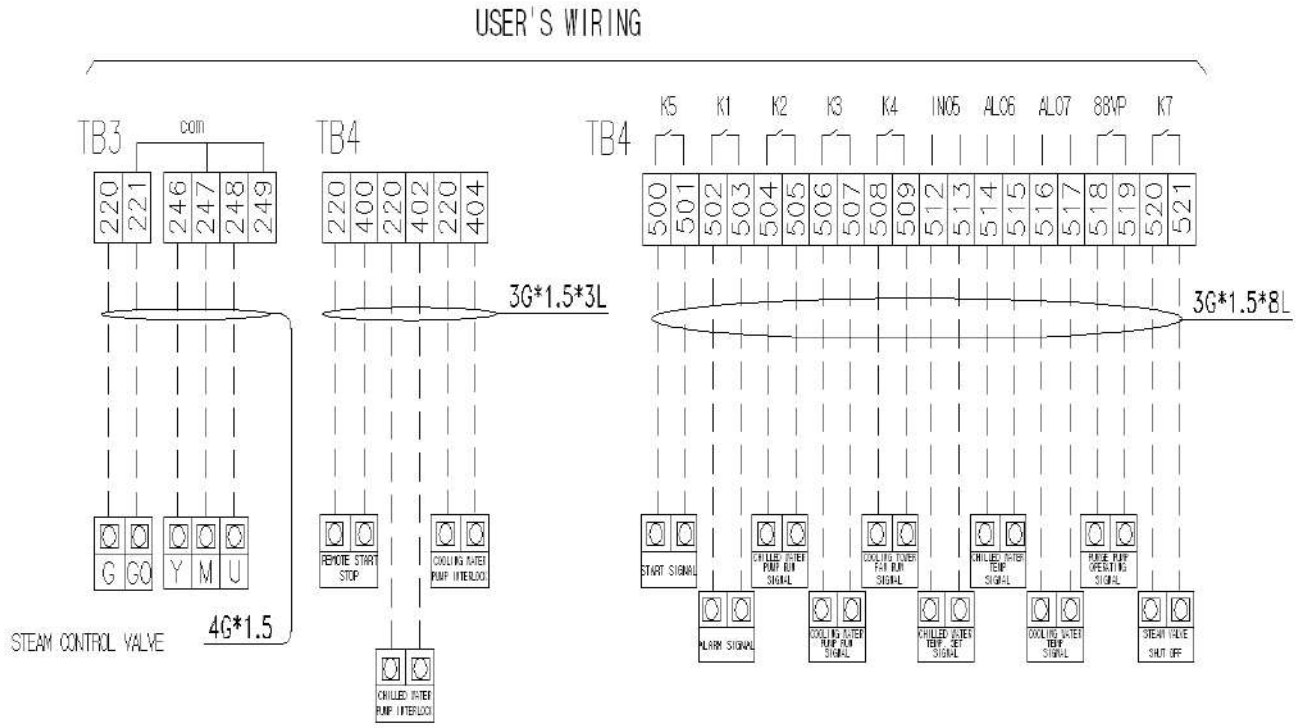


Fig. 3-12. Electric Wiring

1) Control panel and access to the field-wiring terminal block for external power and interface control connections are located at bottom of Control panel

2) Route the prepared power cable through cable inlet opening at the bottom of Control panel.

3) Ensure the phases (R, S, T) and protective earth (GND) conductors of the prepared power cable are correct before clamping terminal lugs to the field-wiring terminal block assigned for power interface.

4) All electrical connection shall be clamped tightly.

WARNING !

Never connect phase conductors (R, S, T) to the protective earth terminal marked GND.

3-7-5. User's Signal Interface

1) Connection Signal with Power Panel (User's MCC)

Signal name	Type of signal	Meaning of signal	Caution
Chilled water pump interlock Cooling water pump interlock	Input (No.-voltage contact)	This is an interlock for checking the operation of the contactor for running the pump. If there is no input signal at the time of starting, the Machine cannot be operated. If there is no input during operation, fault occurs.	DC24V is output, checking the contacting state. Do not allow a contact resistance of more than 100Ω. (Do not insert the other power lines into this conduit tube.)
Chilled water pumps RUN/STOP Cooling water pump RUN/STOP Cooling tower fan RUN/STOP	Output (No-voltage contact)	This is a RUN/STOP signal of the pump or fan. Connect it when operated sequentially with the RUN/STOP signal from the Machine.	Use it within AC250V 0.1A (resistance load)

NOTE Be sure to interface the contactors of chilled water and cooling water pump with the terminal points in control panel of the Absorption Machine to sequentially operate and to protect the chilled water from freezing.

2) Connection Signal with Central Monitor Panel

Signal Name	Type of signal	Meaning of signal	Caution
Contact for running check signal	Output (No-Voltage Contact)	ON when the operation signal is entered. OFF when the stop signal is entered.	Use it within AC250V 0.1A (resistance load)
Contact for fault display	Output (No-Voltage Contact)	ON when there is a fault (alarm)	

Signal name	Type of signal	Meaning of Signal	Caution
Signal for remote STARTING/STOP (No voltage, AC24V, DC24V input)	Input	Signal for starting/stopping the Absorption Machine remotely.	Both of no-voltage AC24V, and DC24V use shield wires, and it should not have conduit tube treated together with other power lines.

When the electrical power interface has been fully completed, the following tests shall be performed.

1) Continuity of the Protective Bonding Circuit

The protective bonding circuit shall be visually inspected for compliance with items 1) to 4) mentioned on last page and a check for tightness of the connection of the protective conductors shall be made according to item 4).

In addition, the continuity of the protective bonding circuit shall be verified by injecting current of at

least 10A at 60Hz derived from a PELV source for a period of at least 10s. The test shall be made between the PE terminal and the various points of test shall not exceed the value given in the table below.

Table for Verification of the continuity of the protective bonding circuit

Minimum Effective Protective Conductor Cross-sectional Area of the Branch under Test (mm^2)	Maximum Measured Voltage Drop (v)
1.0	**3.3**
1.5	**2.6**
2.5	**1.9**
6.0	**1.4**
6.0 or larger	**1.0**

2) Insulation Resistance Tests

The insulation resistance measured at 500Vdc between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ.

3) Voltage Tests

The electrical equipment shall withstand a test voltage applied for a period of at least 1 second between the conductors of all circuits, excluding those intended to operate at or below PELV voltages, and the protective bonding circuit.

The test voltage shall;

- **have a value of twice the rated supply voltage of the equipment or 1000V, whichever is the greater**
- **be at frequency of 60Hz**
- **be supplied from a transformer with a minimum rating of 500VA.**

Components which are not rated to withstand this test shall be disconnected during testing.

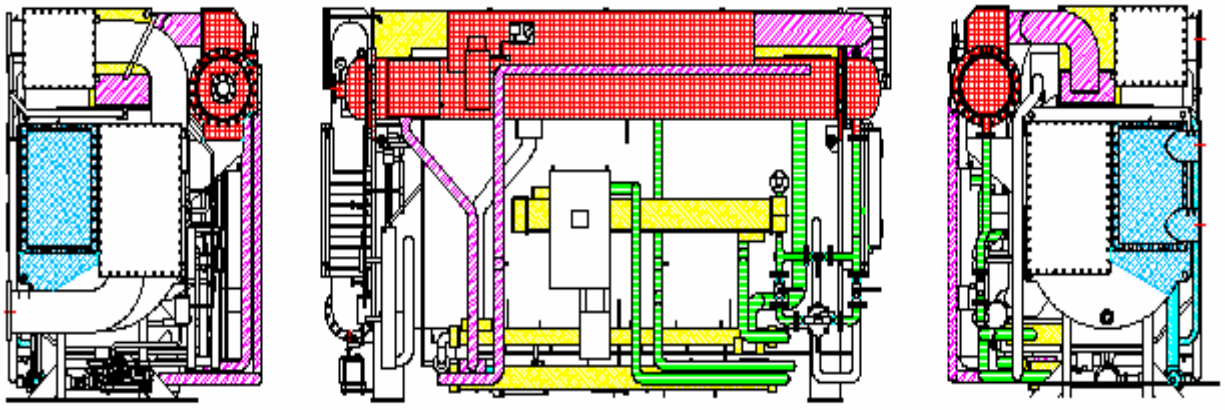
3-8. Insulation

Because the many different materials can be used due to the surrounding conditions of chiller and the local code requirements or regulations are varied according to the region, it may not be possible to specify the insulating material types. The followings describe the materials and the thickness which can be use for many cases.

1) Use only Non-inflammable or Incombustible insulation materials
2) Do not insulate motor of refrigerant pump.
3) Total insulation area includes piping.
4) Do not cover components such as service valves, dampers, diaphragm valves, sight-glass, control valves or thermometers or sensor wells.
5) The standard Material and Thickness as the recommendation :
   (1) HOT Surface insulation
      - Material of insulation : Non-inflammable polymer sponge usable at 120℃ or Glass wool. But, the glass wool should be used for high temperature generator and high temperature piping.
      - Thickness of insulation : 10mm (3/8 inch), 19mm (3/4 inch) when polymer sponge is used
      - Thickness of insulation : 20mm (3/4inch), 50mm (2 inch), 75mm(3 inch) when Glass wool is used

   (2) COLD Surface insulation
      - Material of insulation : Closed cell type Non-inflammable polymer sponge
      - Thickness of insulation : 10mm (3/8 inch), 19mm (3/4 inch)

   (3) Wrapping Material when Glass wool is used.
      - Insulated parts on High temperature generator : Aluminum sheet or Colored galvanized steel with 0.30 mm thickness or over
      - Insulated parts on pipes : Aluminum sheet or Colored galvanized steel with 0.30 mm thickness or over
6) For insulation area for each model, please refer to the picture below.
7) The water box sections should be worked to be disassembled for the repair.
8) If necessary, please perform the finish painting in the field after completing the insulation work.



HOT Surface

- High Temp. Generator
- Low Temp. Generator (with Water Box)
- Heat Exchanger (with Pipe)
- Low Temp. pipes

COLD Surface

- Evaporator (with Water Box)
- Inlet & Outlet Pipes

* SURFACES OF MODELS

MODEL	Hot Surface(㎡)			Cold Surface(㎡)	
	75mm	50mm	19mm	19mm	10mm
SW100	5.2	3.5	2	3.5	0.6
SW120	5.2	3.6	2	3.5	0.6
SW150	7.3	4.8	3	4.8	0.7
SW180	7.3	4.8	3	4.8	0.7
SW210	8.3	5.7	3.5	5.8	0.8
SW240	8.3	5.7	3.5	5.8	0.8
SW280	10.5	6.3	4.5	7.2	0.9
SW320	10.5	6.3	4.5	7.2	0.9
SW360	11.6	7.1	5.5	8.2	0.9
SW400	11.6	7.1	5.5	8.2	1.0
SW450	13.0	7.7	6.5	9.8	1.0
SW500	13.0	7.7	6.5	9.8	1.0
SW560	13.8	8.9	7.5	13.5	1.1
SW630	15.4	9.2	7.8	15.0	1.1
SW700	17.0	9.5	8.2	16.0	1.1
SW800	18.4	11.0	9.5	17.0	1.2
SW900	20.2	11.5	10.0	18.5	1.2
SW1000	22.0	11.8	10.5	20.0	1.2
SW1100	23.5	12.9	11.0	22.5	1.4
SW1200	25.0	14.0	12.0	11.1	1.4
SW1300	26.6	14.6	12.5	11.7	1.4
SW1400	28.5	15.3	13.0	13.3	1.5
SW1500	29.0	16.5	14.1	13.8	1.5

4. Before Start-up

4-1. Inspect the field piping

Refer to the field piping diagrams for your specific installation, and see the typical piping schematic shown in Fig. 3-5 inspect the chilled water and cooling water piping.

1) Verify that the location and flow direction of the water lines are as specified on the drawings and as marked on the chiller.
2) Check that all water lines are vented and properly supported to prevent stress on water box covers or nozzles.
3) Make sure all water box drains are installed.
4) Ensure that water flows through the evaporator and absorber/condenser meet job requirements. Measure the pressure drops across both evaporator and absorber/condenser when the system has been charged with water and the pumps can be operated.
5) Make sure the chilled water temperature sensors are installed in the leaving chilled water piping. Also check that appropriate thermometers or temperature wells and pressure gage taps have been installed in both entering and leaving sides of the evaporator, absorber, and condenser water piping.

4-2. Inspect the wiring and the set point of Electrical components

Refer to the field and chiller wiring diagrams and inspect the wiring for both power supply and connections to other system equipment (cooling tower, water supply pumps, etc.)

WARNING !

Do NOT connect or disconnect any wiring and do NOT touch any bare wires terminals unless power supply disconnects have been locked open and tagged.

1) Examine the wiring for conformance to job wiring diagrams and applicable electrical codes.
2) Check pump and motor nameplates and control panel for agreement with supply voltage and frequency (Hz).
3) Verify the correct overload and fuse sizes for all motors.
4) Check that electrical equipment and controls are properly grounded in accordance with applicable electrical codes.
5) Make sure that customer/contractor has verified proper operation of water pumps, cooling tower fan and associated auxiliary equipment. This includes ensuring that motors are properly lubricated and have proper electrical power supply and proper rotation.

4-3. Chiller Evacuation

The chiller has been factory-charged with solution and refrigerant and then pressurized with nitrogen gas for shipping. Before initial start-up, release the nitrogen gas through the service valve (SV1) and the diaphragm valve (V3) OPEN at purge unit (Fig. 6 – 1) until ambient pressure is achieved. Then close the service valve (SV1) and the diaphragm valve (V3). And, start the purge pump and open the diaphragm valve (V1). After you make sure that the purge pump can make the vacuum less than 4mmHg on the manometer, open the diaphragm valve (V3). And then, the chiller must be evacuated fully with the purge pump continuously ON until deep vacuum. Refer to 6-2. Seasonal Maintenance.

4-4. Input the Service Configuration

The following configurations are done from the SERVICE menu.
- Equipment configuration
- Equipment service
- Time and date

4-5. INITIAL START-UP

Preliminary Check

Check the operation of the auxiliary equipment and the status of the system before starting the CHP chiller.

PREPARATION

1. Check that the chiller is in vacuum pressure. If not, perform the Chiller evacuation procedure.
2. Supply power to the control panel, chilled water and cooling water pumps. Open the chilled water valves and cooling water valves.
3. Verify that chilled/hot and cooling water circuits are filled and operative and that the pumps are powered. For manual system operation, start the chilled pump. With cooling operation, also start the cooling water pump and cooling tower fan.
4. Make sure that control valve is in closed position.

WATER PUMP STARTERS AND OVERLOADS

1. Starters for chilled water and cooling water pump motors should be checked individually according to the manufacturer's instructions. When the pump motor trips out, the chiller will shut down on the dilution cycle, the alarm buzzer will sound and the status screen will display. CHWLF - CWLF

Cooling / Heating Operation Changeover (Option)

Switch between cooling and heating cycles by using the following procedures. This can be done only when the chiller is off.

CHANGING FROM COOLING TO HEATING MODE

1. Open the changeover valve A and E fully. (The additional IOM will be supplied as an Option)
2. Drain all water in the cooling water piping.

CHANGING FROM HEATING TO COOLING MODE

1. Close the changeover valve A and E. (The additional IOM will be supplied as an Option)
2. Fill the cooling water system and vent air from the piping.

Determine Non-condensables Rate

When the initial combination run-in period has been completed, normal operation may begin. Evacuate the machine to remove non-condensables if non-condensable rate is higher than 10cc/10min.

Check Chiller Shutdown

Press the STOP button to verify normal shutdown sequence. The control valve should be driven to close. The chiller will go through a dilution shutdown period and the pumps will stop according to the Normal Cooling Stop or Normal Heating Stop .

Check the Safety Switches Setting

Adjust all the external safeties and cutout switch to the following values

- Low Chilled Water Flow Switch 13.8 kPa (Differential Pressure)
- High Temperature Generator Pressure Switch 101.3 kPa (Absolute Pressure). 0 kPa @ Gauge Pressure

5. Operating Instructions
5-1. Typical Control Panel

Control panel (electrical cabinet) contains electrical and electronic components mounted on 2.0mm zinc coated steel sheet. This enclosure is made of 2.0mm steel sheet and is powder-coated. Its ingress protection is IP 52 grade, which can not protect under water spraying or more severe condition.
Almost all input/output devices(electrical operating switches, indicating lights and operating touch-screen) are on the front of control panel. So, machine operator must be familiar with the layout of input/output devices on the control panel.
Main power supply, pumps running indication, purge operation, alarm buzzer and emergency stop function is distributed in each devices, and the rest normal input/output operation is made through touch screen board. (Make sure to fully understand all of the items explained in “1-4. Safety Guards” before operating the machine)

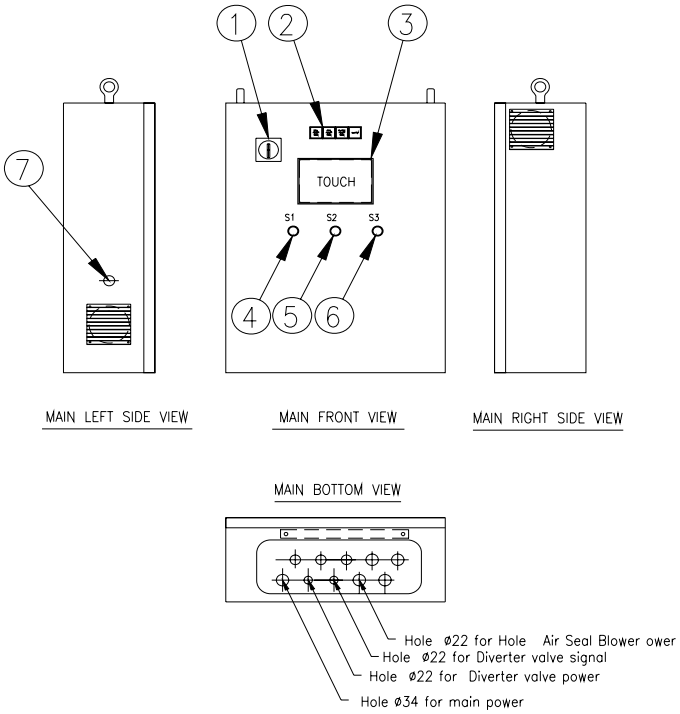


Fig. 5-1 External Layout of Control Panel

No. 1: Power On/Off Switch
No. 2: Pilot Lamp(Solution Pump run, Refrigerant Pump run, Purge Pump run, Alarm)
No. 3: Touch Screen Board
No. 4: Buzzer Stop Switch
No. 5: Purge Pump Start / Stop Switch
No. 6: Emergency Stop Switch
No. 7: Buzzer

5-2. Operation

5-2-1. Power Supply and Initial Home Screen

If you turn「Power On/Off」switch on, electric power source is supplied to the electric or electronic components in the control panel through disconnect switch, and「Touch Screen Board」displays the following initial home screen. After this, all the normal operation (operator’s order, machine status, record, etc.) is performed via this screen board.

Fig. 5-2 Initial Home Screen

5-2-2. Main Menu and Screen Menu Flow

There are 5 main menu buttons in initial home screen, ⌜Setup⌟ menu, ⌜Operation⌟ menu, ⌜CV Open⌟ menu, ⌜Alarm⌟ menu and ⌜AI Reset⌟ menu, and these main menu buttons are also displayed at the lower end of each sub-menu screen(See Fig.5-3), sometimes together with ⌜Home⌟(meaning initial home screen) in cooling status picture and ⌜Previous⌟(meaning setup menu picture) in setup sub-menu pictures.

Typical main menu screen shall be symbolized as follows;

Fig. 5-3 Typical main menu screen

① ⌜**Setup**⌟ **menu button**: After correct password input, setting of temperature, time and schedule is available. During cooling operation, changing buttons in mode selection picture and in cool/heat select picture do not work.

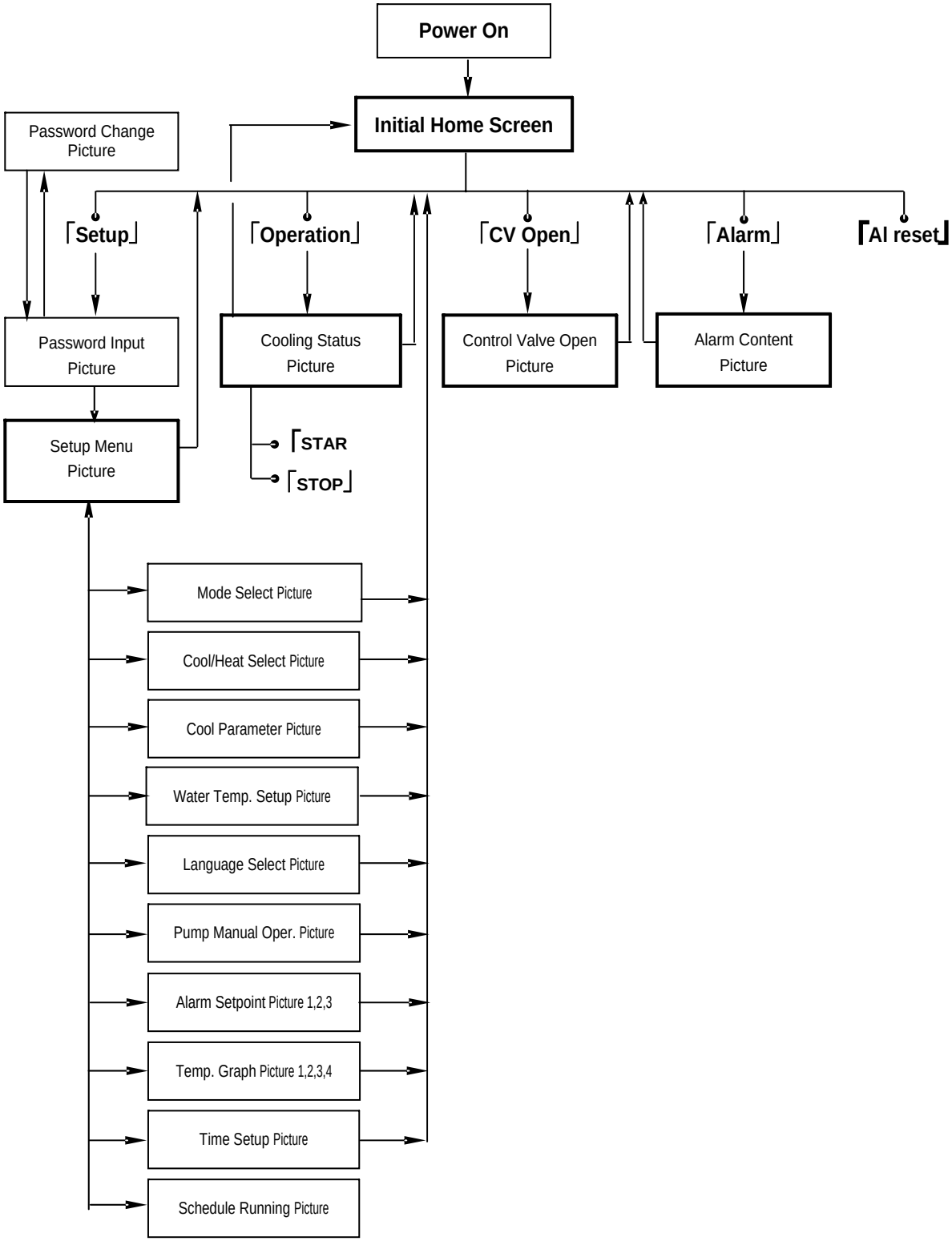
② ⌜**Operation**⌟ **menu button**: If you touch this button, screen shows cooling status picture, in which ⌜Start⌟ button and ⌜Stop⌟ button as well as some important temperatures status are displayed.

③ ⌜**CV Open**⌟ **menu button**: If you touch this button, screen shows control valve picture, and steam control valve can be opened manually.

④ ⌜**Alarm**⌟ **menu button**: If you touch this button, screen shows the list of occurred alarm and its contents (abnormal conditions).

⑤ ⌜**AI Reset**⌟ **button**: If you touch this button after taking actions to correct the abnormal conditions, the machine is ready to restart. So, this button does not work during alarm-dilution running.

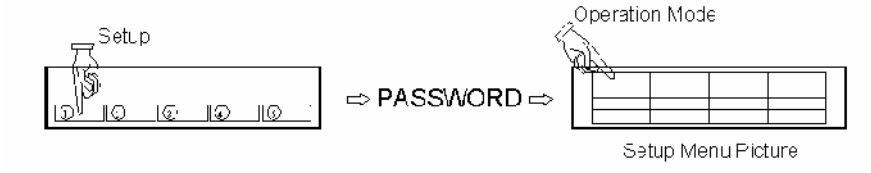
Screen menu flow is as follows;



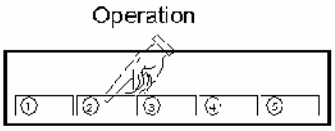
5-2-3. Pre-Operation Check on the Control Panel

The followings are to be checked on the control panel before starting operation.

1) Verify that mode selection, ⌜Remote⌟ or ⌜Local⌟, is correct.
It is displayed if you touch ①⌜Setup⌟ button at the lower end of screen and input correct password and touch ⌜Operation Mode⌟ button in setup menu picture. (Refer to section "5-5-2. Mode Selection".)

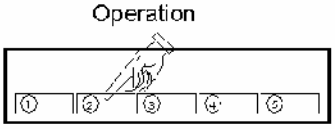


2) Make sure that ⌜Cooling Operation⌟ is selected.
If you touch ②⌜Operation⌟ button at the lower end of screen, then Chilled Water In/Out temperature in cooling status picture will be shown if you are correct. (See Fig.5-4)

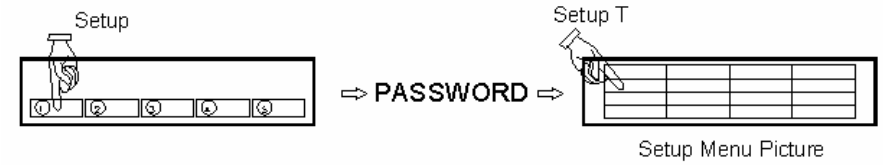


If not, touch ①⌜Setup⌟ button at the lower end of screen, input correct password and touch ⌜C/H Select⌟ button in setup menu picture to select ⌜Cooling Operation⌟. (Refer to section "5-5-3. Cool/Heat Select")

3) Make sure that the chilled water outlet temperatures are correctly set-up.
One of them is displayed as Chilled W.Set in cooling status picture, which is shown if you touch ②⌜Operation⌟ button at the lower end of screen. (See Fig.5-4)



If you want to change this value, touch ①⌜Setup⌟ button at the lower end of screen and input correct password and touch ⌜Setup T⌟ button in setup menu picture. Chilled Water Outlet, Cooling Water Inlet and Cooling Water Inlet Difference is to be fixed. (Refer to section "5-5-5. Water Temperature Setup")



5-2-4. How to start up the machine

1) When the machine is to be started at local operation mode

a) Touch ②「Operation」 button at the lower end of screen; then cooling status picture will be shown on the screen.

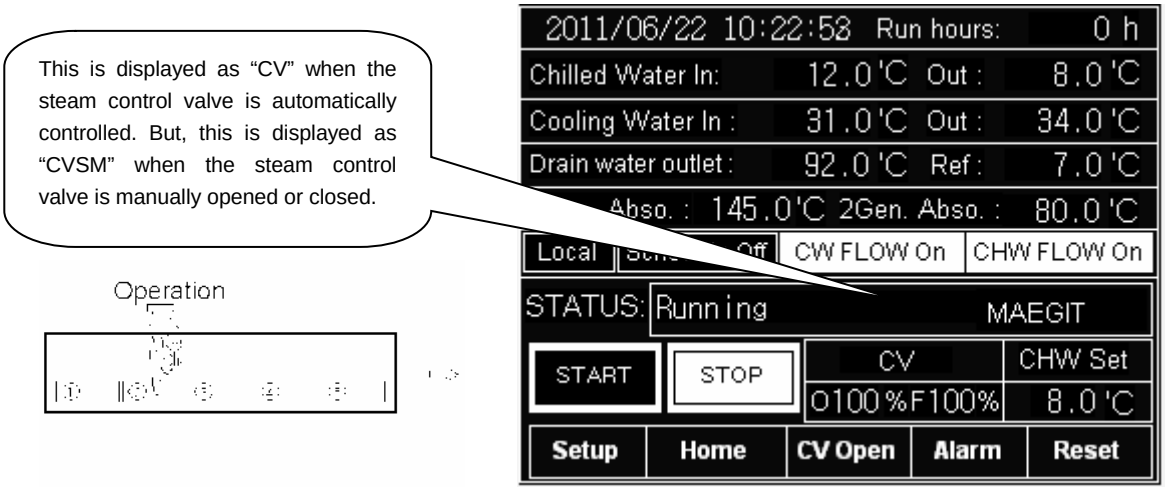


Fig. 5-4 Cooling Status Picture

b) Touch「Start」 button on the screen; automatic operation starts following start procedure of section “5-2. Start and Stop Procedure” and proceeds to start-up process (pump status lights on front of the control panel turn on in their order).

c) During cooling operation, temperatures, control valve and running status data are displayed in the screen of cooling status picture.

2) When the machine is to be started at remote operation mode

a) Start the machine on the remote control panel; automatic operation starts following start procedure of section “5-2. Start and Stop Procedure” and proceeds to start-up process (pump status lights on front of the control panel turn on in their order).

b) During cooling operation, temperatures, control valve and running status data are displayed on the screen of cooling status picture.

IMPORTANT !

In local operation mode, signals coming from the remote control panel are not effective. In remote operation mode,「Start」 button in the screen of the control panel does not work.

3) STATUS display bar shows one or more(rolling) of the following messages;

a) Running mode; The machine is in normal running status.

b) Stop mode; The machine is in stop and is ready to restart.

c) Alarm Stop; The machine is in stop after alarm, and is not ready to restart.

d) Stop-Dilution running; The machine is in dilution process by「Stop」 button input.

e) Alarm-Dilution running; The machine is in dilution process after alarm event.

f) Em stop; The machine is in stop by Emergency Stop Switch on the front of control panel.

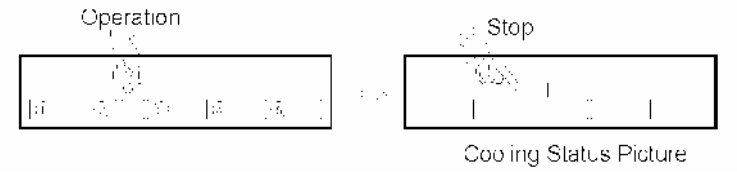
g) Cut out point-MACWIT; Override Max. allowable cooling water inlet temp.
h) Cut out point-MAG1AT; Override Max. allowable G1 absorbent temp.
i) Cut out point-LCHWT; Override low chilled water temp.

In this chapter on touch screen, button means input box, display bar means output text box, and display key means input/output text box in menu pictures.

5-2-5. How to stop the machine

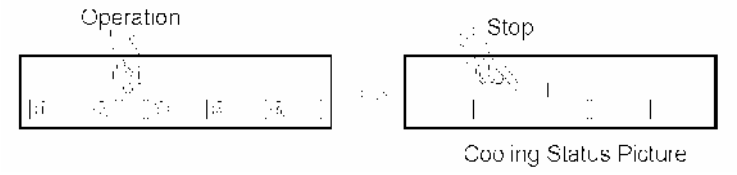
1) When the machine is to be stopped at local operation mode

a) Touch ❷「Operation」button at the lower end of screen; then cooling status picture will be shown on the screen.
b) Touch「Stop」button in the screen of cooling status picture; automatic operation performs dilution process for 10 minutes (status display bar shows stop-dilution running and pump status lights on the front of control panel go out in their order) and stops following stop procedure of section "5-2. Start and Stop Procedure".



2) When the machine is to be stopped at remote operation mode

a) Stop the machine on the remote control panel; automatic operation performs dilution process for 10 minutes (status display bar shows stop-dilution running and pump status lights on front of the control panel go out in their order) and stops following stop procedure of section "5-2. Start and Stop Procedure".
b) Another way to stop the machine is to touch「Stop」button in the screen of cooling status picture during remote operation. In this case, remote operation mode is automatically changed over to local operation mode.



IMPORTANT !

If the chilled water pump, cooling water pump and the Chiller are not interlocked (it is made during jobsite wiring), operator must stop them according to section "5-2. Start and Stop Procedure". The air handling unit must be stopped after the chilled water pump is stopped

5-3. Manual Operation and Setup

5-3-1.Steam Control Valve

The cooling capacity of Absorption Machine is almost proportional to the opening rate of steam control valve, and the machine performs automatic control of the valve to meet cooling load. The opening rate of the control valve is displayed in the screen of cooling status picture.(See Fig.5-4. “CV:xx%” stands for the current opening rate under automatic control, and “CVSM:xx%” stands for the current opening rate by manual input.)
When you want to open or to close the valve manually, touch ③「CV Open」button at the lower end of the screen, then, Control Valve Open Picture will be shown on the screen.

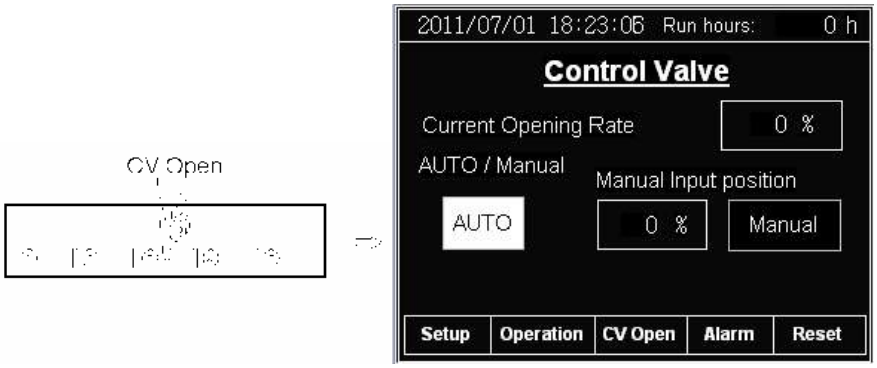


Fig. 5-5 Control Valve Open Picture

And, touch「Manual Input」display key, then pop-up window with numeric keypad appears on the screen.
(This pop-up window is used as regular number input method in many setup sub-menus.)

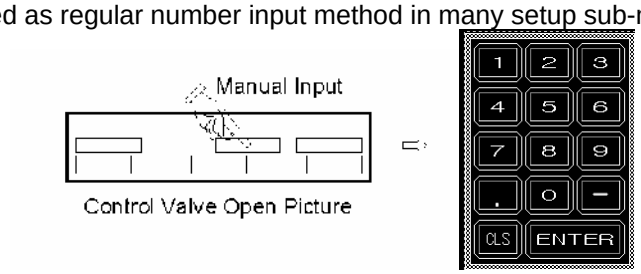
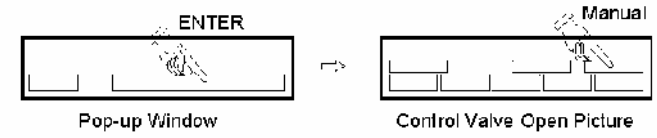


Fig. 5-6 Pop-up Window with Numeric Keypad

Make target opening rate input you wish by numeric keypad (0~100%).「Manual Input」bar of underlying Control Valve Open Picture shows target value entered. The pop-up window will close when you touch 「ENTER」button.
Finally, touch「Manual」button in the control valve open picture. After this, steam control valve is under your control, not under automatic capacity control.



Though manually controlled, as soon as the machine stops, steam control valve closes and automatic control of the valve is restored to the machine.
Don’t forget to change to the auto mode by touching「Auto」button when the manual operation of control valve finishes.

5-3-2. Mode Selection

The machine can be operated from remote area if operation mode is selected as 「Remote」. If not, the machine is locally started or stopped by the jobsite operator. This operation mode is defaulted on local mode if there was no mode change.
If you touch ①「Setup」button at the lower end of screen, the following password input picture is shown.
The initial password value is 1111, if there was no password change.

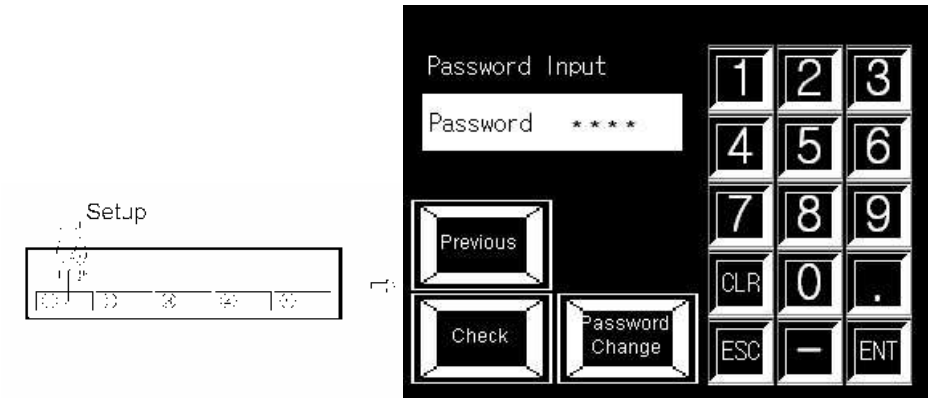


Fig. 5-7 Password Input Picture

<How to input password>

1. Touch password display bar → display bar becomes active blank.
2. Input 4-digit password by numeral button→ black display bar shows bright asterisks.
3. Touch「ENT」button → display bar becomes inactive.
4. Touch「Check」button, then password input is brought to the machine.

Then, if password input coincides with registered password, screen shows the following setup menu picture. In case of incorrect password input, “Password Error” message appears and「Check」,「Password Change」buttons will not work. (If you want to change password, refer to section “5-5-12. Password Change”.)

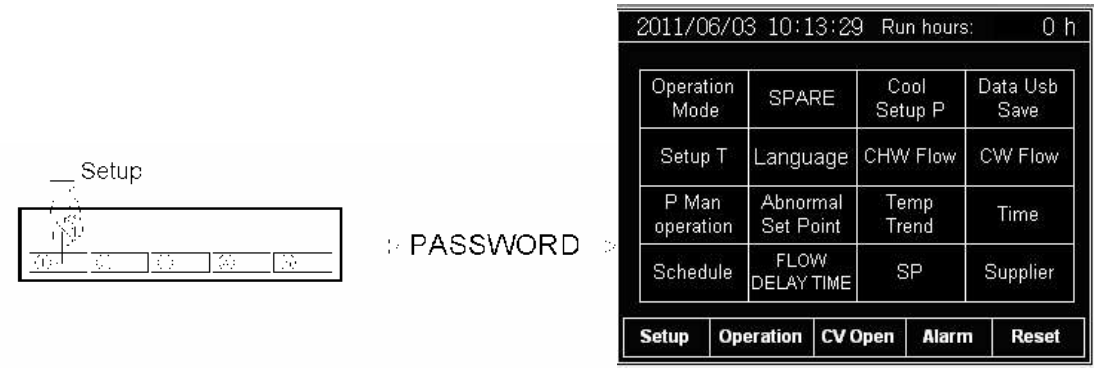


Fig. 5-8 Setup Menu Picture

And touch「Operation Mode」button (upper-left corner button), then the following operation mode picture will be shown.

Operator can select remote operation or local operation mode by touching「Remote」or「Local」button. The defaulted mode is local mode at the initial time.

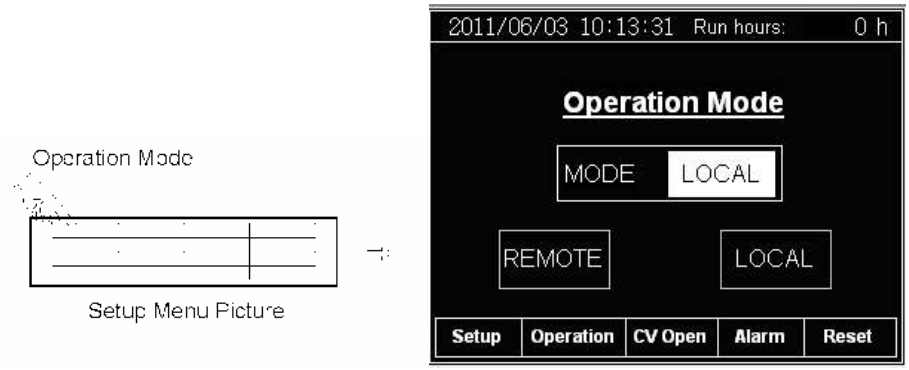


Fig. 5-9 Mode Selection Picture

5-3-3. Cool Parameter

「Cool Setup P」button in the setup menu picture shows PID capacity control parameters of steam control valve. If there is no special requirement, it is unnecessary to change proportional value, Integration rate and differential rate. Max. opening rate of driving steam valve can be set-up according to maximum cooling load.

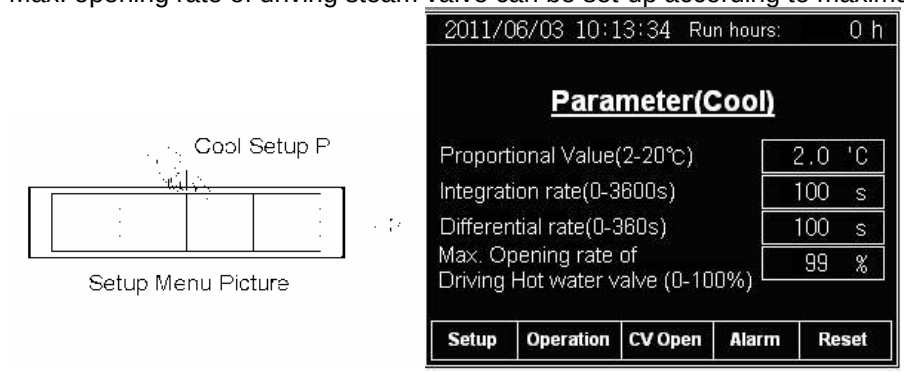


Fig. 5-10 Cooling Parameter

If you want to change a parameter, touch its display key, then pop-up window with numeric keypad appears on the screen.(See Fig.5-6)

5-3-4. Water Temperature Setup

「Setup T」button in the setup menu picture shows the following chilled water outlet temperature setup picture.

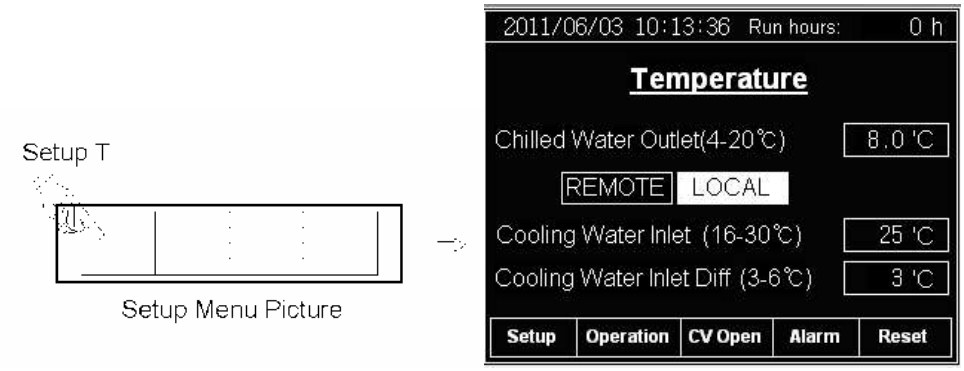


Fig. 5-11 Chilled Water Outlet Temperature Setup Picture

Chilled Water Outlet temperature is the target temperature the Chiller is trying to arrive at. If “LOCAL” is clicked, the target temperature can be input only on the torch screen. And, if “REMOTE” is clicked, the target temperature can be input only from the remote. Cooling Water Inlet and Cooling Water Inlet Difference are parameters for cooling tower operation. Cooling tower will maintain cooling water inlet temperature between Cooling Water Inlet Temperature and Cooling Water Inlet + Cooling Water Inlet Difference Temperature.

If you want to change a parameter, touch its display key, then pop-up window with numeric keypad appears on the screen.(See Fig.5-6)

5-3-5. Pump Manual Operation

This menu is prepared for the manual operation of pumps in stop mode, and do not try out in the other modes.

If you touch「P Man Operation」button in the setup menu picture, the following pump manual operation picture will be shown, and you can operate chilled water pump, cooling water pump, cooling tower fan, absorbent pump and refrigerant pump manually. (Purge pump is manually operated by purge pump start and stop push button switches on the front of control panel.)

If you want to operate a pump, touch its button, then the button is highlighted and the pump runs. Another touch makes the button dark and the pump stops.

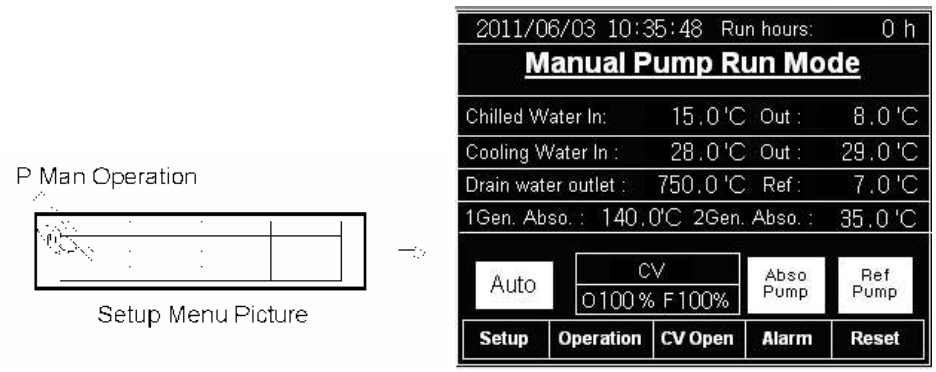


Fig. 5-12 Pump Manual Operation Picture

5-3-6. Alarm Setpoint

If you touch「Abnormal Setpoint」button in the setup menu picture, each one of the following alarm set point pictures will be shown. But, these set points can not be changed.

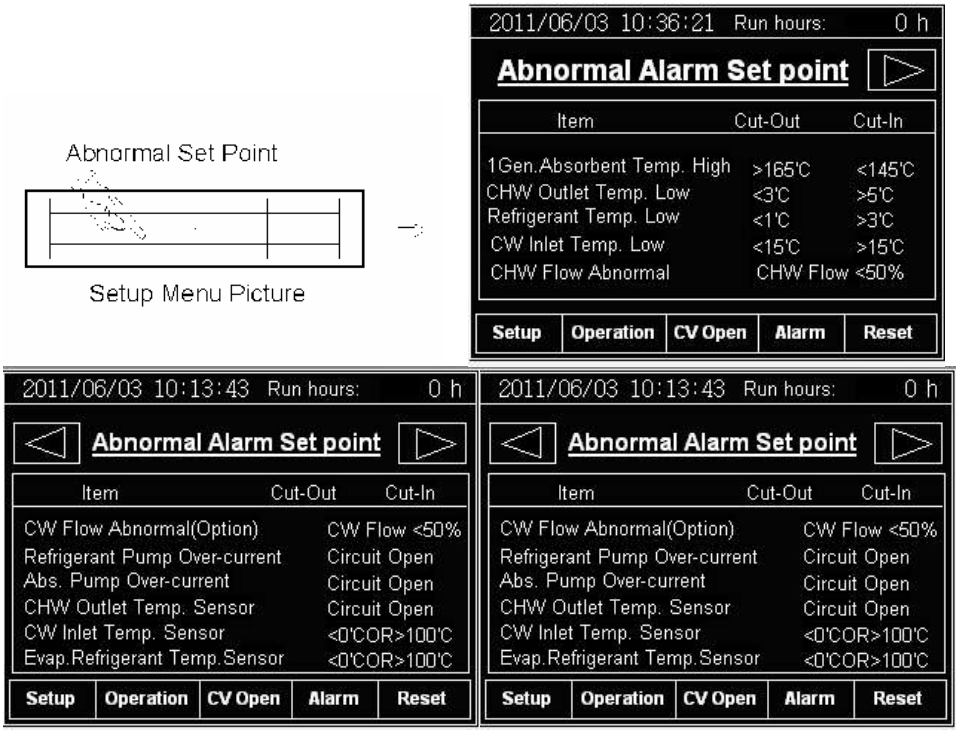


Fig. 5-13 Alarm Setpoint Pictures

5-3-7. Temperature Graph

If you touch「Temp Trend」button in the setup menu picture, temperature graphs of chilled water, cooling water, generator absorbent like the followings will be shown. Temperature data of last 2 minutes is displayed in line graph.

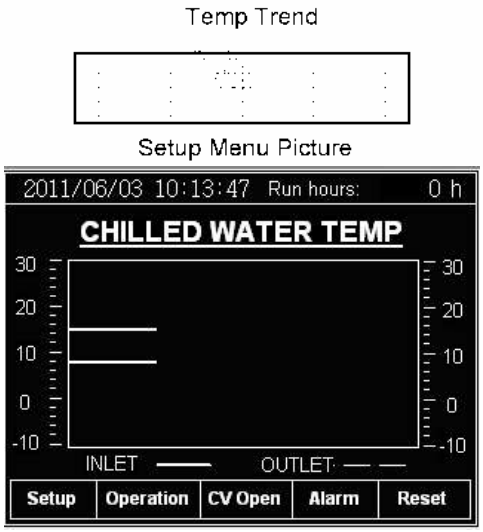


Fig. 5-14 Temperature Graph Pictures

5-3-8. Present Time Change

All the menu pictures display present <Month/Date/Year_Hour:Minute:Second> on the upper row of the screen. If you want to change them, touch「Time」button in the setup menu picture, then the following time setup picture appears.

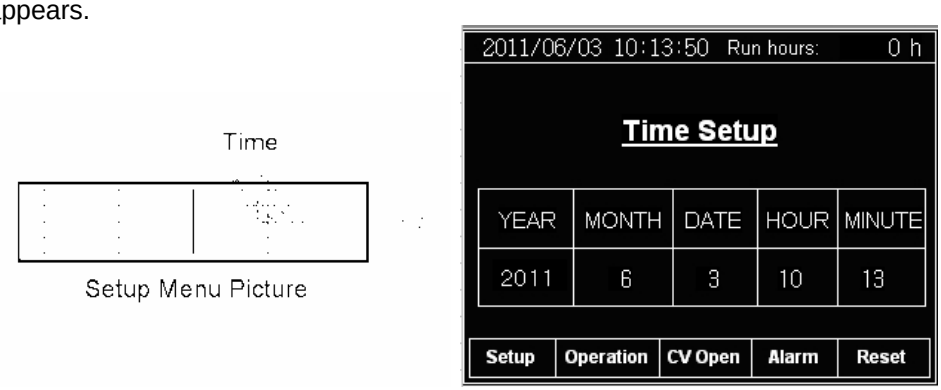


Fig. 5-15 Time Setup Picture

If you want to change a time, touch its number display key, then pop-up window with numeric keypad appears on the screen.(See Fig.5-6)

5-3-9. Scheduled Running

When you touch「Schedule」button in the setup menu picture, weekly operation schedule is displayed as follows.

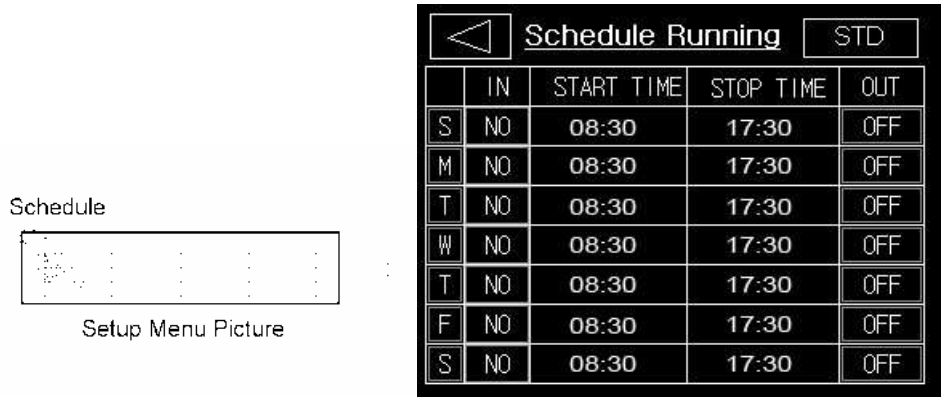


Fig. 5-16 Scheduled Running Picture

When you want to operate Schedule Running, if you touch the part of "IN" and "TIME" in Schedule Running button at what you want, you can operate.

"STD" located on the up and right side of the screen means that the machine is not run in schedule. But, if the "STD" is pushed and the indication is changed over to "SCH", the machine will be operated according this weekly operation schedule. And, if the "SCH" is pushed and the indication is changed over to "STD", this weekly operation schedule will be ignored.

5-3-10. Password Change

If you touch「Password Change」button of password input picture, the following password change picture is shown.

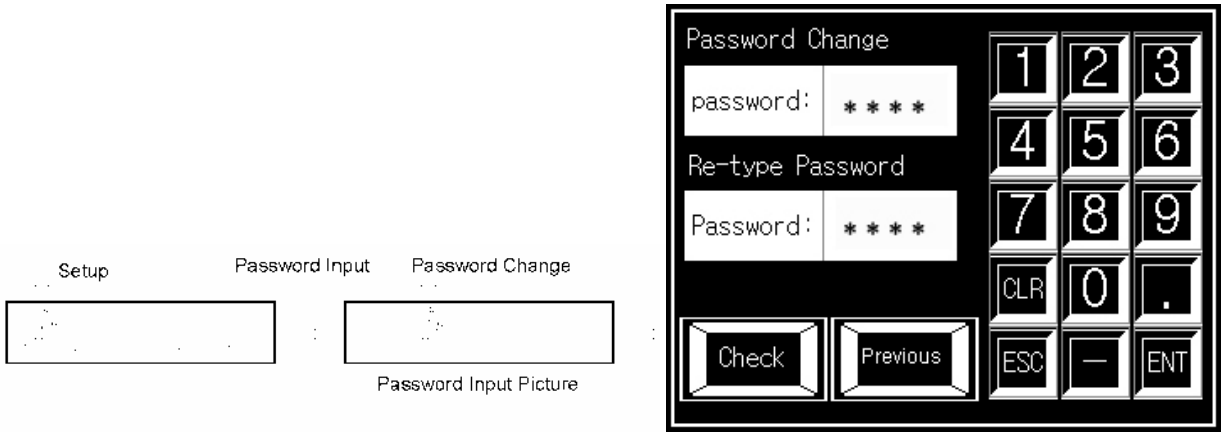


Fig. 5-17 Password Change Picture

At first, touch password change display bar and write your new 4-digit password by numeral button and touch「ENT」button. And, then, touch re-type password display bar and write the same new 4-digit password by numeral button and touch「ENT」button. If so, your password is changed to new number and the screen will be moved to setup menu picture.

5-3-13. Start Up Delay Time Change

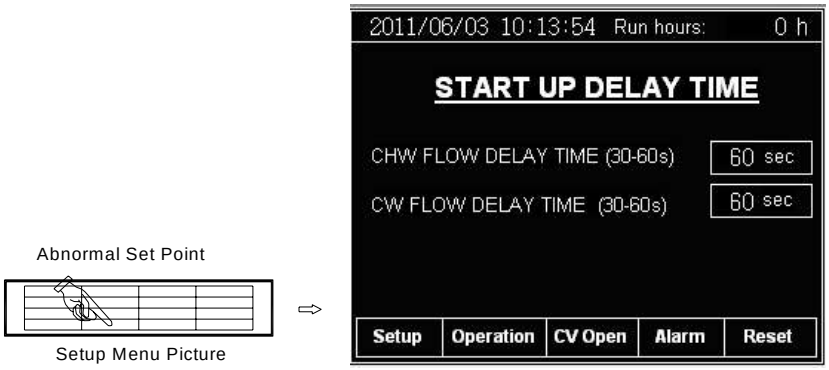


Fig. 5-20 Start Up Delay Time Picture

At the beginning of machine operation you can set up the delay time. The delay time is the monitering one of the flow of the chilled water and cooling water. If you get the delay time that you want, touch the DELAY TIME button that you want. And then you can get it.

5-4. Alarm

During machine operation, the controller monitors the operation condition (temperatures, flows and sensor) without cease.

If any failure or abnormal condition is detected, the alarm buzzer sounds, and the Chiller goes into arlam-dilution running mode for 10 minutes and finally all pumps stop.
And, if the alarm is caused by any one of CHW Temp. Low/ Refrigerant temp. Low/ CHW flow abnormal/ Absorbent Pump Over-current/ Refrigerant Pump Over-current, the Chiller goes into arlam stop mode for 3 minute (all pumps except chilled water pump stop immediately) and finally all pumps stop.

The alarm buzzer can be stopped by the buzzer stop switch, however, it only makes the alarm noise stop.

If you touch ④「Alarm」button at the lower end of any picture, screen shows the following alarm content picture.

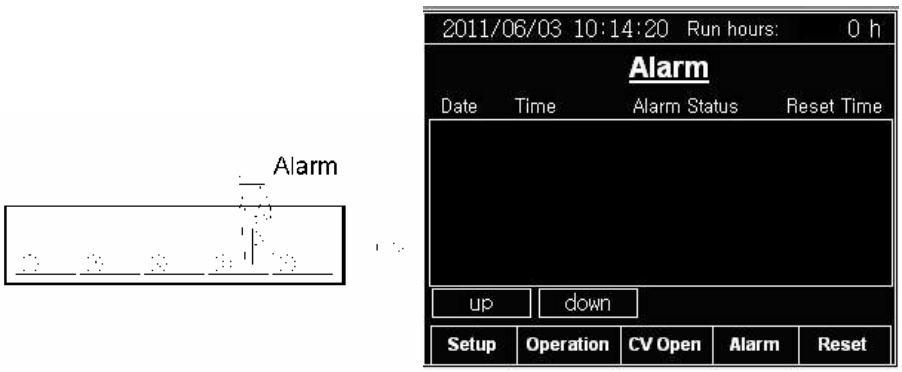


Fig. 5-21 Alarm Content Picture

On the alarm content picture, the abnormal condition is displayed under the alarm status column as the following symbol.
<Alarm Status and its Symbol>

1) 1stGenerator Absorbent Temp. High; 1GAHTCO
2) Chilled Water Outlet Temp. Low; CHWLTCO
3) Refrigerant Temp. Low; ERLTCO
4) Cooling Water Inlet Temp. Low; CWLTCO
5) Chilled Water Flow Abnormal; CHWLF
6) Cooling Water Flow Abnormal; CWLF
7) Refrigerant Pump Over-current; RPAN
8) Absorbent Pump Over-current; MPAN
9) Chilled Water Outlet Temp. Sensor; CHWOTSAN
10) Cooling Water Inlet Temp. Sensor; CWITSAN
11) Evaporator Refrigerant Temp. Sensor; ERTSAN
12) Condenser Refrigerant Temp. Sensor; CRTSAN
13) 1stGenerator Absorbent Temp. Sensor; G1ATSAN
14) 2ndGenerator Absorbent Temp. High ; 2GAHTCO
15) 1stGenerator Pressure High ; 1GAHPCO
16) 1stGenerator Level Low ; 1GALL

After taking actions to normalize the operating condition, touch「Al Reset」button at the lower end of any picture. The alarm events can be stored into the controller by 200, and, if the alarm event number exceeds more than this, the new alarm content erases the oldest event.

6. Maintenance & Inspection

Normal preventive maintenance requires periodic, scheduled inspection and service as below. Each item is detailed in 6.1 ~ 6.5 and 7.1 ~ 7.12.

Item	Every Day	Every Month	Every 6 Months	Every Year	Every 3 Years	Every 5 Years	Every 10 Years
Record the operation data of the chiller	●						
Check the water leakage	●						
Check the abnormal temperature and abnormal vibration or noise of pumps	●						
Check non-condensable accumulation rate		●					
Check Steam control valve and the leakage		●					
Check High temperature generator pressure switch, Differential pressure switches (flow switches)			●				
Blow down refrigerant to absorber			●				
Check octyl alcohol. Charge if necessary			●				
Take solution sample to be analyzed. Charge the inhibitor as necessary			●				
Check tubes for scale and fouling in Evaporator, Absorber, Condenser & Generator. Clean up the tubes if necessary				●, ★			
Replace Manometer, Diaphragm valve rubber gaskets, Sight glasses and V belts of Purge pump					●, ★		
Check High temperature generator pressure switch, Differential pressure switches (flow switches) and replace if necessary					●	★	
Inspect Purge pump, Solution and Refrigerant pumps and replace if necessary						●	★
Check Control valve actuator and replace if necessary						●	★
Check the Components in Control panel and replace if necessary						●	★

● means to be checked.
★ means to be replaced if needed

Every Day
1. Log the chiller and system readings.
2. Check for water/ exhaust leakage, vibration, abnormal temperature and unusual noise.

Every Month
1. Check non-condensable accumulation rate.
2. Check control valve control and leakage.
3. Exhaust purge tank.

Every 2 Months
1. Check low temperature cutout (cooling only).
2. Check other limit and safety devices.

Every 6 Months or Cooling/Heating Changeover
1. Check refrigerant charge (cooling only).
2. Check octyl alcohol (cooling only).
3. Take the solution sample to be analyzed

Every Year
1. Check tubes for scale and fouling.
2. Check / adjust level electrodes in high temperature generator

Every 2 Years
1. Replace valve diaphragms.
2. Replace high-temperature generator level electrodes.
3. Check the flow switch and the pressure switches and replace if necessary.

Every 5 Years or 20,000 Hours (Whichever Is Shorter)
1. Inspect hermetic pumps.
2. Filter or regenerate the solution.
3. Check the actuator and replace if necessary.
4. Check the cooling / heating changeover valve and replace the parts if necessary.

6-1. Daily Maintenance

If you find the abnormal condition, please contact the manufacturer or sales representative.

1) Abnormal noise of absorbent pumps, refrigerant pump, burner blower.
2) Abnormal noise when the control valve is opened or closed

Please ask below items to system constructor.
- Cleaning of the cooling tower and strainer of the cooling water line.
- Check the condition of cooling tower
- Check the air vent of the pipe line

6-2. Seasonal Maintenance

It is necessary for the Absorption Machine to perform the purging, refrigerant blow down and solution treatment.

6-2-1. Air Purging

Non-condensable gas and Air exiting in the Absorption Machine will decrease the cooling capacity and shorten the machine life time. So, it is recommended to perform air purging works at least one time per week or month. But, please perform the purging works immediately if the Machine is initially started or started after no-operation for a long time.

1) Purging from the non-condensable gas storage tank
   Perform this work only during Cooling mode operation and machine Stop
   (1) Operate the purge pump
   (2) Open the No. 1. purge valve (V1)
   (3) Check the attained vacuum by the manometer.
   (Vacuum must be below 4mmHg)
   (4) Open the No.2 purge valve (V2) for 1 minute
   (5) Close the No.2 purge valve (V2)
   (6) Keep continuously operating the purge pump for 30 minutes to dry the purge piping.
   (7) Close the No.1. purge valve (V1)
   (8) Stop the purge pump

NOTE When the machine is purged, the refrigerant gas (steam) is compressed and condensed in purge pump. And, the purge pump oil is contaminated with this condensed water. So, dry the purge pump and the connection piping by running the purge pump for 30 minutes continuously after purging the machine.

2) Purging directly from the absorber
Perform this work only during Cooling mode operation and machine Stop
(1) Operate the purge pump
(2) Open the No. 1. purge valve (V1)
(3) Check the attained vacuum by the manometer.
(Vacuum must be below 4mmHg)
(4) Open the No.2 purge valve (V2) for 5 seconds
(5) Close the No.2 purge valve (V2)
(6) Open the No.3 purge valve (V3) for 30 minutes.
(7) Close the No.3 purge valve (V3)
(8) Keep continuously operating the purge pump for 30 minutes to dry the purge piping.
(9) Close the No.1. purge valve (V1)
(10) Stop the purge pump

NOTE Please perform this work only at the machine stop when the machine is in heating mode. If the this work is performed during the heating operation, the high temperature refrigerant gas is compressed in the purge pump and the purge pump may be broken with the high temperature

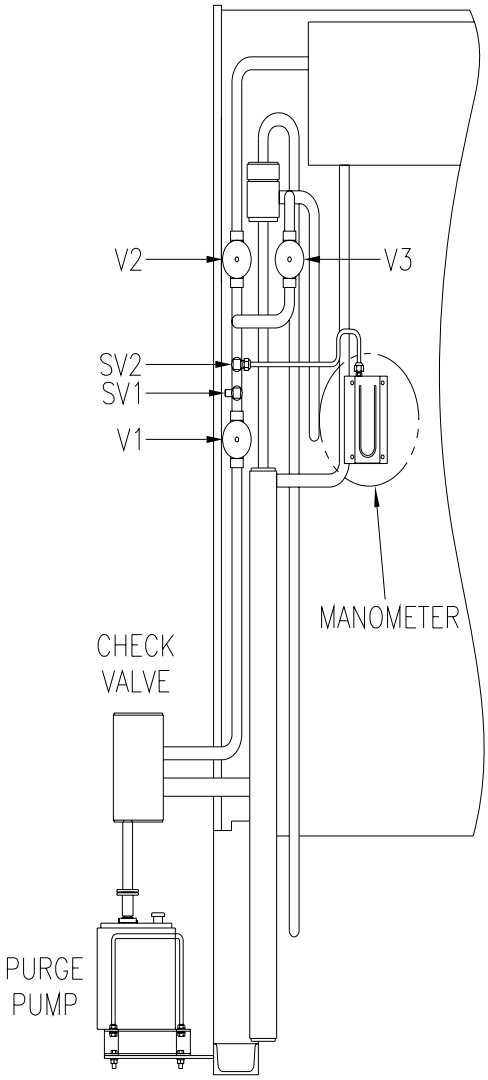


Fig. 6-1. Purge unit

2) Method of Measuring Vacuum

(1) The following three kinds of vacuum pressure can be measured by the manometer.

	Manual Purge Valve		
Measuring parts	V 1	V 2	V 3
Attained vacuum of purge pump	Open	Close	Close
Pressure of shell (evaporator & Absorber)	Close	Close	Open
Pressure of non-condensable gas storage tank	Close	Open	Close

(2) Reading method of manometer
(mercury type vacuum gauge)

- Please read the differential of mercury surface.
- Usually, the right side surface of mercury is higher than left side.
- If it is reverse, please call your service representative or manufacturer.

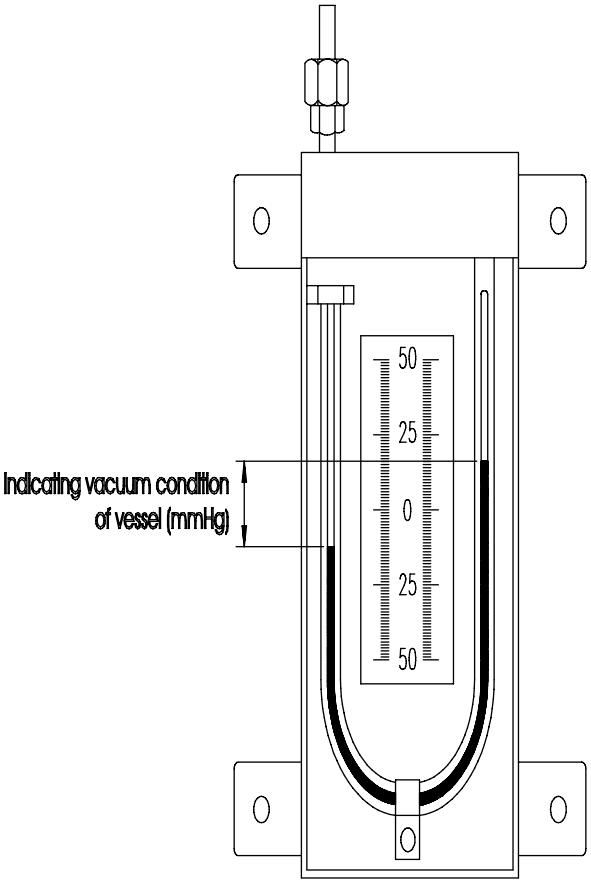


Fig. 6-2. Manometer

DANGER !

Please pay hot attention to the manometer, where located on purge unit, not to leak the mercury from the manometer. If it is necessary to replace the manometer, please follow local regulation for the disposal of mercury and it the influence not to affect environmental conditions.

3) Maintenance and Inspection of Purge Pump

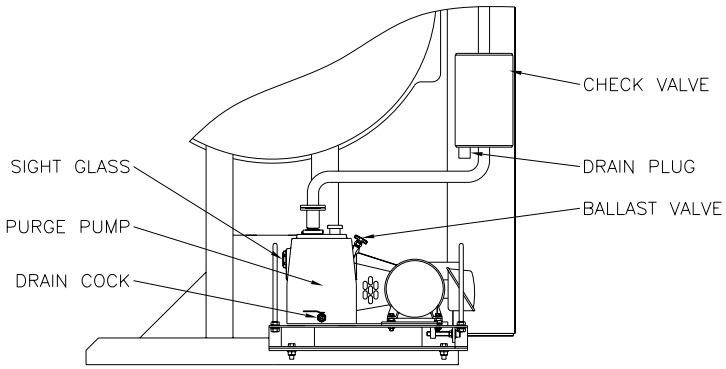


Fig. 6-3. Purge Pump

(1) When the vacuum is not lowered less than 4 mmHg, replace the purge pump oil.

How to replace the purge pump oil
(a) Drain out the purge pump oil by opening the drain cock
(b) Close the drain cock and remove the oil charge port cap at the top of the purge pump.
(c) Pour new oil through the oil charge port up to the center of sight glass.
(d) Install the oil charge port cap

NOTE

- Recommended oil : Turbine oil or Vacuum pump oil (ISO viscosity grade 56, 68)

(2) If the purge pump does not be operated or if the vacuum is still higher than 4mmHg after you replace the oil, please call your service representative.

4) How to clean the Purge Pump when the purge pump oil is contaminated with Absorbent Solution

In case that inside pressure is above 40mmHg, make sure to open No.3 valve when you take the purging.(If you take the purging with No.2 valve opened, absorbent solution may overflow toward purge pump.)

Clean the purge pump immediately as per the following instructions when you take the purging in the higher inside pressure and absorbent solution get into the purge pump.

(1) Drain all the oil and absorbent in purge pump
(2) Pour water into pump and drain again after one hour operation for cleaning
(3) Inject the kerosene into pump and drain again after one hour operation for cleaning
(4) Inject the vacuum oil into pump and drain again after one hour operation for cleaning
(5) Inject the new oil into purge pump

6-2-2. Refrigerant Blow Down

During the cooling operation, a very few amount of absorbent may be mixed and accumulated to the refrigerant liquid of evaporator. And, this mixed absorbent could reduce the refrigerant cooling capacity. So, the blow down of refrigerant should be performed once a cooling season according to the following procedure while the machine is operated. The blow down of refrigerant means the work to generate the new and clean refrigerant by transferring the contaminated refrigerant to the absorber. (The refrigerant contamination is estimated with the specific gravity of the refrigerant liquid taken out from the outlet of refrigerant pump. And, the specific gravity must be maintained less than 1.02 for the normal operation)

IMPORTANT !

Under refrigerant blow down work, the leaving chilled water temperature will rise, but the chilled water temperature will go down again after this work is finished.

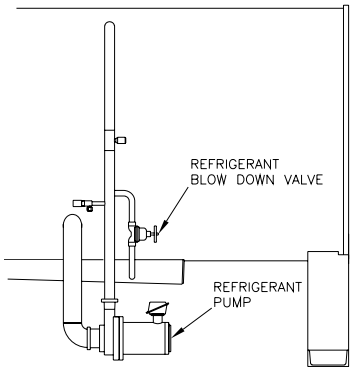


Fig. 6-4. Refrigerant Blow Valve

(1) Confirm that the machine is running at low load
(2) Open the refrigerant blow down valve completely
(3) Close the refrigerant blow down valve soon when the refrigerant level becomes very low and the cavitation noise starts to be generated from the refrigerant pump.
(4) If the refrigerant level comes up (it can be checked through the evaporator sight glass), open the valve again. Repeat this procedure 2 or 3 times. If the refrigerant sample is taken at the time, please check the refrigerant specific gravity. It should be less than 1.02.

6-2-3. Management of Absorbent Solution

1) Inspection and Control

Absorbent ($LiBr$) has very similar characteristics with the salt water so that it tends to have strong corrosiveness against steel materials with very small quantity of air. To prevent the inside of machine from being corroded, the inhibitor must be added into the absorbent. As the inhibitor is consumed proportionally according to the operation hours, periodically take the absorbent sample and check if the proper concentration (ppm) is being maintained in the absorbent. If it comes below than standards, you should add enough quantity of the inhibitor. And if that this absorbent management is neglected, the machine could be corroded at the inside and the life time of the machine could be shorten.

2) Refining or Replacing the absorbent

When the absorbent is seriously contaminated with the oxidized steel or copper, absorbent should be refined or replaced. Contact your service representative for details.

6-3. Water Treatment

6-3-1. Troubles in the Cooling Water System

1) Why the Cooling Water is Soiled

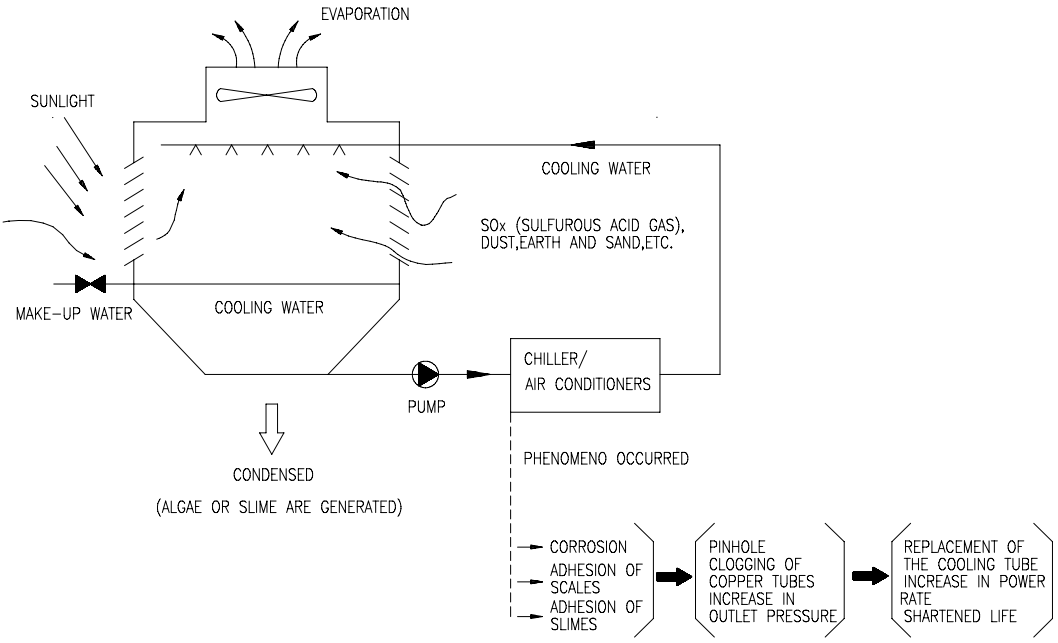


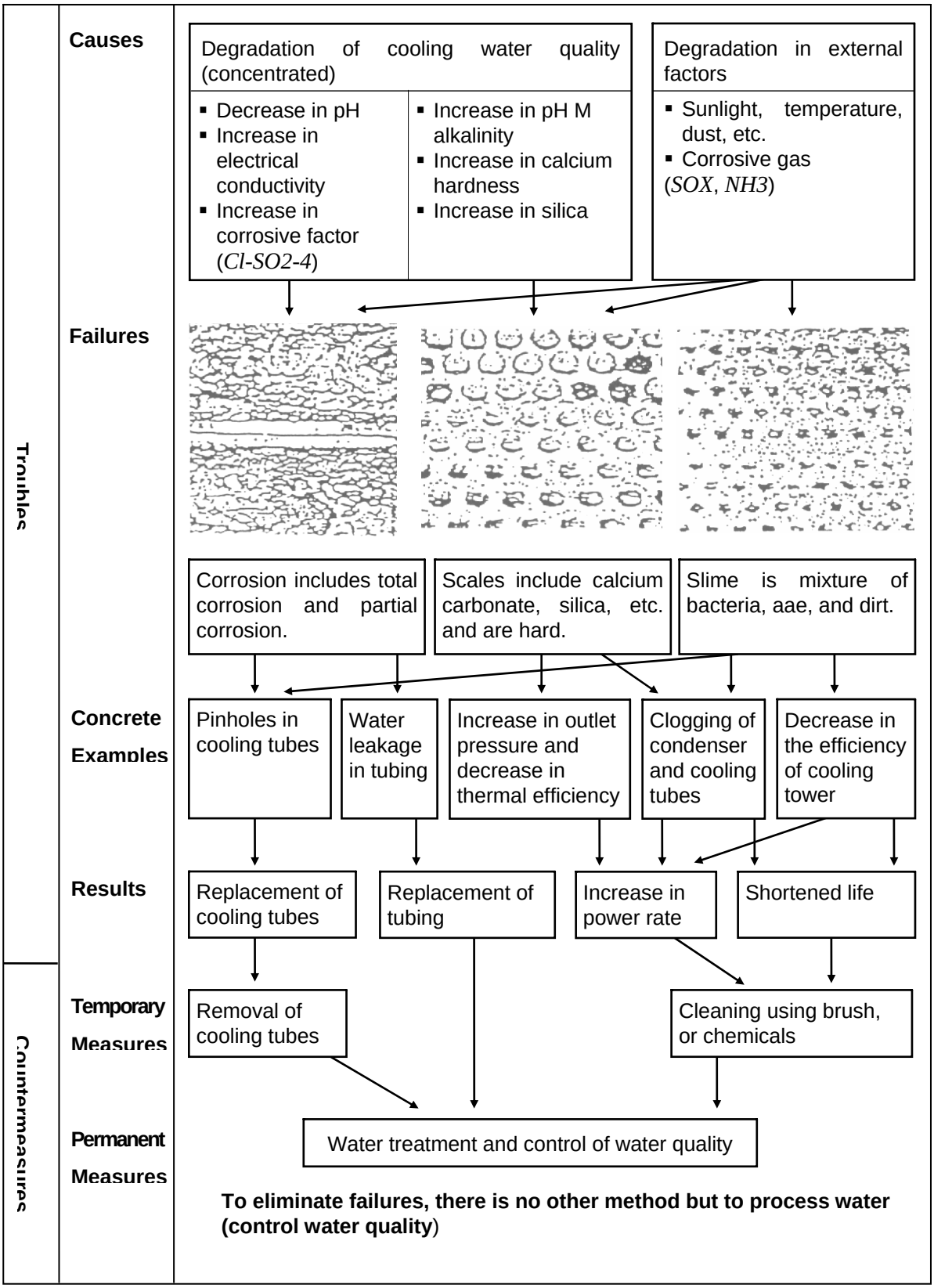
Fig. 6-5. Troubles in the Cooling Water System

The open type recycling cooling tower lowers the temperature of the cooling water using the vaporized latent heat and the cooling water is reused. At this time, the water is evaporated and dissolved salts (hardness component, chloride ion, sulfate ion, etc.) in water will increase. Namely, the condensation phenomena of water occur, and water quality will be gradually degraded. As water and air are always in contact with each other in the cooling tower, the sulfurous acid gas, dust, earth and sand, etc. in the atmosphere will intrude into the cooling tower, further degrading the water quality.

In the cooling water system, the troubles arising from water are mostly caused by these causes and typical causes include corrosion, adhesion of scales and generation of slimes.

2) Troubles with the Cooling Water and Countermeasure

Table 6-1 Troubles and Countermeasures



3) Repairing the holes in the cooling tubes due to corrosion
In case that the holes are made in the cooling water tubes due to corrosion, etc. and water rushes into the machine, the following operation and parts are required.

(1) Arranging the absorbent (replacing all absorbent).
(2) Arranging the refrigerant.
(3) Executing the eddy current testing for cooling water tubes.
- Cleaning by brush + cleaning by chemicals.
- Eddy current testing.
- Sampling inspection of tubes.

(4) Replacing of cooling water tubes.
(5) Arranging the replacement cooling water tubes.
(6) Transportation charge and other indirect charges.

6-3-2. Water Quality Control Method (Water Treatment) of Cooling Water

1) Standard Values of Water Quality
Firstly, water quality control method is determined due to the results of analyzing the water quality.
The standard values of water quality are shown in table 6-2. as an example. And water quality should be controlled within the standard values. The control method includes the blow control method in which all water is replaced periodically or water is continuously and forcibly replaced as suppress the concentration of water as much as possible and a method in which water processing chemicals are put into the water because of the poor quality of the make-up water or saving the water.

Table 6-2 Standard values of water quality

Items	Cooling Water		Chilled Water		Tendency	
	One-pass or Circulating	Make-up water	Circulating	Make-up water	Corro-sion	Scale
pH (25°C)	6.5 ~ 8.0	6.5 ~ 8.0	6.5 ~ 8.0	6.5 ~ 8.0	O	O
Electrical Conductivity (25°C $\mu s/cm$)	800 or less	200 or less	500 or less	200 or less	O	
M alkalinity (ppm)	100 or less	50 or less	100 or less	50 or less		O
Total Hardness (ppm)	200 or less	50 or less	100 or less	50 or less		O
Chlorine (ppm)	200 or less	50 or less	100 or less	50 or less	O	
Sulfuric acid ion (ppm)	200 or less	50 or less	100 or less	50 or less	O	
Total iron (ppm)	1.0 or less	0.3	1.0 or less	0.3	O	O
Sulfur ion (ppm)	Not detected	Not detected	Not detected	Not detected	O	
Ammonium ion (ppm)	1.0 or less	0.2 or less	0.5 or less	0.2 or less	O	
Silica (ppm)	50 or less	30 or less	50 or less	30 or less		O
Free carbonic acid (ppm)			10	10	O	

Note 1.
Each item of the standard values has a strong bearing on the failure due to corrosion of scale and if any value in either item deviates from the standard value, it is assumed that corrosion of scale tends to be caused, therefore, these should be periodically controlled.

Note 2.
As the range of the quality of which may become useable if the water is processed differs depending on the chemicals to be used, it is not given here. It is desirable to set the appropriate water quality control values under the guidance of a water processing specialist periodically control it.

2) Blow Control of Cooling Water

(1) The blow control means the forced replacement of the cooling water in order to suppress the excessive concentrating of the circulating water (cooling water) in the cooling tower and to prevent to changing of pH value and the concentrating of corrosive matter and scale producing matter.
In general, there are following methods.

- Continuous manual blow method
- Automatic blow method (Fig. 6-6.) in which electrical conductivity of the cooling water is continuously detected to permit automatic blow.

Next, the variations in electrical conductivity of the cooling water are graphically represented with various methods.

It can be found from this graph that in the continuous manual blow, as predetermined blowing is done irrespective of the magnitude of the load, excessive blow may result if the load is small, causing more loss than the automatic blow.

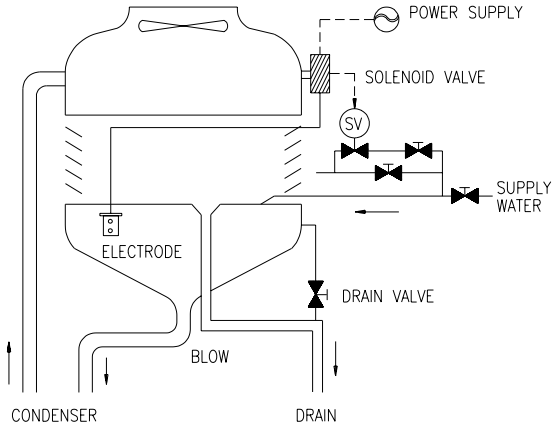


Fig. 6-6. Cooling Water Automatic Blow Unit

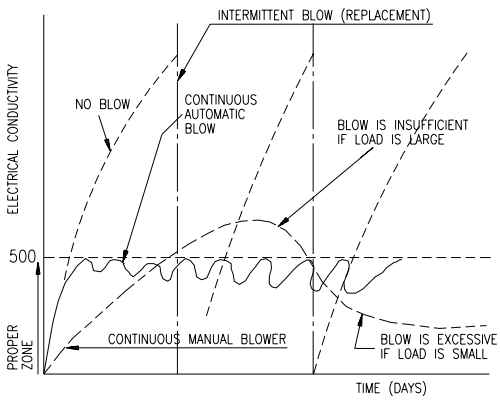


Fig. 6-7. Relation between Blow Method and Electrical Conductivity (Concentration Multiples)

(2) Concentration multiples (dirtiness degree of water)

With the open type recycling cooling tower, the temperature of cooling water is decreased using the vaporized latent heat and the water is reused. At this time, the water is evaporated and dissolved salts in water will be concentrated. However, due to splash or the presence of proper blow water, the water-will not be concentrated infinitely. Here, the water balance of the cooling water system is expressed by equation (1).

$$N = (E+B+W) / (B+W) \quad \text{----------} \quad (1)$$

Where, N : Concentration multiples (dirtiness degree of water)
E : Amount of evaporation loss with respect to the amount of circulating water
B : Amount of forced blow water with respect to the amount of circulating water
W : Splash with respect to amount of circulating water
$E + B + W$: Equivalent to the amount of make-up water

$$B = \frac{1}{N - 1} E - W \qquad \text{----------} \quad (2)$$

One example is described using Fig. 6-8.

< Example >

Machine : Centrifugal Chiller 260 USRT
Circulating : Water Flow Rate : 200m^3/h
Evaporation : 1.8m^3/h(0.1%) = E
Splash : 0.2m^3/h (0.1%) = W

$A1$ Amount of retained water : 2,000 l
Amount of blow : 0
Max. concentration multiples: 10

$A2$ Amount of retained water : 2,000 l
Amount of blow : 0
Max. concentration multiples: 10

Note $A1$ and $A2$ above shown an example of the changing in concentration speed depending on the amount of retained water.

$B1$ Amount of retained water : 5,000 l
Amount of blow : 0.35%
Max. concentration multiples: 3

$B2$ Amount of retained water : 5,000 l
Amount of blow : 0.8%
Max. concentration multiples: 2

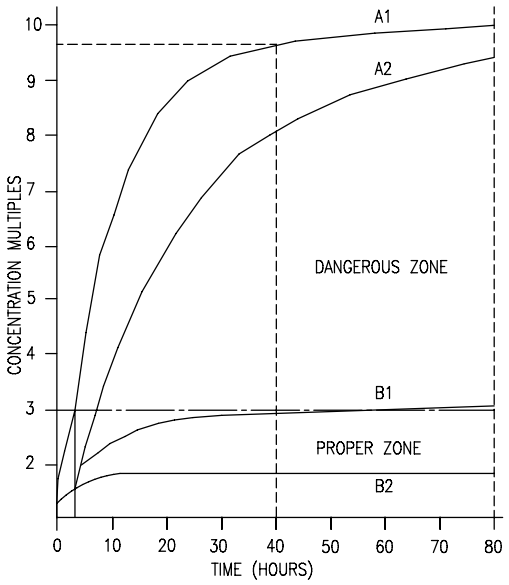


Fig. 6-8. Concentration Multiple and Operating Time

Note ***B1*** and ***B2*** above shown the changing in concentration multiples when the amount of blow is changed.

Let us explain the changing in water quality of the cooling water used under the above operating conditions; in the case of ***A1***, in 2.5 hours after operation, a concentration multiple of **3** is reached and in about 40 hours, a maximum concentration multiple of **10** is reached.
Generally speaking, trouble tend to occur more at concentration multiple of **3** of **4** or more, which therefore is referred to as a dangerous zone.
For this reason, if water is controlled by the blow method as in $B1$ and $B2$, it falls within a so-called “proper zone”, satisfying the standard set by the Korean Refrigeration / Air conditioner Industry Association or JRA 9001.

Under the above condition, the amount of blow is obtained as follows;
(from equation (2) of the foregoing concentration multiple)

$$B = \frac{1}{N - 1} E - W$$

With Absorption Machine, the temperature difference is made larger than Centrifugal Chiller, therefore, concentration time will be even shorter.

■ **In the case of a concentration multiple of 4**

$$B = \frac{1}{4 - 1} 1.8 - 0.2 = 0.4 m^3/h$$

■ **In the case of a concentration multiple of 3**

$$B = \frac{1}{3 - 1} 1.8 - 0.2 = 0.7 m^3/h$$

Whether the concentration multiple is **3** of **4** differs depending on the water quality of the make-up water and the environment where the cooling tower is installed.

3) Water treatment using processing agents (Chemicals)
In order to satisfy the water quality standard, it is necessary to analyze the water quality of the make-up water and determine the concentration multiple and amount of blow; if the water quality of the make-up water is not good, the amount of blow will increase and the water changes tend to increase. For this reason, there is this water processing system which combines the automatic blow unit which intend to save water and automate water processing and processing agent injector. (Fig. 6-9.)

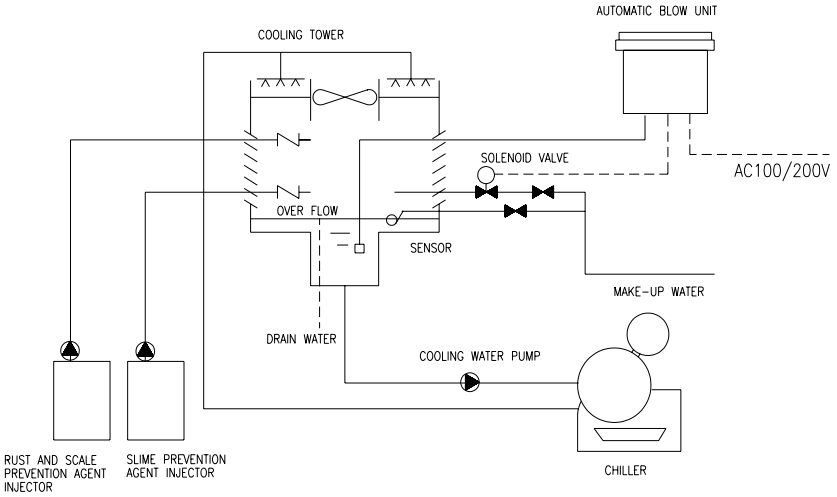


Fig. 6-9. Example of Water Processing System

This water processing system maintains the water quality of the cooling water within a predetermined range and automatically injects water processing chemicals.

(1) Features
- Water is saved to a great extent (economy)

- Automatic control method (labor saving)
- Complete water processing control (maintenance-free)

(2) The types of chemicals
- Rust preventive
- Scale prevention agent
- Slime control agent

(3) Why water-saved operation at high concentration is possible.

The scale prevention agent prevents the crystal growth of scale components and has an effect to disperse them into the water. Usually, this is used together with a rust preventive. The use of this scale prevention agent allows plenty of scale components(hard components) to be contained in the water. Namely, it is possible to maintain a high concentration multiple (4 to 10), saving the make-up water though there is slight difference depending on the water quality of the make-up water. (However, with the make0up water with abnormally high content of silica component, it is necessary to review the concentration multiples separately.)

The relation between the forced blow rate and concentration multiples is as shown in the graph on the left. As can be seen from this, if N=2 and N=6 are compared, there is a difference of 0.72% in the forced blow rate.

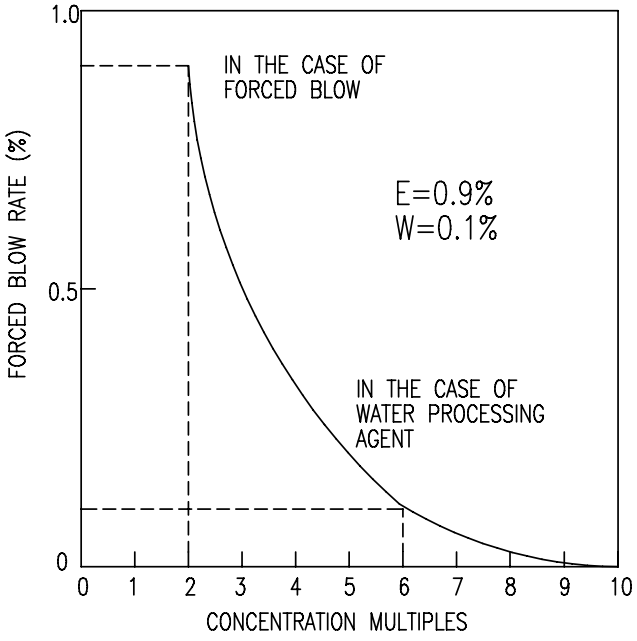
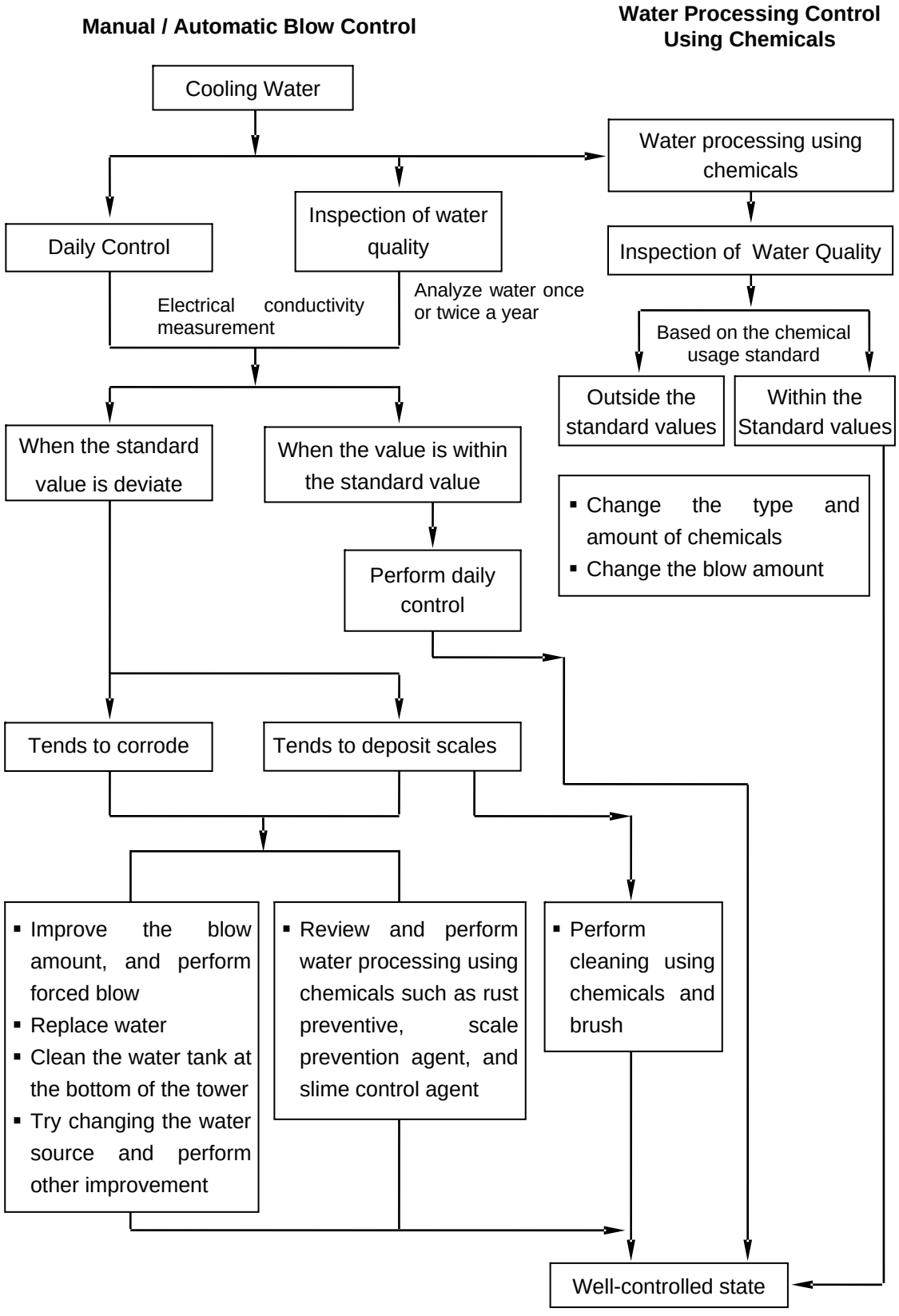


Fig. 6-9. The Relation between the Concentration Multiples and Forced Blow Rate

(4) Summary of water control procedure



6-3-3. Maintenance and Control of the Chilled(Hot) Water System

1) In Case of a Semi-Closed Chilled(Hot) Water System Having Thermal Storage Tank
As “lye” is eluted from a newly installed thermal storage tank made of concrete, it is not unusual that the pH of the water in the thermal storage tank exceeds 10. If the pH exceeds 9, the corrosion speed of the steel material increases; therefore, water should be replaced beforehand. If the thermal storage tank is used for a long term, water may spring or leak due to the crack in the tank. Leakage water does not prove so detrimental as far as the control of water quality is concerned. However, if there is spring water from sea or contaminated underground water, it may present a great problem in most cases. Depending on the type of spring water, may microbes are generated in the water of the thermal storage tank, causing the slime to be generated of calcium carbonate to be deposited. *Therefore, it is desirable that the water be replaced periodically (once per one year to two years) and the bottom of the thermal storage tank be cleaned and inspected. In case chemicals are used as necessary to process the water, as the stays in the system for a long period of time, in most case, you have only to introduce the chemicals from a manhole intermittently.

It is absolutely necessary to periodically perform visual checking of the heat transfer tubes of the chilled water of the heat exchanger for the Absorption Machine.

At the same time due to the careless disposal of filthy water and filth of mixture of contaminated material over an extended period of time, water may degrade, causing verdigris of basic carbonate of basic copper nitrate on the inner walls of the heat transfer tubes, leading to corrosion.

2) In Case of a Closed Chilled(Hot) Water System
The circulating water will not degrade due to external factors and problems such as the deposition of scales hardly occur. However, it is not inconceivable for steel tubes to be corroded for some reasons or other. In such a case, since secondary corrosion due to oxide scales is conceivable, ***periodical inspection of the heat exchanger in a chilled water system is required.***

6-3-4. Water Processing Using Chemicals in View of Saving Energy and Resources

Let us explain how scales, slime and corrosive product adversely affect the electric consumption rate.

1) Relation between the Thickness of Scale and Electric Consumption and Fuel Consumption
Even if the thickness of scale is the same, depending on the type of scale (slim, calcium scale, silica scale), the degree of the decrease in heat-exchange performance will vary. The below graph shows and example of silica scale which exhibits large decrease in the heat-exchange performance.

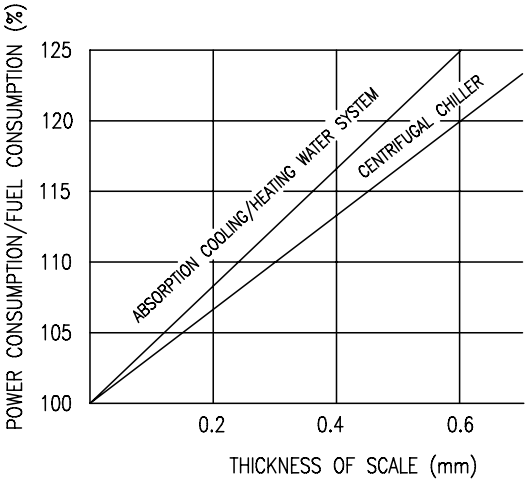


Fig. 6-10. Relation between the Thickness of Scale and Electric Consumption and Fuel Consumption

2) Trial calculation of energy saving when the water processing is performed.

Formula for running cost;

- In the case of Centrifugal Chiller
  Electric Power Rates = Basic Rate + Consumption Rate X Rate Tonnage X Input Valve per usRT X Operating Hours
- In the case of gas direct fired Absorption Machine
  Gas Rates = Rated Basic Rate + Specific Charge X Rated Tonnage X Rated Consumption X Operating Hours

If water processing is performed, energy can be saved by about 5 to 7%.

6-3-5. Tube Cleaning

Generally, there are two cleaning method. One is cleaning by brushes and the other is cleaning by chemicals (chemical cleaning).

Cleaning method is determined depending on the kind of scale, site conditions and model of machine. Some heat exchangers (modular types) permit only chemical cleaning. Prior to chemical cleaning, it is an ordinary practices to analyze water quality (analyze scales if possible).

Even if water quality control has been fully implemented, the water system is always subject to the accumulation of scales and deposits or sediments. It is a common practice to perform cleaning using brushes once a year.

By opening the system and inspecting it every year, it will become possible to visually check the heat transfer tubes and water quality control state with eyes.

6-3-6. Reference Material on Corrosion

1) Corrosion
Corrosion means that a metal is chemically or electrochemically attacked or eroded. The loss due to corrosion includes the direct losses such as material costs for replacing corroded structures and machine, labor charges, expenses for various countermeasures against corrosion and indirect losses such as loss due to the decrease in efficiency such as reduction in thermal conduction and increase in pump pressure due to corrosion product and loss due to the interruption in operation. Corrosion is not limited to the cooling water system but occurs everywhere, causing great loss. Here, corrosion phenomena which occur at the cooling water system is described.

2) Corrosion Reaction and Mechanism
The corrosion of metals in cooling water is considered to be an electrochemical reaction in which metal ions are eluted from the anode of local cells which are formed on the metal surface countlessly due to various causes then reduction reaction of dissolved oxygen occurs as an accepting of electrons at the cathode.

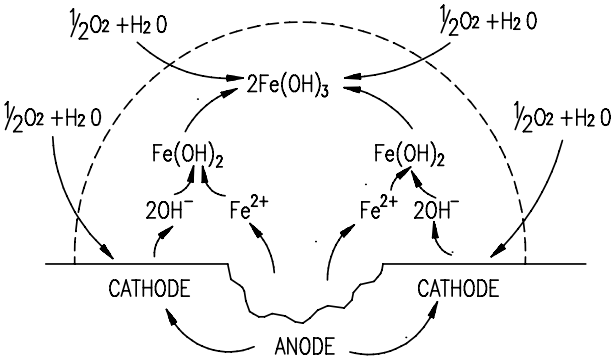


Fig. 6-12. Steel Material

3) The corrosion reaction of iron in the neutral solution is given below.

Anode $Fe \rightarrow Fe2 + 2e^-$ ---------- (1)
Cathode $1/2\ O2 + H2O + 2e^- \rightarrow 2OH^-$ ---------- (2)

The following chemical reaction progresses, then as a corrosion product, ferric hydroxide(rust) is generated.

$Fe2 + 2OH^- \rightarrow Fe2^+ + 2e^-$ ---------- (3)
$Fe(OH)2 + 1/2\ O2 + H2O \rightarrow Fe(OH)3$ ---------- (4)

In an environment where pH is 4 or loss, the reaction at the cathode will be of hydrogen generating type as follow ;

Cathode $2H+ + 2e^- \rightarrow H2$ ---------- (5)

The reason for the formation of local cells is thought to be unevenness in the metal composition, surface state, dissolved oxygen concentration , temperature, etc. ***Especially when slime, sand and earth, corrosion product etc. are deposited, an oxygen concentration cell is formed. Beneath which local corrosion occurs.***

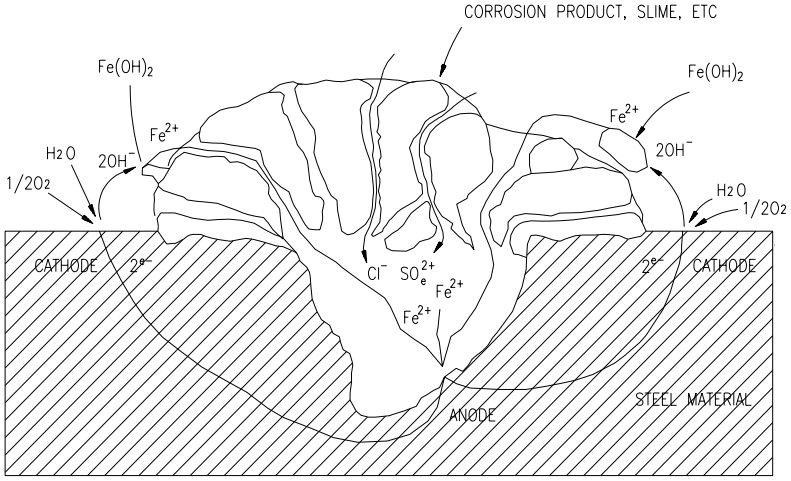


Fig. 6-12. Simplified Illustration of the Generation of Corrosion beneath Filth

Namely, the location where the dissolved oxygen concentration is low beneath filth becomes the anode. And the location surrounding the filth where dissolved oxygen concentration is high becomes the cathode. Then corrosion reaction progresses, resulting in local corrosion. These deposits are porous, and corrosive ions such as chloride ions or sulfuric ions in the cooling water migrate to the anode, producing $FeCl_2$ of $FeSO_4$. However, as hydrolysis occurs instantaneously, the concentration of hydrogen ions(H^+) increases, promoting the dissolution of iron at the portion. When these deposits are electrically conductive and more corrosion-proof than irons, the hetero electrode cell is formed with the result that corrosion progresses extremely.

< Remarks >

Example of hetero electrode cell (dry battery)
Anode : $Zn \rightarrow Zn2^+ + 2e^-$
Cathode : $2H^+ + 2e^- \rightarrow H2$

The conductive deposits adhered to the surface of iron serves a similar purpose to the carbon electrode of a dry battery, and current flows between the iron and deposits, causing the corrosion of iron.

6-4. Maintenance during Long Term Shut-Down

6-4-1. Maintenance for Machine

In the case of shut-down for one week or more, select and perform either 1) of 2) on the following methods. And also be sure to close main cock in gas train.

1) By Air-Purging
Perform air-purging once a week to maintain allowable vacuum in the machine.

2) By Charging Nitrogen Gas in the Machine
Charge nitrogen gas into the machine at little high above atmospheric pressure.
No air-purging required once a week in this case.

6-4-2. Water Circuit Preparation for Long Term Shut-Down

Perform following treatment during long-term shut-down with no-circulating of chilled, water, cooling water and steam line in the machine.

1) Cooling Water

IMPORTANT !
The absorber and condenser tubes should be kept with dry condition.
First of all, perform tube cleaning then tubes are kept with dry condition after

(1) Discharge cooling water from the cooling water discharge port at the absorber header.
(2) Remove scale and/or slime clung to the tubes by brush (nylon) cleaning. (If scale and/or slim can not be removed by brush cleaning, perform chemical cleaning).
(3) Perform cleaning with water sufficiently.
(4) Pour anticorrosion chemicals into the water, and circulate the water with anticorrosion chemicals for 30 min. or more.
(5) Discharge the water completely.
(6) (Continue to open the cooling water discharge port.)
(7) Dry up the inside of tubes.

2) Chilled(Hot) Water

IMPORTANT !
The evaporator tubes should be kept fully with water.

(1) Keep the evaporator tubes with water

6-4-3. Freeze Protection

If the machine is located where ambient temperature will be below freezing, drain all water thoroughly and dry up the inside of tubes. Simply draining is not sufficient.

6-5. Operation Records Sheet

■ **Machine Registration**

No. of Unit	Manufacturing No.

■ **Operation Records** **Date :**

Items		Check Results					
Checked Time		:	:	:	:	:	:
Ambient Temp. (°C) or (°F)							
Chilled Water	Flow Rate (m^3/h) or (gpm)						
	Inlet Temp. (°C) or (°F)						
	Outlet Temp. (°C) or (°F)						
Cooling Water	Flow Rate (m^3/h) or (gpm)						
	Inlet Temp. (°C) or (°F)						
	Outlet Temp. (°C) or (°F)						
Steam	Flow Rate (kg/h) or (lb/h)						
	Inlet Pressure (bar)						
	Drain Outlet Temperature (°C) or (°F)						
	Control Valve Opening %						
High Temperature Generator Absorbent Temp. (°C) or (°F)							

7. Instructions

7-1. Sampling of Absorbent

This instruction describes the procedure for sampling the small amounts of the absorbent to measure the absorbent concentration.

IMPORTANT !

(1) Because a vacuum exists inside the Absorption Machine, take great care to ensure that air does not leak into the Absorption Machine when your performing the above work.
(2) Handle the vacuum valve carefully so as not to damage it.
(3) Carefully wash equipment and rubber hose with water to remove dirt before using it in the above work.
(4) Do not discard the solution after measurement. Store it in an empty bottle and return the solution to the Absorption Machine when it becomes full.
(See 7.3 Charging of Solution.)

1) Instruments
- Absorbent Sampling cylinder set (transparent plastic cylinder with Vacuum valve)
- Vacuum rubber hose
- Monkey spanner 8"(Adjustable wrench, Length 8 inch)

2) Procedure
(1) Prepare equipment as per Fig. 7-1.
(2) Operate purge pump
(3) Open up No.1. manual air-purge valve
(4) Open up No.1. service valve.
(5) Open up vacuum valve on sampling cylinder.
(6) Once final pressure becomes about 5mmHg as indicated on mercury manometer, close up vacuum valve.
(7) Close up No.1 service valve and No.1. purge valve.
(8) Remove vacuum rubber hose from No.1. service valve, and connect it to the sampling service valve through which the sampling solution is extracted. (Fig. 7-2.)
(9) Open up the sampling service valve.
(10) Open up vacuum valve on sampling cylinder.
(11) When sampling cylinder becomes full of absorbent, close up the sampling service valve.
(12) Remove vacuum rubber hose from the service valve.
(13) Measure concentration of absorbent after removing the rubber plug from the sampling cylinder.
(14) Upon completion of measurement, pour absorbent into another container, and wash sampling cylinder with water
(15) When sampling solution from another part of Absorption Machine, repeat steps (2) to (12)
(16) Upon completion of above work, replace caps on No.1 service valve and the sampling service valve after checking the packing.
(17) Stop purge pump.

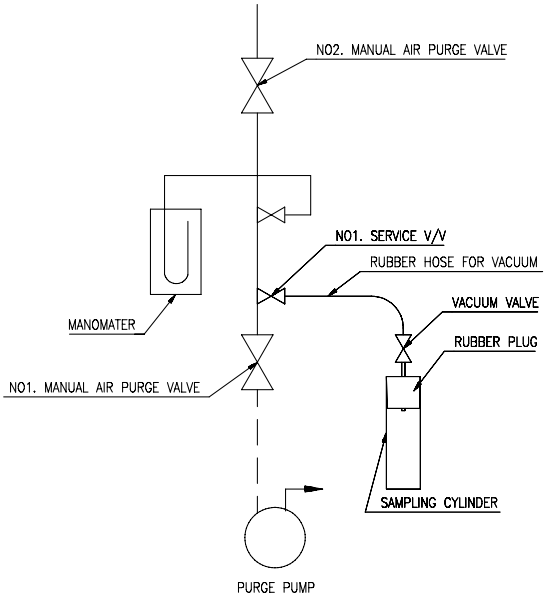


Fig. 7-1. Air Purging from Sampling Cylinder

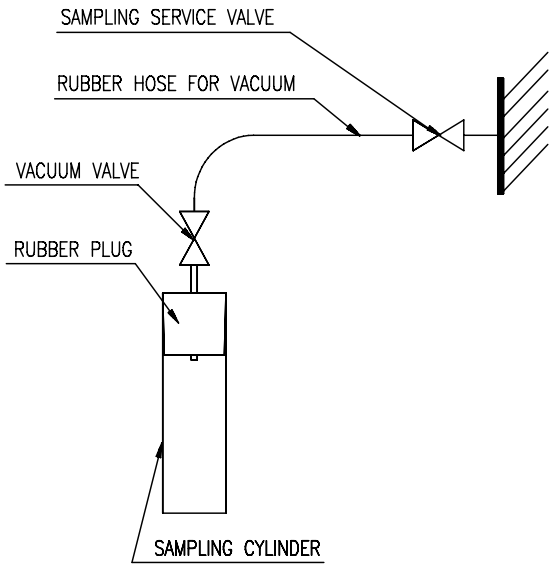


Fig. 7-2. Method of Absorbent Sampling

7-2. Measuring of Concentration

This instruction describes the procedure for measuring the concentration of the absorbent and refrigerant.

IMPORTANT !

(1) Take care not to damage the gravimeter and thermometer.
(2) Be careful not to spill any solution.
Do not fill the sampling cylinder more than about 80%.
(3) Perform specific gravity and temperature measurements quickly.

1) Instruments
- Sampling cylinder
- Gravimeter (Scale graduations between 1.0 and 1.8 for absorbent and refrigerant)
- Thermometer (0~100 degree C)
- Concentration Diagram of Lithium Bromide Solution
- Absorbent or refrigerant (solution to be measured)

2) Procedure
(1) Fill sampling cylinder to about 80% with solution to be measured.
(2) Maintain sampling cylinder vertical, and insert gravimeter.
(3) When the indication of the gravimeter stops moving up and down, read the indication on the graduated gravity of the solution.
(4) Remove the gravimeter and put it aside. Next, insert the thermometer into the sampling cylinder and stir the solution thoroughly.
(5) When the temperature stabilizes, read the indication on the thermometer.
(6) Remove the thermometer and put it aside.
(7) Store the solution in an empty bottle.
(8) Using the Concentration diagram of Lithium Bromide solution, read the concentration.
(9) Upon completion of measurement, wash the gravimeter, thermometer, and sampling cylinder with water, and then store them so that they do not get damaged.
(10) Neatly arrange the containers, etc.

Example : The horizontal axis represents specific gravity and the vertical axis temperature. The lines going down from left to right represent fixed concentrations. For example, if the specific gravity is 1.77 and the temperature is 45℃, the concentration given by the point of intersection of lines projected from these values will be 63.1%, as shown in Fig. 7-3 (Concentration Diagram of Lithium Bromide Solution).

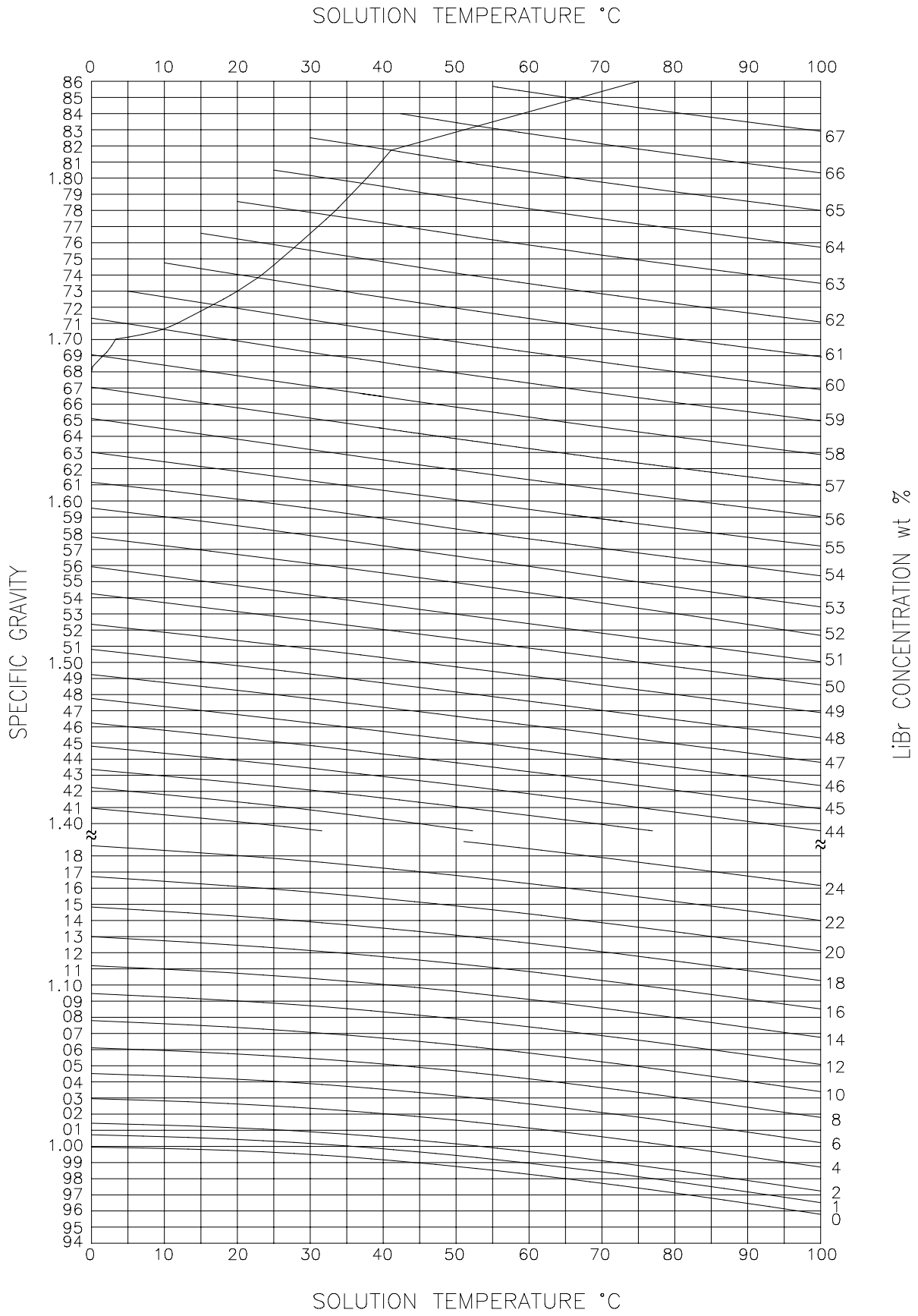


Fig. 7-3. Concentration Diagram of Lithium Bromide Solution

7-3. Charging of Solutions

This instruction describes the procedure of charging the Absorption Machine with Absorbent solution and Refrigerant.

IMPORTANT !

(1) When charging solution, be careful to prevent spillage.
(2) Because a vacuum exists inside the Absorption Machine, be careful to prevent air leaking in during the above work.
(3) Carefully wash the hose used in the above work with water so as to prevent dirt ingress.
(4) Wear rubber gloves.
(Do not handle equipment or solution with bare hands)
(5) Thoroughly wash off any absorbent which gets on hands, skin or clothes. Take care to prevent absorbent entering eyes or mouth.
(6) If absorbent spills on metal plates, etc. thoroughly wash it off with water.

1) Instruments
- Solution container (Absorbent and Refrigerant)
- Vacuum rubber hose (fitted with copper tube)
- Hose band
- Pliers
- Monkey spanner 8” (Adjustable wrench, Length 8”)

2) Procedure (Perform this work after stopping the Absorption Machine)
(1) Prepare solution containers.
(2) Operate the purge pump and perform air purging from shell.
(3) Connect one end of the vacuum rubber hose to the sampling service valve, where solutions are charged, and fix it with the hose band.
(4) Insert the copper tube on the end of the vacuum rubber hose into the container (keep it slightly above the bottom of the container).

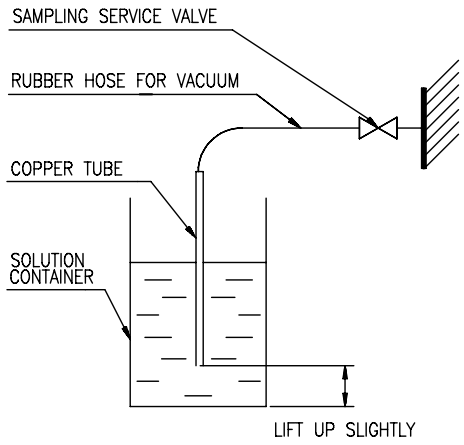


Fig. 7-4. Method of Solution Charging

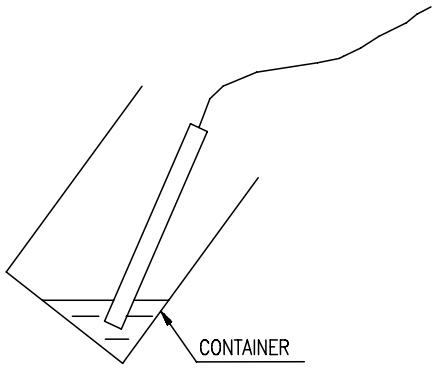


Fig. 7-5. Method of Solution Charging Bottom of Container

(5) Open up the sampling service valve.
(6) When solution starts being sucked into the Absorption Machine, watch carefully to ensure that air does not leak in.
(7) Before the container becomes empty, tilt it so that air does not enter the tube. (Fig. 7-5.)
(8) When the container become more or less empty, bent the rubber vacuum hose with both hands to ensure that air does not leak in, and quickly insert it in the next container. (Fig. 7-6.)
(9) Repeat steps (6) to (8) until all containers have been emptied.
(10) Once the required amount of solution has been charged close up the sampling service valve.
(11) Remove the rubber vacuum hose from the sampling service valve, and put the cap on the service valve.
(12) Stop the purge pump.
(13) Wash the rubber vacuum hose, etc. with water.
(14) Continue air purging for 30 minutes after completion of this work.
(15) Neatly arrange the containers and equipment used.

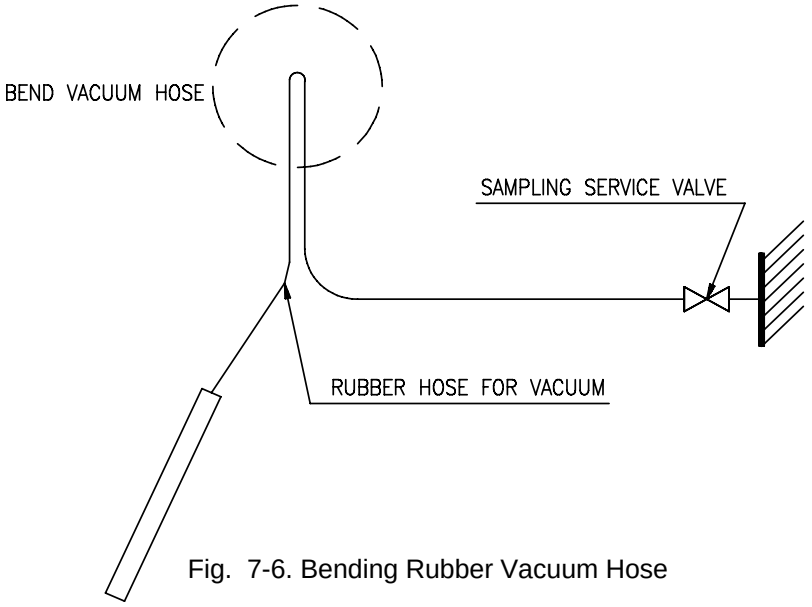


Fig. 7-6. Bending Rubber Vacuum Hose

7-4. Absorbent Solution Analysis of Lithium Molybdate

7-4-1. Lithium Molybdate ($LiBr+Li_2MoO_4+nH_2O$)

This instruction describes the procedure for analysis of the absorbent solution of Lithium Molybdate

1) Notice for Analysis
   (1) The proper time for sampling absorbent solution
      - In the case of operation for about 8 (eight) hours per day
      ⇒ Perform the sampling in the cooling season (once per year)
      - In the case of operation for more 18 hours per day
      ⇒ Perform the sampling every 2 (two) months during only cooling operation.
   (2) Kind of absorbent and sampling position
      - Kind of absorbent
      ⇒ Diluted absorbent
      - Sampling position
      ⇒ Service valve furnished on the diluted absorbent pipe between absorbent pump and low temperature heat exchanger.
   (3) Sampling quantity
      Perform sampling of 2 (two) times, sampling quantity of one time is 100cc.
      - Absorbent at first sampling (100cc) : Abandonment
      - Absorbent at second sampling (100cc) : For analysis
   (4) Be sure to perform sampling during operation of absorbent pump.
   (5) The sampling absorbent taken during cooling operation can be just used for analysis.

2) Analyzing Items
   (1) Concentration of Inhibitor (Lithium Molybdate : Li_2MoO_4)
   (2) Concentration of Alkalinity (Neutralization analysis)
   (3) Concentration of All Copper and All Iron

3) Instruments
   - Solution sampling tool
   - Bottle for solution with a cap (50ml)
   - Pipette with scale
   - Beaker (100ml)
   - Burette
   - Syringe
   - Phenolphthalein solution
   - Hydrochloric acid solution (HCI)
   - Hydrochloric acid solution (HCI)
   - Aluminum nitrate ($Al_2(NO_3)_3 \cdot 9H_2O$)
   - Pure water

4) Sampling of Absorbent Solution
   (1) Extract the absorbent solution for analysis from the machine by the sampling tool.
      (This work should be done during operating of the absorbent pump.)
   (2) Pour the above absorbent solution to the bottle from the sampling tool.

5) Analysis for Concentration of Inhibitor (Lithium Molybdate : Li_2MoO_4)

Standard of Concentration of the inhibitor : 50 ~ 300ppm

(1) Stand the bottle for about 24 hours.
(After 24 hours, solid is accumulated at the bottom of the bottle.)
(2) Collect the absorbent solution (5ml) from the top of the bottle by the pipette.
(3) Pour the absorbent solution by above work into the beaker.
(4) Mix 4ml aluminum nitrate and 1ml 50% Hydrochloric acid solution.
(5) Add 1ml solution made in the item (4) into the beaker by another pipette.
(6) Pour 94ml pure water into the beaker by the burette.
Items from (1) to (6) are procedures of making solution for analysis.
(Total quantity of the solution in the beaker is 100ml. This means that absorbent solution is diluted to 1/20.)
(7) The concentration of the Lithium Molybdate must be checked by "Atomic absorption spectro-chemical analysis". Therefore, this check can not be done at site. It is preferred to request the analysis to an official organization.
(8) If concentration of the inhibitor is less than standard value, add inhibitor (Li_2MoO_4)

6) Analysis for Concentration of Alkalinity (Neutralization analysis)

Standard of Concentration of the alkalinity : 0.03N ~ 0.08N

(1) Stand the bottle for about 24 hours.
(After 24 hours, solids is accumulated at the bottom of the bottle.)
(2) Collect the absorbent solution (10ml) from the top of the bottle by the pipette.
(3) Pour the absorbent solution by above work into the beaker.
(4) Pour 50ml pure water into the beaker by the burette.
(5) Add Phenolphthalein (2~3drops) into the beaker by the syringe.(Absorbent solution in the beaker is colored to pink.) Items from (1) to (6) are procedures of making solution for analysis.
(6) Add N/10 Hydrochloric acid solution little by little into the above absorbent solution by the burette until the color of the absorbent solution is changed to colorless.
(7) Calculate the alkalinity according to the following formula.
$N = A \times 0.01$
N : Required alkalinity
A : Quantity of adding Hydrochloric acid solution (ml)
(8) Procedures for adding chemicals
① Alkalinity is 0.03 N ~ 0.08 N : No addition
② Alkalinity is less than 0.03 N : Add $LiOH$
③ Alkalinity is more than 0.08 N : Add HBr

7) Analyses for Concentration of All Copper and All Iron

Standard of Concentration of the All Copper : 20mg / l max.
Standard of Concentration of the All Iron : 10mg / l max.

(1) Shake the bottle before collecting the absorbent solution.
(2) Collect the absorbent solution (1ml) from the top of the bottle by the pipette.
(3) Pour the absorbent solution by above work into the beaker.
(4) Add 1ml N/10 Hydrochloric acid solution into the beaker by another pipette.

(5) Pour 98ml pure water into the beaker by the burette.
Items from (1) to (5) are procedures of making solution for analysis.
(Total quantity of the solution in the beaker is 100ml. This means that absorbent solution is diluted to 1/100.)

(6) The concentration of the All Copper and All Iron Must be checked by "Atomic absorption spectro-chemical analysis". Therefore, this check can be done at site. It is preferred to request the analysis to an official organization.

(7) If concentration of the All Copper and All Iron are more than standard value, absorbent solution in the machine is required filtering.

8) Notes

(1) In case that crystallization of the absorbent solution occurs, melt the crystallization and perform them.

(2) In case that all Copper and all Iron are analyzed, wait for a while after adding the Hydrochloric acid solution into the absorbent solution.

7-4-2. Method of Adjusting Inhibitor Content and Alkali

1) Method of Adding Inhibitor

This instruction describes the procedure to add inhibitor for controlling corrosion.

(1) Instruments

- Inhibitor : Li_2MoO_4 (10wt% solution)
- Pure water
- Container
- Vacuum rubber hose with copper tube
- Hose band
- Pliers
- Monkey spanner
- Rubber gloves

(2) Target concentration of inhibitor : 300ppm

Calculate additional volume of the inhibitor in accordance with following formula.

$$\frac{\textbf{(300ppm - } X \textbf{ ppm) x 10}}{\textbf{1000,000 x 1.1}} \textbf{ x } A \textbf{ = } D$$

X : Measured value of inhibitor concentration (ppm)
A : Charging quantity of absorbent solution (kg)
D : Required volume of inhibitor (l)
10 : Diluted rate (10wt% solution)
1.1 : Specific gravity of Li_2MoO_4 Inhibitor (10wt% solution)

(For example)

X = 40 ppm
A = 3,070kg

$$\frac{\text{(300ppm - 40ppm) x 10}}{\text{1000,000 x 1.1}} \text{ x 3,070 = } \textbf{7.3 } \boldsymbol{l}$$

(3) Procedure

(a) Pour pure water into the vacuum rubber hose in order to remove air in the vacuum rubber hose. (refer to Fig. 7-7.)

(b) Connect the vacuum rubber hose to service valve (for refrigerant) and fix it with hose band. (refer to Fig. 7-8.)

(c) Pour the inhibitor into container.

(d) Insert the copper tube on the end of the vacuum rubber hose into the container after wearing rubber gloves.

(e) Perform air-purging from shell.

(f) Open up the service valve.

(g) When solution starts being sucked into the machine, watch carefully to ensure that air does not leak in.

(h) Close up the service valve after charging all inhibitor.

(i) Remove the vacuum rubber hose.

(j) Place the cap of the service valve after confirming the packing inside.

(k) Wash all instruments with water.

(l) Perform refrigerant blow down after that these procedures are completed and circulate Refrigerant with refrigerant pump.

(m) Continue air-purging from shell for 30 minutes after completion of this work.

(4) Notes

(a) Be sure to perform this work during cooling operation.

(b) Wear rubber globes while this work.

(c) Thoroughly wash of any inhibitor which gets on hand, skin and clothes.

(d) Take care to prevent inhibitor from entering mouth and eyes.

(e) Do not spill inhibitor on floor and do not throw it in a drain.

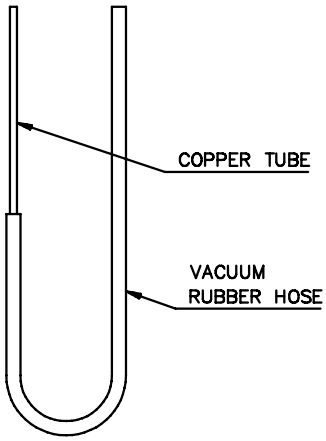


Fig. 7-7.

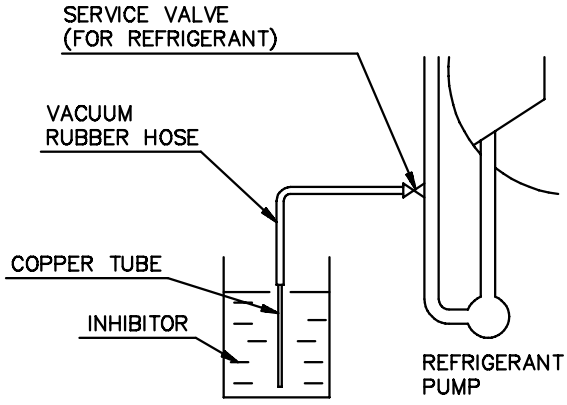


Fig. 7-8.

2) Method of Adding Alkali

This instruction describes the procedure to add Alkali ($LiOH$) when alkalinity is less than 0.03N.

IMPORTANT !

(1) Be sure to perform this work during cooling operation.
(2) Be sure to inspect again alkalinity after charging of $LiOH$.
(3) Wear rubber gloves while this work.
(4) Thoroughly wash of any $LiOH$ which gets on hand, skin and clothes.
(5) Take care to prevent $LiOH$ entering mouth and eyes. Do not spill $LiOH$ on floor and do not throw it in a drain.
(6) In case that machine is operated for 18 hours or more per day during only cooling operation, be sure to check and adjust alkalinity every three months.

(1) Instruments

- Alkali : $LiOH \cdot H_2O$ (White powder)
- Pure water
- Container
- Vacuum rubber hose with copper tube
- Hose band
- Pliers
- Wrench
- Rubber gloves

(2) Target alkalinity : 0.07N

Calculate weight of $LiOH \cdot H_2O$ in accordance with following formula.

$$D = 25.8 \times (C - A) \times B$$

A : Measured value of alkalinity (N)
B : Charging quantity of absorbent solution (kg)
C : Target alkalinity = 0.07N
D : Required weight of $LiOH \cdot H_2O$ (g)
25.8 : Molecular weight (41.86) of $LiOH \cdot H_2O$ / Specific gravity (1.62) of 55% LiBr solution

(For example)
A = 0.01N
B = 3,070kg
D = 25.8 x (0.07-0.01) x 3,070 = 4,752 (g)

(3) Procedure

(a) Pour pure water into the vacuum rubber hose in order to remove air in the vacuum rubber hose. (Refer to Fig. 7-7.)
(b) Connect the vacuum rubber hose to service valve of Heat Exchanger and fix it with hose band. (Refer to Fig. 7-9.)
(c) Put $LiOH \cdot H_2O$ into container and melt it with pure water.
(d) Insert the copper tube on the end of the vacuum rubber hose into the container after wearing rubber gloves.

(e) Perform air-purging from shell.
(f) Open up the service valve.
(g) When solution starts being sucked into the machine, watch carefully to ensure that air does not leak in.
(h) Close up the service valve after charging all $LiOH$ solution.
(i) Remove the vacuum rubber hose and wash inlet of service valve with water.
(j) Place the cap of the service valve after confirming the packing inside.
(k) Wash all instruments with water.
(l) Continue air-purging from shell for 30 minutes after completion of this work.

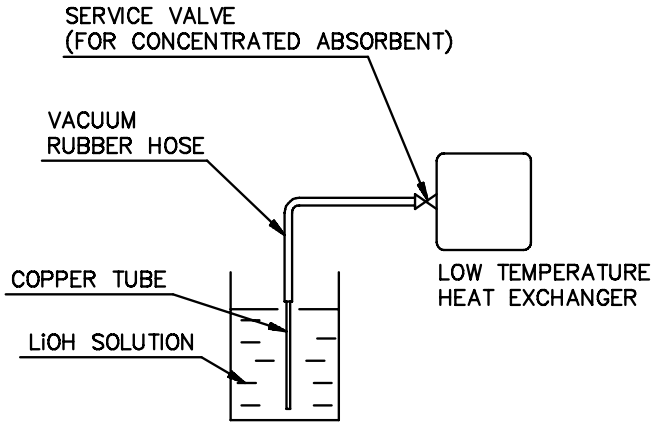


Fig. 7-9.

3) Method of Adding Acid
This instruction describes the procedure to add Acid (HBr) when alkalinity is above than 0.07N.

IMPORTANT !

(1) Be sure to perform this work during cooling operation.
(2) Be sure to inspect again alkalinity after charging of HBr.
(3) Wear rubber gloves and mask while this work.
(4) Thoroughly wash of any HBr which gets on hand, skin and clothes.
(5) Take care to prevent HBr entering mouth and eyes.
(6) Do not spill HBr on floor and do not throw it in a drain.
(7) In case that machine is operated for 18 hours or more per day during cooling operation, be sure to check and adjust alkalinity every three months.

(1) Instruments
- Acid : HBr (concentration : 40wt%)
- Pure water
- Container
- Vacuum rubber hose with copper tube x 2
- Hose band x 2
- Pliers
- Wrench
- Rubber gloves
- Mask
- pH test paper

(2) Target alkalinity : 0.07N
Calculate volume of *HBr* in accordance with following formula.

D = 90.5 x (A - C) x B

A : Measured value of alkalinity (N)

B : Charging quantity of absorbent solution (kg)

C : Target alkalinity = 0.07N

D : Required volume of *HBr* (*ml*)

90.5 : Molecular weight (80.92) of *HBr* / (HBr solution weight % (0.4) *x* HBr solution Specific gravity (1.38) *x* Specific gravity (1.62) of 55% LiBr solution)

(For example) *A* = 0.12N
B = 3,070kg
D = 90.5 x (0.12 - 0.07) x 3,070 = **13,892(*ml*)**

(3) Procedure
(a) Pour pure water into one vacuum rubber hose in order to remove air in the vacuum rubber hose. (Refer to Fig. 7-7.)
(b) Connect the vacuum rubber hose to service valve of Heat Exchanger and fix it with hose band. (Refer to Fig. 7-8.)
(c) Connect other one of vacuum rubber hose to service valve which is furnished on diluted absorbent pipe between the absorbent pump and Low Temperature Heat Exchanger, fix it with hose band. (Refer to Fig. 7-10.)
(d) Insert the two copper tubes on the end of the vacuum rubber hoses into the container.
(e) Perform air-purging from shell.
(f) Open up the service valve for diluted absorbent.
(g) Remove absorbent solution about 50 liter from service valve into the container when absorbent pump operates.
(h) Close up the service valve for diluted solution after removing absorbent solution about 50 liter.
(i) Wear rubber gloves and mask.
(j) Pour *HBr* little by little. At this time, check pH value of this solution by pH test paper. (Allowable degree of pH value is 6.)
(k) Stop pouring *HBr* when pH value of this solution has become above 6.
(l) Open up the service valve for concentrated absorbent.
(m) When solution starts being sucked into the machine, watch carefully to ensure that air does not leak in.
(n) Close up the service valve for concentrated absorbent after charging all solution.
(o) Repeat item (f) to item (n), and charge all required volume of *HBr* solution into the machine.
(p) Remove the vacuum rubber valves after confirming the packing inside
(q) Please the caps of the service valves after confirming the packing inside.
(r) Wash all instruments with water.
(s) Continue air-purging from shell for 30 minutes after completion of this work.

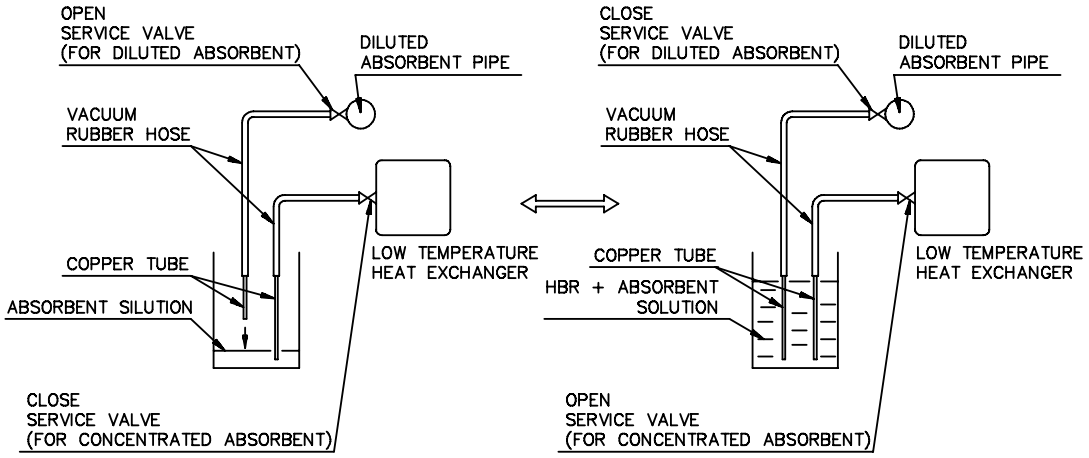

OPEN
SERVICE VALVE
(FOR DILUTED ABSORBENT)
DILUTED
ABSORBENT PIPE
VACUUM
RUBBER HOSE
COPPER TUBE
ABSORBENT SILUTION
LOW TEMPERATURE
HEAT EXCHANGER
CLOSE
SERVICE VALVE
(FOR CONCENTRATED ABSORBENT)
CLOSE
SERVICE VALVE
(FOR DILUTED ABSORBENT)
DILUTED
ABSORBENT PIPE
VACUUM
RUBBER HOSE
COPPER TUBE
HBR + ABSORBENT
SOLUTION
LOW TEMPERATURE
HEAT EXCHANGER
OPEN
SERVICE VALVE
(FOR CONCENTRATED ABSORBENT)

Fig. 7-10.

7-5. Charging of Nitrogen Gas

This instruction describes the procedure of charging the Absorption Machine with N_2 gas.

DANGER !

(1) The N2 gas cylinder is pressurized to 150kg/cm^{2}G. Take care when handling.
(2) Do not suddenly raise the primary or secondary pressure of the pressure regulator on the N_2 gas cylinder.
(3) Fix the N_2 gas cylinder so that it does not fall over.
(4) Be sure not to open No. 1. And No. 3. manual air-purge valve during this work.

1) Instruments
- N_2 gas (Required number of cylinders for one complete charge)
- Pressure regulator
- Pressure Gauge only for Single effect (Hot water or low pressure steam driven) absorption chiller
- Vacuum rubber hose
- Hose band
- Pliers
- Monkey spanner 8" (Adjustable wrench, Length 8")

2) Standards

The charging pressure in the Machine is measured by the pressure gauge on the Generator.
- For storage of Absorption Machine : 0.2kg/cm^{2}G
- For leakage test : 1.0kg/cm^2 G
- For equipment replacement : 0.1kg/cm^{2}G

3) Procedure

(1) Prepare N_2 gas cylinder, and attach pressure regulator to N_2 gas cylinder.
(2) Connect the vacuum rubber hose to the outlet of the pressure regulator, then open the valve on the top of cylinder slightly in order to purge the air in the hose. After purging, close the valve.
(3) Connect the other end of the hose to No.1. service valve and fix it by means of the hose band. And, in parallel with the hose connection, connect the pressure gauge (76cmHgV ~ 2 kg/cm$_2$G) to No.1. service valve for Single effect (Hot water or low pressure steam driven) absorption chiller.
(4) Check that No. 1., No. 2. and No. 3. manual air-purge valves and also No.1. service valve are fully closed.
(5) Open up No. 2. manual air-purge valve.
(6) Open up No. 1. service valve.
(7) Using the pressure regulator, release a small amount of N_2 gas at a time into the shell.
(8) Charge N_2 gas while watching the pressure gauge on the Generator or the pressure gauge on the No. 1 service valve. When the specified pressure is reached, close up No. 1. service valve and No. 2. manual air-purge valve and also close up the valve on the outlet of the cylinder.
(9) Remove the rubber hose from No.1 service valve, and place the cap on No.1 service valve.
(10) Remove the pressure regulator, and neatly arrange the N_2 gas cylinder and rubber hose.

7-6. Expelling of Nitrogen Gas

This instruction describes the procedure of expelling nitrogen gas from the Absorption Machine.

IMPORTANT !

(1) Be sure not to open No. 1. and No. 2. manual air-purge valve during this work.

(2) When expelling N_2 gas, adequately ventilate the surrounding area.

1) Instruments
   - Monkey spanner (Adjustable wrench)

2) Standards
   Make shell pressure equal to atmospheric pressure (0 kg/cm^{2}G). In Double effect absorption chiller (Direct fired or High pressure steam fired), shell pressure can be checked on generator pressure gauge.

3) Procedure
   (1) Open up No. 3. manual air-purge valve.
   (2) Remove the cap from No. 1. service valve and open the No. 1. valve using the spanner so as to discharge N_2 gas until the internal pressure becomes equal to atmospheric pressure.
   (3) When the reading on the Generator pressure gauge becomes atmospheric pressure (0 kg/cm^{2}G) in Double effect absorption chiller (Direct fired or High pressure steam fired) or when there is not any more gas discharge from No. 1. service valve, close up No. 1. service valve.

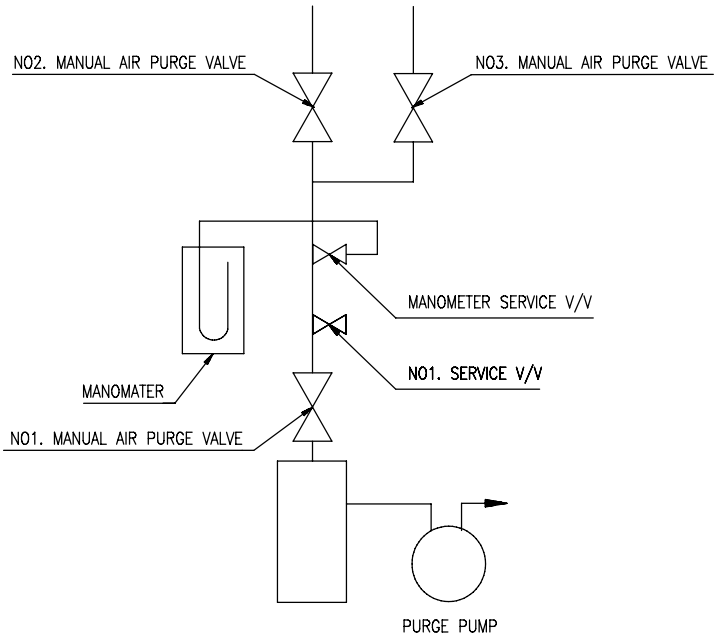


Fig. 7-12. Method of Expelling Nitrogen(N_2)Gas

7-7. Leak Test

7-7-1. Leak Test Schedule

1) Purpose
This schedule covers leakage tests, work procedure, outline, and precautions for Absorption Machine.

2) Scope
This schedule is applicable to leakage tests for Absorption Machine.

3) Instruments
- Nitrogen gas cylinder
- Pressure regulator
- Pressure proof hose.
- Oiler
- Flashlight
- Soapy water
- Adjustable wrench
- Wire
- Cutting pliers
- Hose band
- Freon Gas (Freon 12)
- Nitrogen gas cylinder
- Various pressure regulator
- Halogen leak tester
- Pressure gauge (76cmHgV ~ 2 kg/cm_2G) for Single effect (Hot water or low pressure steam driven) absorption chiller

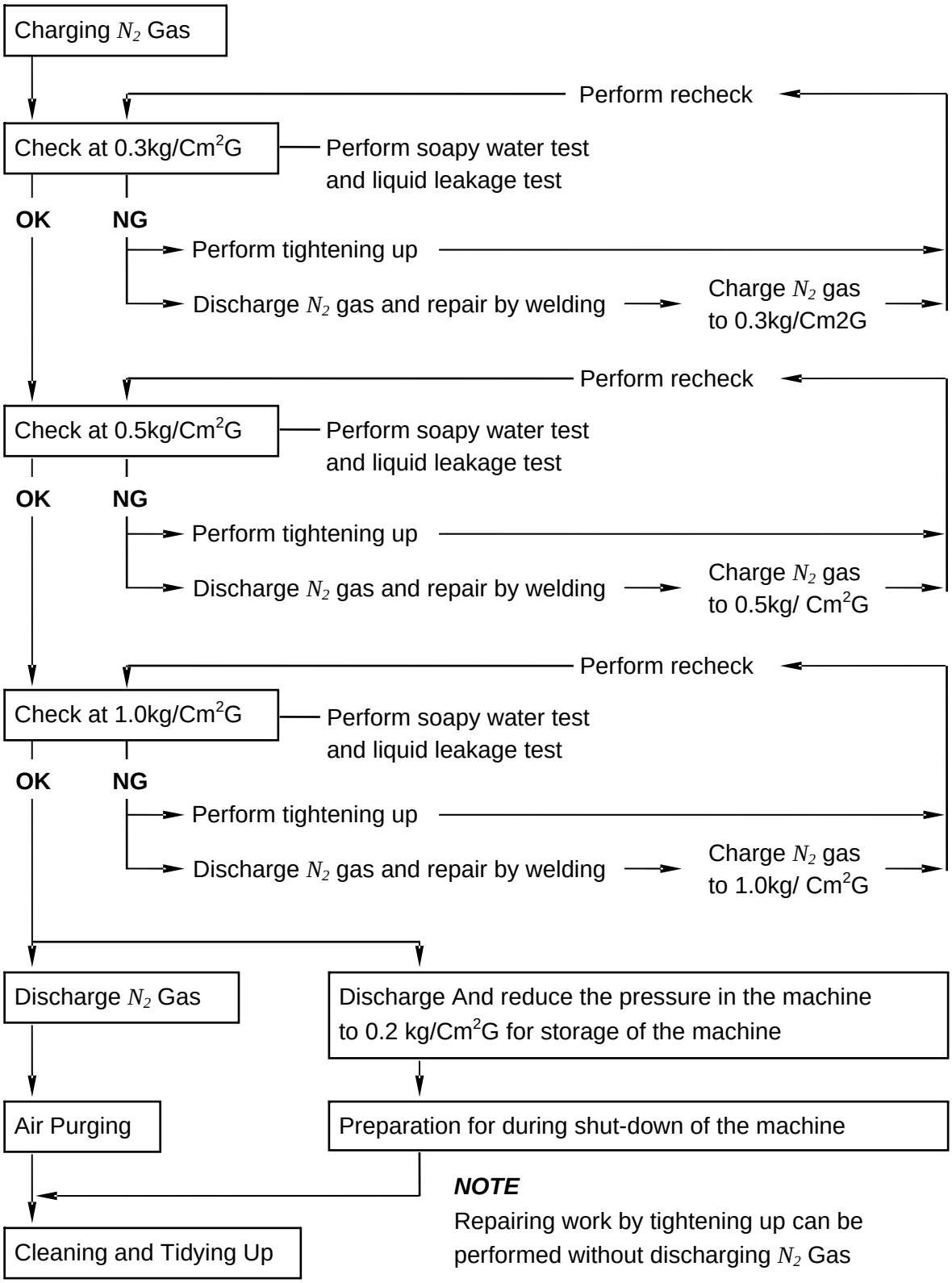
4) Standards
(1) Nitrogen pressurizing test
Charge Nitrogen gas to a pressure of 1.0kg/cm^2G and using soapy water, confirm that there are no bubble. At liquid filling parts, confirm that no liquid oozes out.

(2) Freon gas test
Charge freon gas to a pressure of 0kg/cm^2 from -500mmHg, and then charge nitrogen gas to pressure of 1.0kg/cm^2G. There shall be no reaction when a detector having a sensitivity of 10^{-5} atm·cc/sec is used.

5) Work Procedure
(1) Nitrogen pressurizing test
(2) Freon gas test

7-7-2. Detail of Nitrogen(N_2) Pressurizing Test

1) Sequence



NOTE

Repairing work by tightening up can be performed without discharging N_2 Gas

2) Procedures

(1) Confirm that No.1., No.2., No.3. manual air purge valves and service valves for charging/discharging of nitrogen gas and freon gas are fully closed.

(2) Confirm that inlet/outlet valves of absorbent pump and inlet/outlet valves of refrigerant pump are fully opened.
In case of Direct Fired Machine, confirm that **A** valve **B** valve and **C** valve are also fully opened.

(3) Connect the N_2 gas cylinder to the service valve and charge the N_2 gas into the machine.
(Refer to "7-5. Charging of Nitrogen Gas".)

(4) Pressurize the machine to 0.3kg/cm^{2}G with N_2 gas. Check the pressure in the machine by generator pressure gauge or additionally installed pressure gauge. In

(5) The pressure in the machine will reach to 0.3kg/cm^{2}G, close the service valve and valve of N_2 gas cylinder.

(6) Perform leak test the following positions with a soap water.
① All field welded portions (One shipping machine is not needed.)
② Sight glasses
③ Flare nut joints of service valve, manometer and pressure gauges.
④ Electrodes
⑤ Flange connection (absorbent pump, refrigerant pump and etc.)
⑥ Diaphragm valves

(7) If there are any leakage at the above item ② to ⑥, tighten them. In this time, discharging of N_2 gas is not needed.

(8) If there are any leakage at the welded portions, discharge the N_2 gas and then repair them by welding.

(9) Perform recheck at pressure of 0.3kg/cm^{2}G.

(10) There is no leakage, Perform leak test at pressure of 0.5kg/cm^{2}G and 1.0kg/cm^{2}G.

(11) If there is no leakage at pressure of 1.0kg/cm^{2}G, keep the machine under pressurizing condition of 1.0kg/cm^{2}G for 24 hours. Then perform leak test at pressure of 1.0kg/cm^{2}G again.

(12) After completion of the leak test, discharge the N_2 Gas. (Refer to "7-7. Expelling of Nitrogen Gas".)

3) Detail of Freon Gas Test

(1) Perform air purging from the machine to -500mmHg vacuum.

(2) Prepare a cylinder of freon 12. and connect the cylinder to the service valve
- A pressure regulator shall be used usually. However, direct charging is also allowed.
- After connecting the hoses, fix them with wire or hose bands.
- During cold season, the cylinder shall be heated with hot water.
- Install Pressure gauge (76cmHgV ~ 2 kg/cm$_2$G) on the service valve of refrigerant pump outlet for Single effect (Hot water or low pressure steam driven) absorption chiller

(3) Confirm that No.1., No.2., No.3. manual air purge valves and service valve for charging/ discharging of nitrogen gas and freon gas are fully closed.

(4) Conform that inlet/outlet valves of absorbent pump and inlet/outlet valves of refrigerant pump are fully opened.
In case of Direct Fired Machine, confirm that **A** valve **B** valve and **C** valve are also fully opened.

(5) Open No. 2. Manual air purge valve fully.

(6) Fully open the service valve and the valve of the freon gas cylinder.

(7) Pressurize the machine to 0kg/cm^{2}G with freon gas by means of the pressure regulator. In this time, check the pressure in the machine by the pressure gauge on the Generator.

(8) The pressure in the machine will reach to 0kg/cm^{2}G, close the service valve and the valve of the freon gas cylinder.

(9) Disconnect the freon gas cylinder from the service valve.

(10) Connect the N_2 gas cylinder to the service valve and charge N_2 gas into the machine.
(Refer to “7-5. Charging of Nitrogen Gas”)
(11) Pressurize the machine to 1.0kg/cm^{2}G with N_2 gas.
(12) Check leakage point by using halogen leak detector.
- When leakage points are detected by the halogen leak detector, handle the detector carefully and slowly.
- Also if leakage point is detected, repeat the check several times at surrounding this point. The point at which the maximum reading is obtained is the leakage point.

(13) Once the leakage point has been found, discharge the gas and perform repairing work by tightening up or welding.
(14) After repairing work, perform freon leak test again.
(15) If there is no leakage, keep the machine under this pressurizing condition for 12 hours. Then perform leak test again.
(16) After completion of the leak test, discharge the gas. (Refer to “7-6. Expelling of Nitrogen Gas”)
(17) Perform air purging. (Refer to “6-2-1. Air-Purging Procedure)
(18) Perform cleaning and tidying up.

CAUTION !
When discharging the Gas, perform ventilation sufficiently.

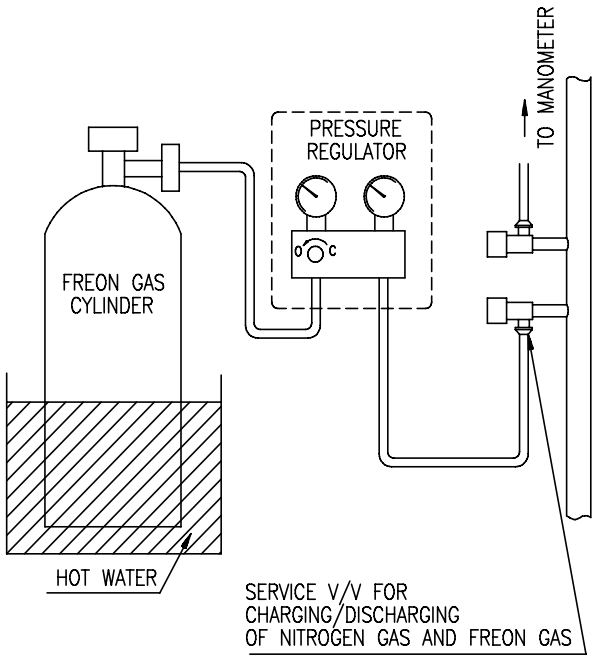


Fig. 7-13. Charging and Discharging Device for Nitrogen Gas and Freon Gas

7-8. Bubble Test

The purpose of this instruction is to describe procedures and instructions for bubble leak test.

1) Instruments
   - Connecting attachment to exhaust port of purge pump.
   - Graduated cylinder
   - Vinyl hose (diameter 6mm)
   - Bucket
   - Putty
   - Stop watch

2) Standards
   Leak test shall be performed during shutdown of the machine.
   Average of three times measurement is less than 15cc per 10 minutes.

3) Procedure
   (1) Perform air-purging until the inside pressure of the machine reaches the allowable degree of vacuum, and then continue air-purging at least for one hour.
   (2) Make sure that the attained vacuum of the purge pump is under 4mmHg.
   (3) Remove the exhaust port cap of the purge pump, and Install the connecting attachment to the exhaust port of purge pump and fix the vinyl hose to the connecting attachment as shown Fig. 7-14.
   (4) Manual air-purge valves(Diaphragm valves) should be set as follows
   Valve No.1 : **OPEN**
   Valve No.2 : **CLOSE**
   Valve No.3 : **CLOSE**
   (5) Continue to operate purge pump for about one minute under the condition as mentioned above, then measure bubble volume. During this measuring, keep the vinyl hose within depth of 10mm. If bubbles are absorbed, inspect and tighten downstream connections from the manual air purge valves. If bubbles are still collected in spite of the above handling, measure the volume of bubbles collected in 10 minutes.

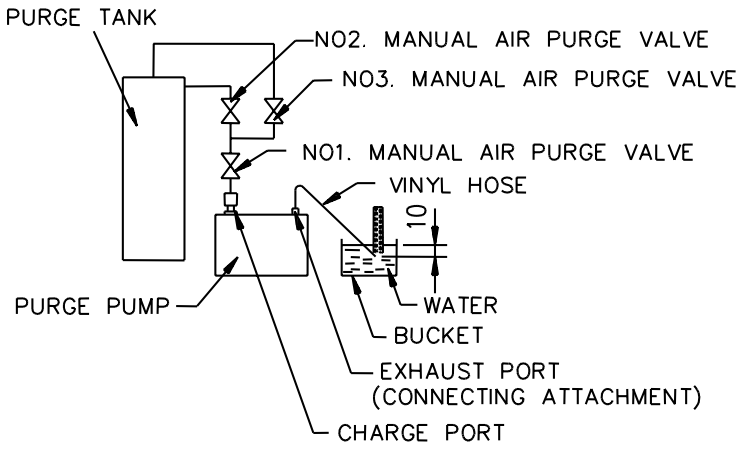


Fig. 7-14.

   (6) Then set the manual air purge valves as follows,
   Valve No.1 : **OPEN**
   Valve No.2 : **CLOSE**
   Valve No.3 : **OPEN**
   Gas ballast valve and oil delivery valve should be kept closed.
   (7) Continuing operation of the purge pump under the above condition, measure the volume of bubbles in 10 minutes. Measurement should be performed at least three times.
   During intervals of each measurement, make sure that the attained vacuum of purge pump is under 4mmHg.

(8) Calling the measured volume in item (5) as A cc and that in item (7) as B cc, (B-A) is a result of the bubble leak test.

(9) After bubble leak test, gas ballast valve and oil delivery valve should be opened and check weather water is contained in oil or not. If water is absorbed, drain water and fill oil to an appropriate level.

4) When is Bubble Leak Test performed ?

- At the leak test after the Absorption Machine is assembled at site.
- At the periodical inspections.

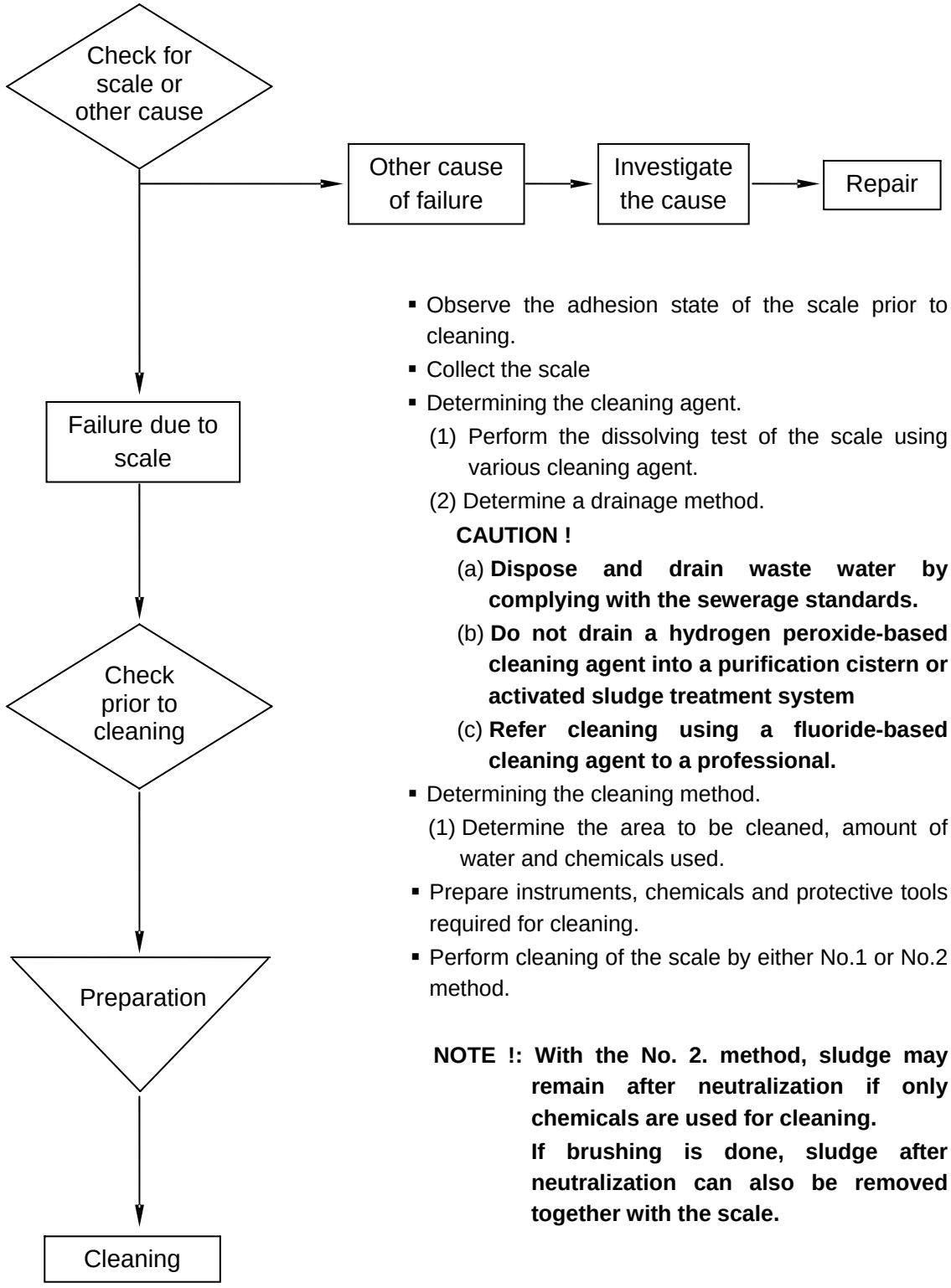
5) Remarks

If the attained vacuum of purge pump is above 4mmHg, refer to “6-2-1. Air Purging”.

7-9. Tube Cleaning

This instruction describes the method to remove the scale attached to the cooling water system the Absorption Machine.

1) Cleaning Procedure



- Observe the adhesion state of the scale prior to cleaning.
- Collect the scale
- Determining the cleaning agent.
  (1) Perform the dissolving test of the scale using various cleaning agent.
  (2) Determine a drainage method.
  CAUTION !
  (a) **Dispose and drain waste water by complying with the sewerage standards.**
  (b) **Do not drain a hydrogen peroxide-based cleaning agent into a purification cistern or activated sludge treatment system**
  (c) **Refer cleaning using a fluoride-based cleaning agent to a professional.**
- Determining the cleaning method.
  (1) Determine the area to be cleaned, amount of water and chemicals used.
- Prepare instruments, chemicals and protective tools required for cleaning.
- Perform cleaning of the scale by either No.1 or No.2 method.

NOTE !: With the No. 2. method, sludge may remain after neutralization if only chemicals are used for cleaning.
If brushing is done, sludge after neutralization can also be removed together with the scale.

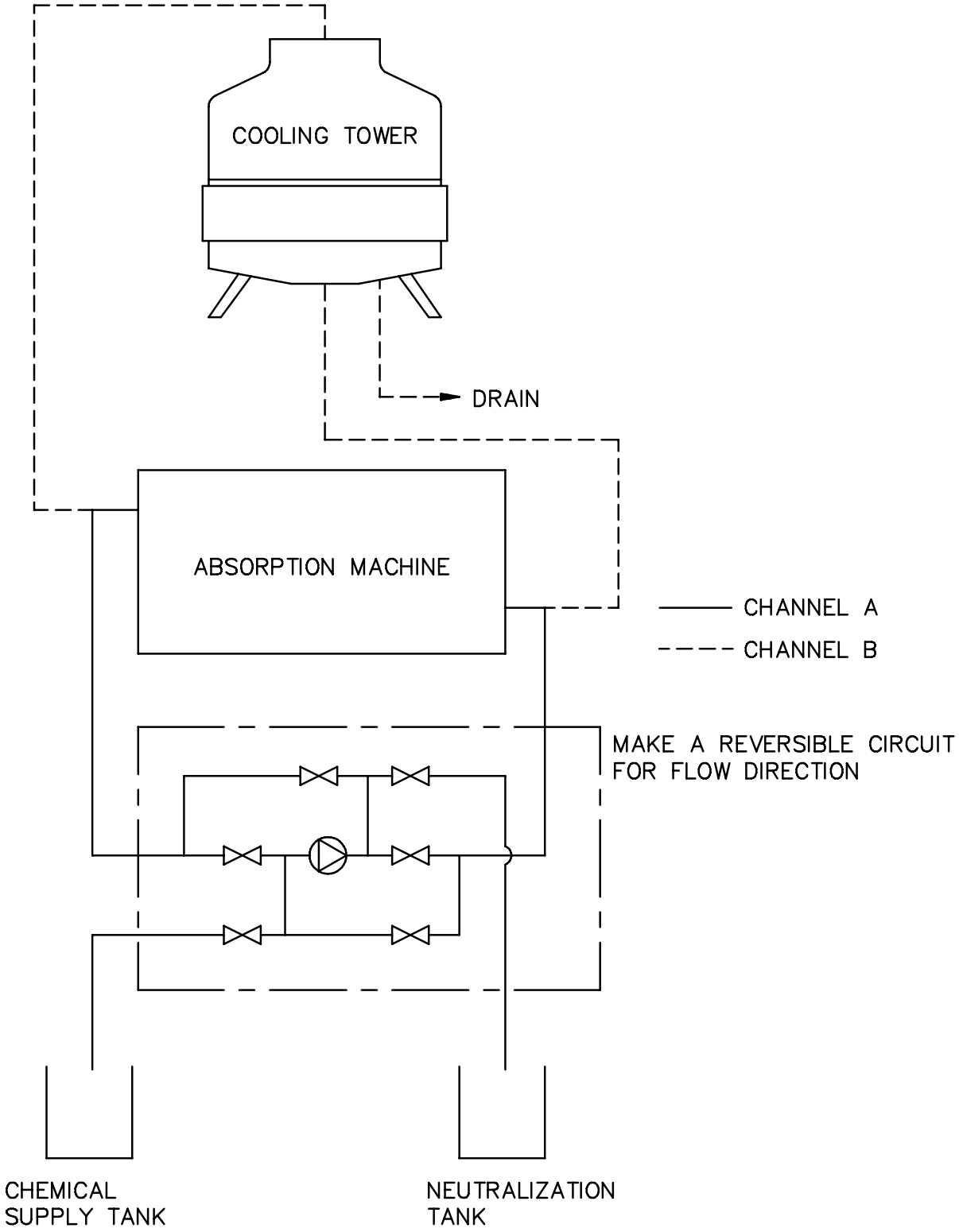
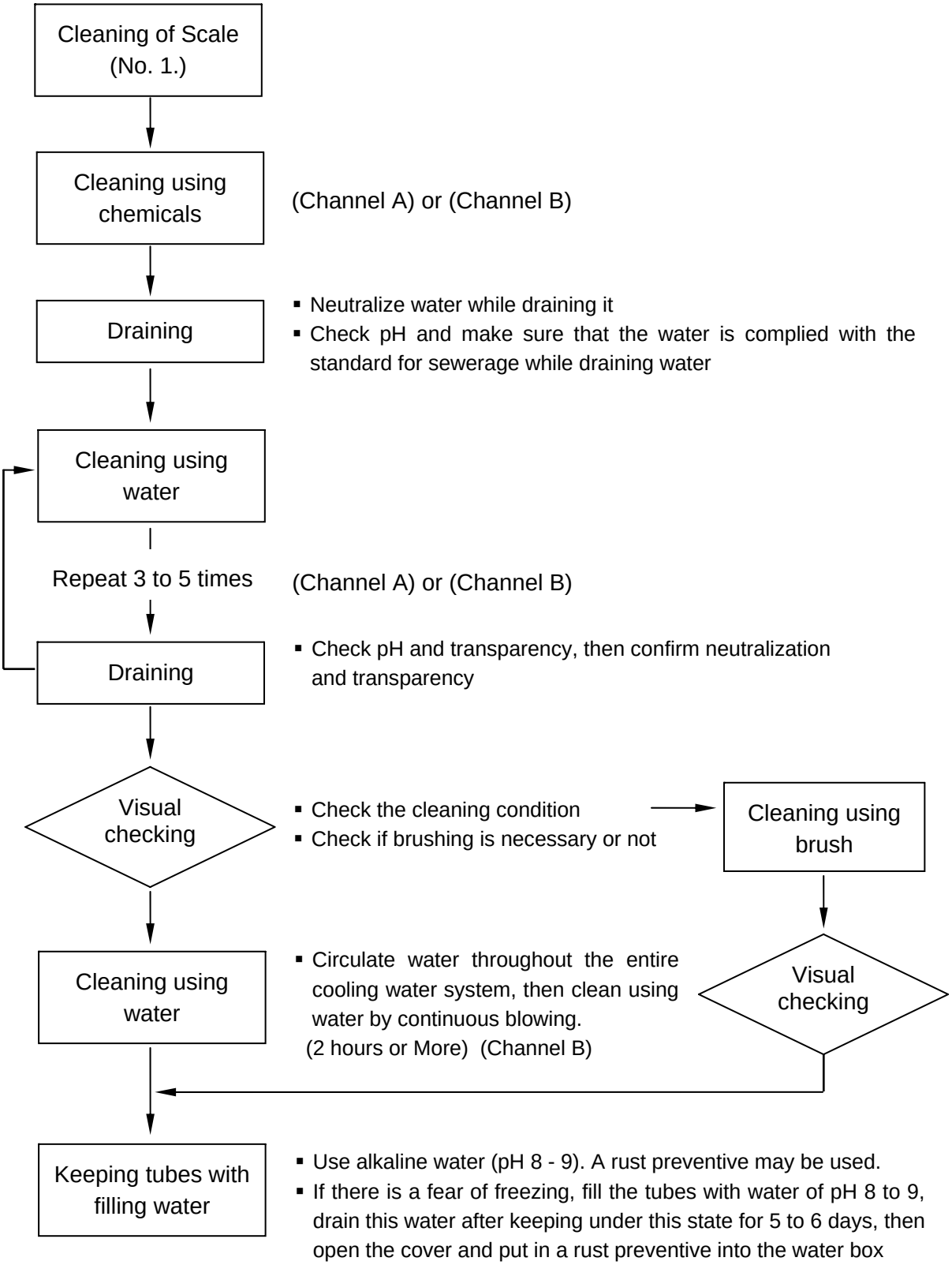
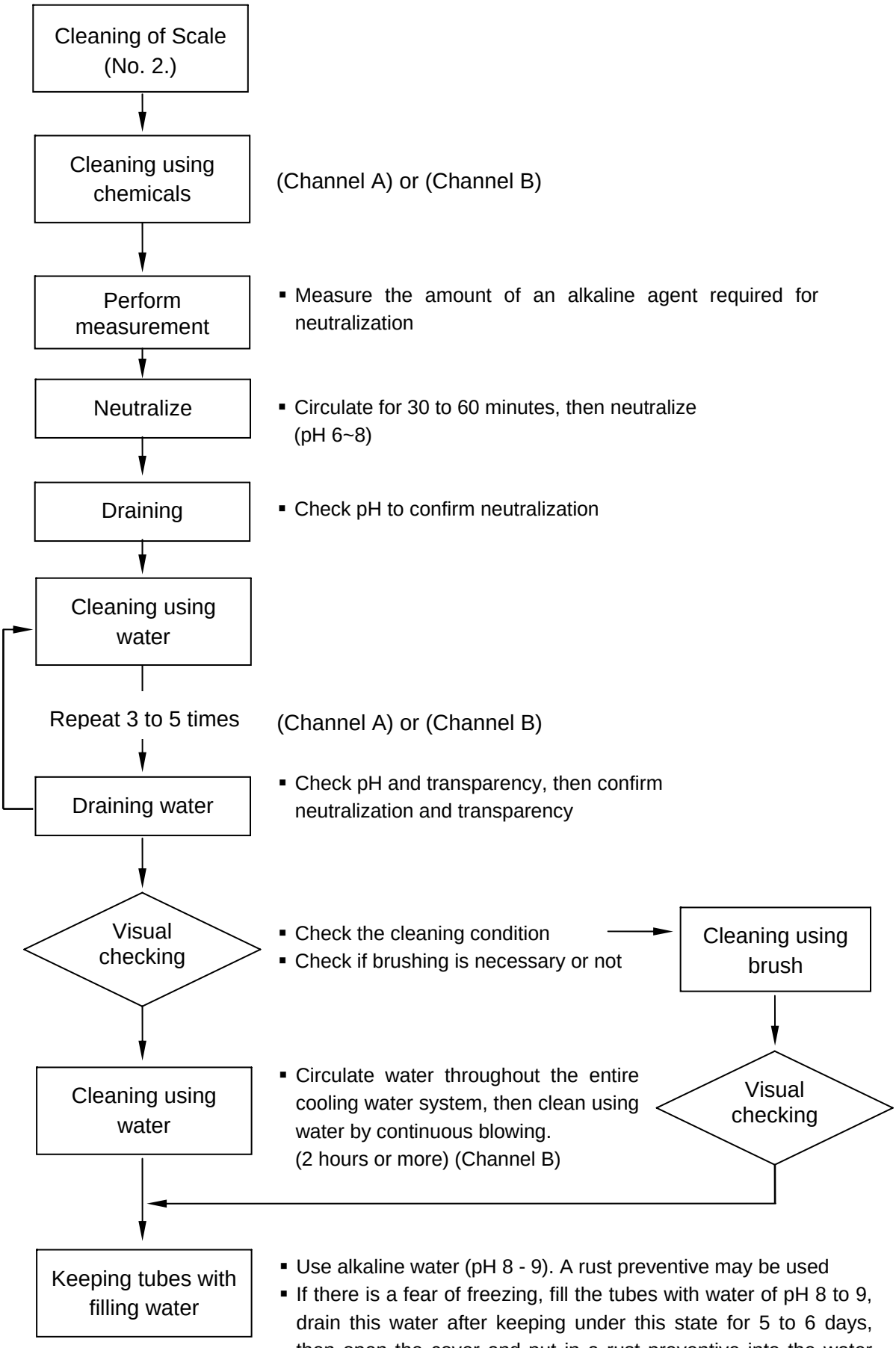
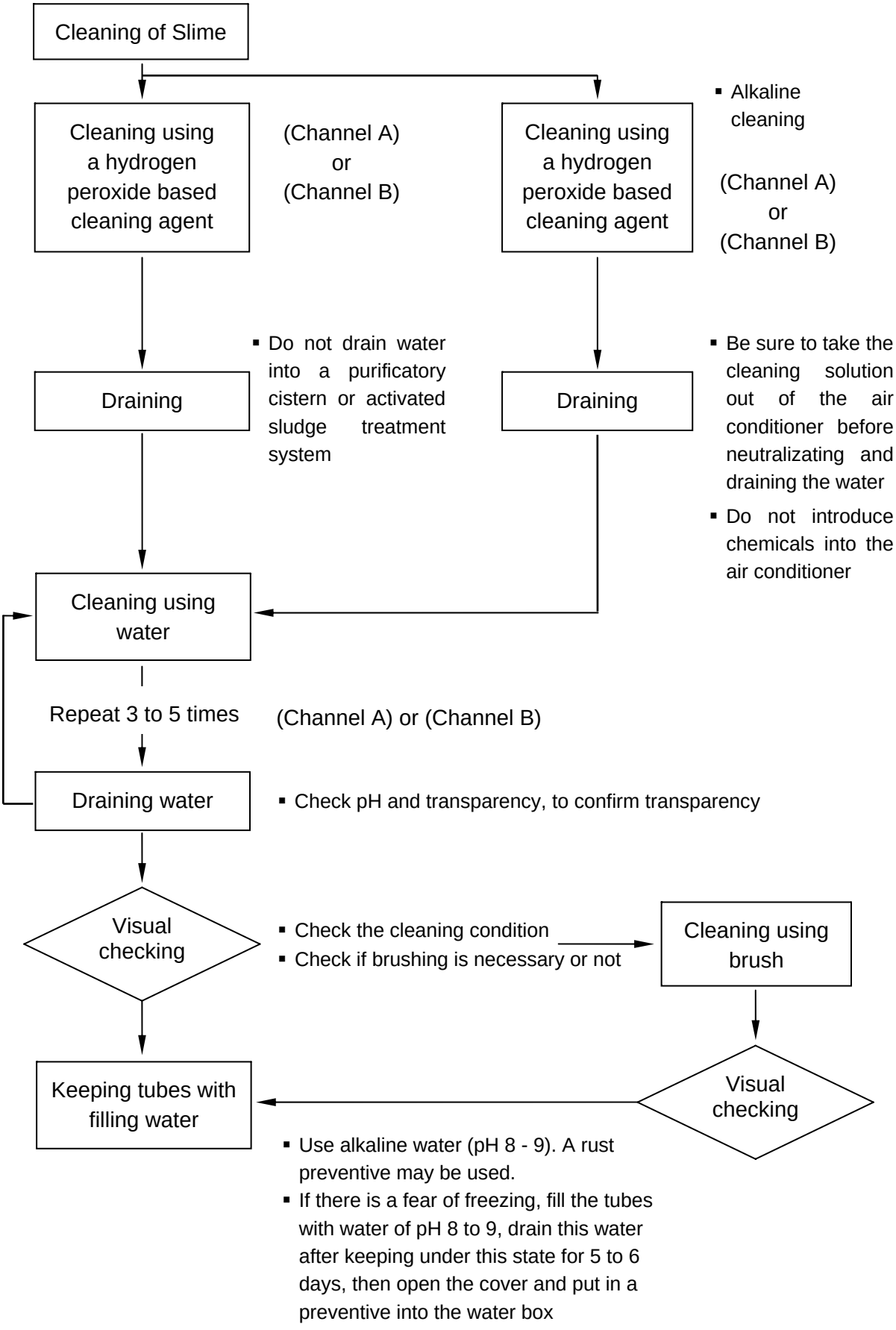


Fig. 7-15. Tube Cleaning Facility

2) Cleaning Method Procedure




Cleaning of Scale (No. 2.)
Cleaning using chemicals
(Channel A) or (Channel B)
Perform measurement
▪ Measure the amount of an alkaline agent required for neutralization
Neutralize
▪ Circulate for 30 to 60 minutes, then neutralize (pH 6~8)
Draining
▪ Check pH to confirm neutralization
Cleaning using water
Repeat 3 to 5 times
(Channel A) or (Channel B)
Draining water
▪ Check pH and transparency, then confirm neutralization and transparency
Visual checking
▪ Check the cleaning condition
▪ Check if brushing is necessary or not
Cleaning using brush
Visual checking
Cleaning using water
▪ Circulate water throughout the entire cooling water system, then clean using water by continuous blowing. (2 hours or more) (Channel B)
Keeping tubes with filling water
▪ Use alkaline water (pH 8 - 9). A rust preventive may be used
▪ If there is a fear of freezing, fill the tubes with water of pH 8 to 9, drain this water after keeping under this state for 5 to 6 days, then open the cover and put in a rust preventive into the water


Cleaning of Slime
Cleaning using a hydrogen peroxide based cleaning agent
(Channel A) or (Channel B)
Cleaning using a hydrogen peroxide based cleaning agent
▪ Alkaline cleaning
(Channel A) or (Channel B)
Draining
▪ Do not drain water into a purificatory cistern or activated sludge treatment system
Draining
▪ Be sure to take the cleaning solution out of the air conditioner before neutralizating and draining the water
▪ Do not introduce chemicals into the air conditioner
Cleaning using water
Repeat 3 to 5 times
(Channel A) or (Channel B)
Draining water
▪ Check pH and transparency, to confirm transparency
Visual checking
▪ Check the cleaning condition
▪ Check if brushing is necessary or not
Cleaning using brush
Visual checking
Keeping tubes with filling water
▪ Use alkaline water (pH 8 - 9). A rust preventive may be used.
▪ If there is a fear of freezing, fill the tubes with water of pH 8 to 9, drain this water after keeping under this state for 5 to 6 days, then open the cover and put in a preventive into the water box

3) Determining a Cleaning Agent (Dissolving Test)

Collect the scale to be cleaned, then perform the dissolving test using an available cleaning agent, and determine the most suitable cleaning agent.
Put the scale into the cleaning agent with the specified concentration, then observe the condition of bubbles and condition of dissolving the scale.
The more bubbles are emitted and the more scale is dissolved, the more effective the cleaning agent is.

DANGER !
The fluoride based cleaning agent requires qualification when handling it and is extremely hazardous to both humans and equipment. Therefore, in this case, the professional should be required.

4) Notice for Drain Waste Water
- Sewerage

: Drain water in accordance with a regulation of each area.
(The below standard is one of the example in Japan.)
- Rivers/lakes/swamps/farm land/fish farm

: Do not drain.
- Waste water treatment facilities

: The hydrogen peroxide based waste water cannot be drained into a purificatory cistern or activated sludge treatment system.

Table 7-1. Waste Water Standard of Public Sewerage

Item	Standard
Temperature	Less than 45℃
Hydrogen ion concentrator	5 < pH < 9

5) Cleaning Method

(1) In the case of cleaning together with cooling water

DANGER !
If the cooling water is on the roof, pay attention to the direction of wind to see that other buildings have not damages.

(2) In the case of cleaning for the machine only

6) Preparation
(1) Prepare water, cleaning agent. neutralizing agent and rust preventive.
(2) Confirm the area and circuit to be cleaned.
(3) Prepare protection tools (Gloves, Goggles, Mask, Etc.)
(4) Make the cleaning circuit around the pump as shown in Fig. 7-17. for reversing water flow.

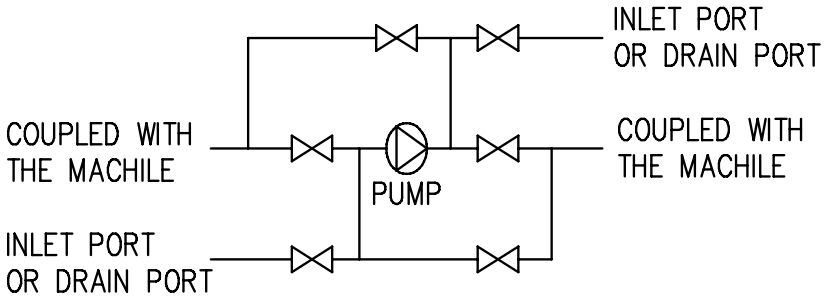


Fig. 7-17. Tube Cleaning Circuit around Pump

Use suitable capacity pump for cleaning. Table 7-2. shows one of the example of pump.

Table 7-2.

Flow Rate (m^3/h)	Total Head (m)	Output (kW)
0.8	9.5	2.2

7) Others

(1) Check if it is harmless to spill water, acid, or alkaline agent at the floor. If it is harm, prepare a sheet of examine another cleaning method.

(2) If cleaning takes two days of more, fill the tubes with clean water (city water) at the end of daily work.

7-10. Removing Refrigerant from Machine

This instruction describes the procedure of removing refrigerant from machine for following works.

- Adjusting charging quantity of refrigerant
- After de-crystallization with charging pure water.

1) Instruments
   - Small pump for removing refrigerant
   example of pump specifications
   - Flow rate : 20 $liter/min.$
   - Total head : 14 m
   - Vacuum rubber hose (1 ~ 2m) : 2 numbers
   - Wire (50cm) : 3 numbers
   - Pliers
   - Adjustable wrench
   - Bucket with scale(30 liter)

2) Procedure
   (1) Perform air purging from shell.
   (1) Make the circuit for removing refrigerant as shown in Fig. 7-18.
   (2) Start small pump for removing refrigerant.
   (3) Slightly open the service valve furnished on refrigerant pipe by using adjustable wrench.
   (4) Fully open the service valve when refrigerant is discharged into the bucket.
   (5) Fully close the service valve when required quantity of the refrigerant is removed.
   (6) Stop the small pump for removing refrigerant.
   (7) Continue the air purging for 30 minutes after completion of this work.
   (8) Disassemble the circuit.
   (9) Confirm that cap of the service valve is closed completely.
   (10) Wash the tools with water.

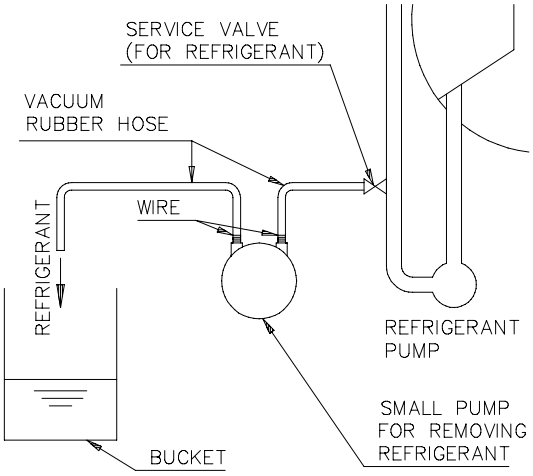


Fig. 7-18. Refrigerant Removing Device

3) Notice
   (1) Pour water into the small pump before starting up the small pump.
   (2) For adjusting of charging quantity of refrigerant, perform this work under condition of full load. Also checking refrigerant level though evaporator sight glass (see punch marks on evaporator sight glass.), discharge refrigerant little by little.

7-11. Solution Pumps

1) Introduction

(1) Please follow these instructions carefully when you operate the pump.
(2) Do not operate a dry pump (do not switch on when there is no liquid in the pump.)
(3) Completely remove foreign matter and rust from piping and accessories.
(4) Check for any abnormalities in circulating channels at the time of inspection.
(5) Do not run the pump with discharge valve closed for more than one minute.
(6) Do not run the pump in reverse rotating direction.
(7) Do not operate if there is any cavitation.
(8) When a safety device is triggered, check the cause without delay and operate the pump only after the problem is corrected.
(9) Bearings should be replaced in a fixed cycle.

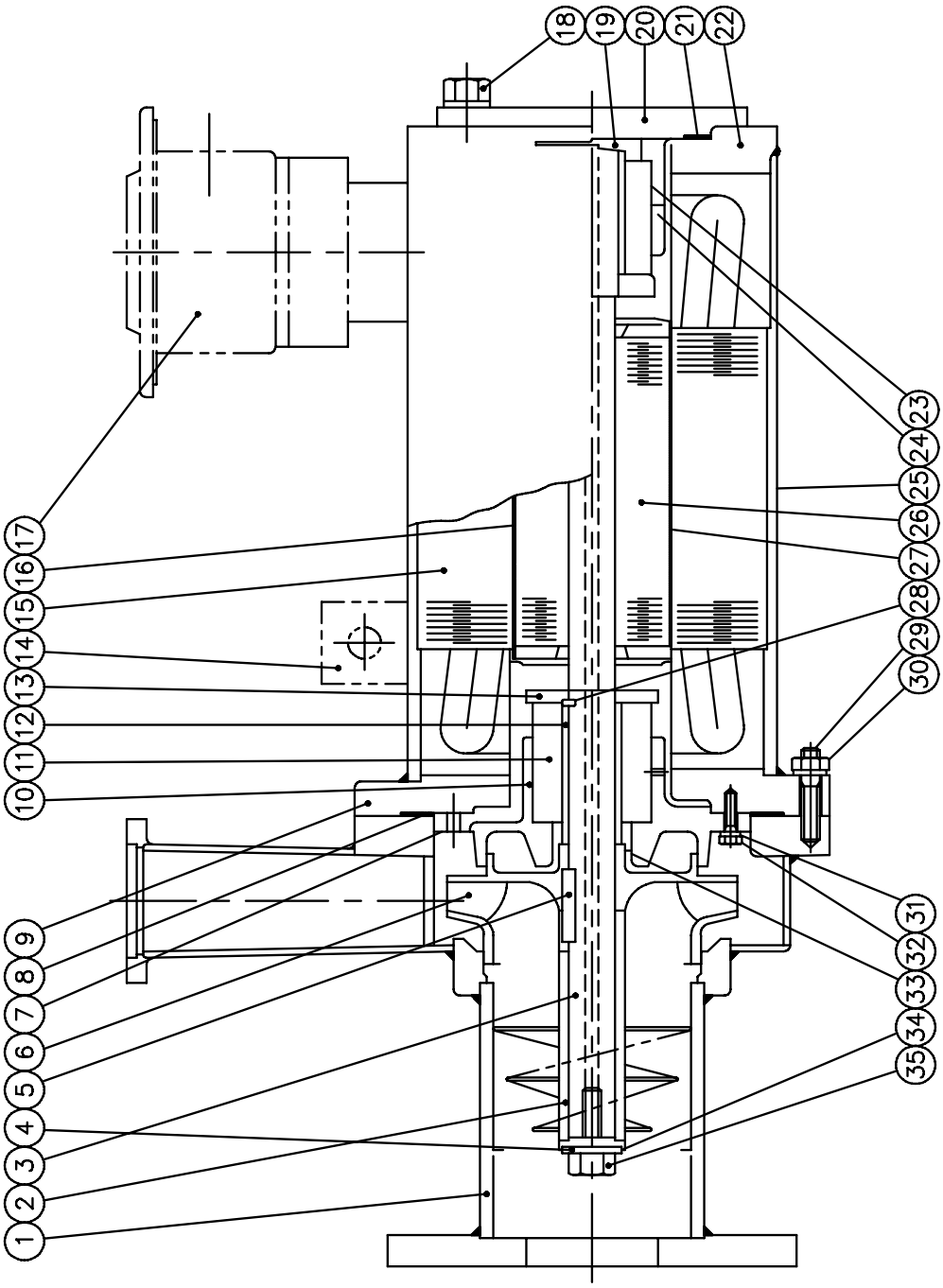
A canned motor pump has the following advantageous features;
(1) Perfectly free from leakage and air tight
(2) Silent operation with little vibration
(3) Small space required for installation
(4) Low running cost

This manual has been prepared as an essential guide for the operation, best use, and proper care of the pump. It is to be understood that proper operation, checking and maintenance are prerequisites to take best advantage of the above features, and also for keeping the pump in the best condition for a long time.

2) Construction

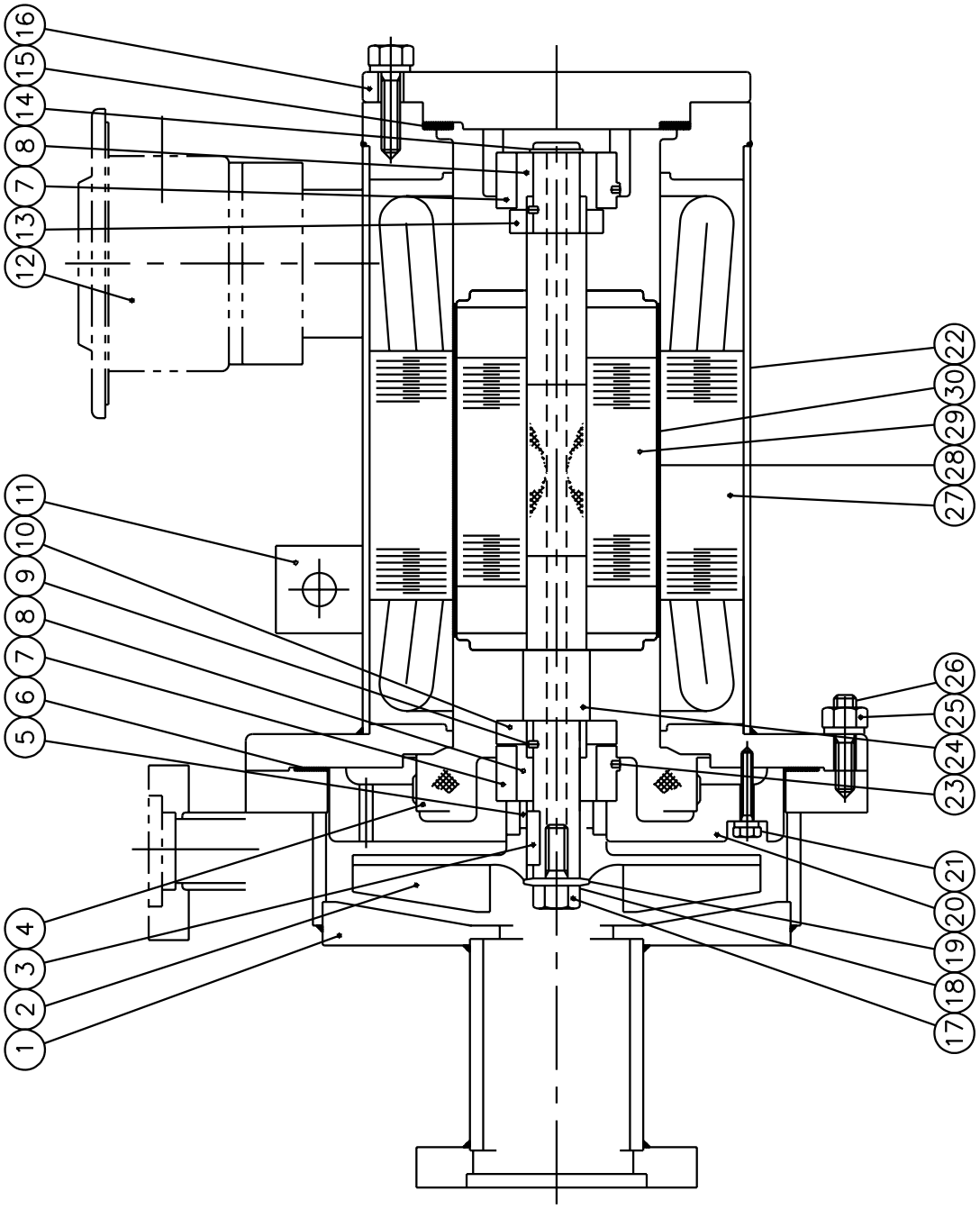
This construction of the pump is shown in Fig. 7-23. and Fig. 7-24. Since they are basically the same construction, only pump in Fig. 7-23. is explained here.

The motor is of a radial air-gap induction type, and the inside of the stator and the outside of the rotor are welded and hermetically sealed with a thin sheet of non-magnetic metal.
The pump is so designed that a certain quantity of liquid being handled enters into the motor chamber through Filter(No. 7.) mounted on circulatory hole on the Front Bearing Housing(No. 10.) and flows in the gap between Bearing(No. 11.) and Sleeve(No. 12.) and is led into the inlet of Casing(No. 1.) through balancing hole of Impeller(No. 6.).
And at the same time a certain quantity of liquid runs through space between stator Can(No. 16.) and Rotor Can(No. 27.), gap between Bearing(No. 11.) and Sleeve(No. 12.) in rear side, and is led into the inlet of Casing through circulatory hole inside the Shaft(No. 3.).
This circulating liquid serves to lubricate Bearings 11 and cool motor.
Rotor Assembly(No. 26.) is supported by two Bearings(No. 11.) on either side. Impeller(No. 6.) is mounted on the Shaft(No. 3.) which is with Rotor.
Revolving parts of Rotor and Impeller are placed fully in the liquid being handled so that there is no movable part that passes through the liquid contact part and outer part.
This, therefore, eliminates the necessity of a shaft seal, which is the source of many problems.
Inducer(No. 2.) is mounted on the shaft end and this, together with Impeller(No. 6.), considerably improves total suction performance.



No.	Name
1	Casing
2	Inducer
3	Shaft
4	Lock washer
5	Key
6	Impeller
7	Filter
8	Inducer
9	Motor F.flange
10	F.B. Housing
11	Bearing
12	Sleeve
13	Thrust collar
14	Hook
15	Stator assembly
16	Stator can
17	Terminal box
18	Bolt
19	Snap ring
20	R.B.Housing
21	Gasket
22	Motor R.flange
23	Seat plate
24	Set screw
25	Name plate
26	Rotor assembly
27	Rotor can
28	Pin
29	Stud bolt
30	Nut
31	Washer
32	Bolt
33	Adjusting washer
34	Washer
35	Bolt

Fig. 7-19.



No.	Name
1	Casing
2	Impeller
3	Key
4	Filter
5	Spacer
6	Gasket
7	Bearing
8	Sleeve
9	Pin
10	Thrust collar
11	Hook
12	Terminal box
13	Spacer
14	Snap ring
15	Gasket
16	R.B.Housing
17	Bolt
18	Lock washer
19	Washer
20	F.B. Housing
21	Bolt
22	Name plate
23	Pin
24	Shaft
25	Nut
26	Stud bolt
27	Stator assembly
28	Stator can
29	Rotor assembly
30	Rotor can

Fig. 7-20.

3) Operation

(1) Check Pump Rotation

Connect the electric source (R,S,T) to the terminals (U,V,W) of the pump as follow;

R-U, S-V, T-W

Then the pump rotates in a normal direction.(counter clockwise viewed from impeller side) To make sure, switch on the pump just for a second and check the direction.

(2) Preparation for operation and trial operation

(a) Setting of overload relay

As rated ampere at normal output of the canned motor is higher than the one of general motors, set at the rated ampere indicated on the name plate. It is effective as a protecting device for canned motors to set the overload relay at as low amperage as possible. Generally, it is recommended to set the relay at the current 1.1~1.25 times as high as the operating current.

- Smaller fluctuation of voltage and load ..... 1.1 times
- Bigger fluctuation of voltage and load ..... 1.25 times

(b) Trial operation

Note the following points during operation.

- Pressure gauge — *Any abnormal pressure fluctuation ?* *Is specified pressure indicated ?*
- Ammeter — *Is the amperage too high ?*
- Abnormal noise — *Is metal rubbing noise or cavitation noise heard ?*

If there is any abnormality, switch off the pump and check the cause as per instructions in the following chapter.

4) Maintenance and Inspection

(1) Dismantling

Dismantling manner is basically the same among the pumps in Fig. 7-19. and Fig. 7-20., so the pump in Fig. 7-20. is explained here.

(a) Remove Nuts (No. 30.) and pull the motor backward. At this time pay full attention not to hit Inducer (No. 2.) and Impeller(No. 6.) against Casing(No. 1.).

(b) Extend the bent of Lock Washer(No. 4.) on the shaft end and remove Bolt(No. 35.), then Inducer(No. 2.) and Impeller(No. 6.) can be removed.

(c) Remove Bolt(No. 32., No. 18.) and pull out Front Bearing Housing(No. 10.) and Rear Bearing Housing(No. 20.) from either end of Stator. At this time, pay attention not to damage Bearing(No. 11.).

(d) In taking out Rotor assembly(No. 26.) from Stator assembly(No. 15.), pull it carefully, slowly and horizontally along Stator Can, for otherwise shaft end might hit against Stator Can, possible causing cracking of damaging to both. Remove Rotor should be put on clean cloth so as not to damage Rotor Can.

(e) Remove Key(No. 5.), Adjusting washer(No. 33.), Front Sleeve(No. 12.) and Thrust Collar(No. 13.) from Rotor assembly(No. 26.). Sleeve(No. 12.) and Thrust Collar(No. 13.) in rear side of Rotor Can be removed after taking out of Snap Ring(No. 19.).

Note 1. Take care not to loose small parts, such as key, blots and washers.

Note 2. On solution pump, do not leave parts wet for a long time, otherwise corrosion might occur on sliding surface of sleeves and collars. Wipe the parts with clean cloth or wash them with water. Wetted part of shaft and impeller shall also be cleaned.

(2) Reassembling

Reassembling can be made in the reverse manner of dismantling, but please note the following points.

(a) When bearing is replaced with new one, take care to put seat plate on the cut part of bearing and insert bearing to the housing with seat plate on which set screw presses to lock bearing. (Pump in Fig. 7-20. does not need seat plate and set screw)

(b) When sleeve and collar are replaced, set pin on the shaft without fail. Thrust collar shall be set on the shaft as shown in Fig. 7-21.

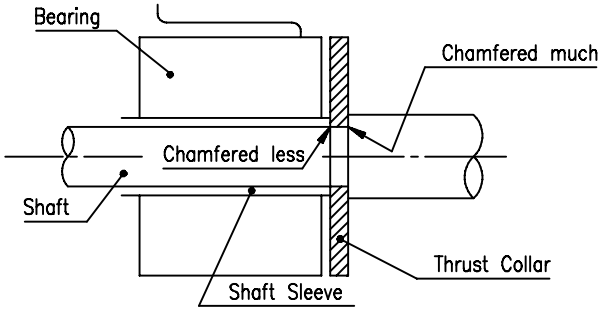


Fig. 7-21. Thrust Collar Setting

(c) Adjustment of axial gap of impeller (Pump in Fig. 7-20. does not need the adjustment) Adjust the gap “g” shown in Fig. 7-22. with adjusting washer to 0.5 ~ 0.9mm. Measurement of gap “g” shall be done as shown below.

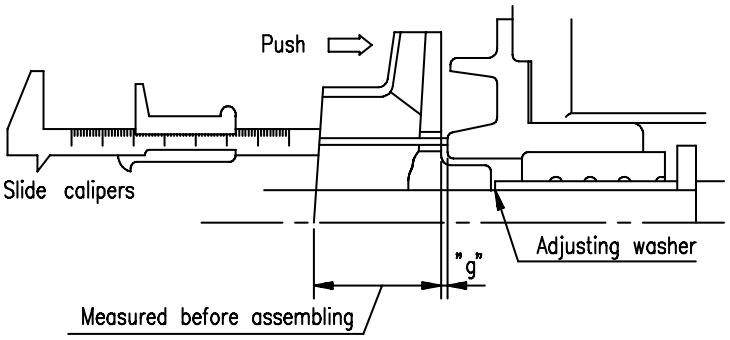


Fig. 7-22. Axial Gap of Impeller

(d) Bolts must be fastened with particular care to tighten up uniformly.

(e) After assembling Lock Washer (No. 4.), never fail to bend so as to work as locking.

(f) Clean gaskets and other accessories before fixing.

(3) Periodical Inspection

It is advised that the pump be overhauled once a year.

(4) Maintenance and Inspection

As to how often or what extent the maintenance or inspection should be done, it is not always the same according to the operating conditions, etc.

Check points in general are as per following list.

■ **BEARING WEAR LIMIT**

In case TRG indication is in the range of caution of danger or abnormal vibration and noise can be

noticed, overhaul the pump and check the bearings.

Replacement of bearing shall be done in the followings;
D - d ≥ limit value L ≤ limit value

NOTE : In case of bearing replacement, sleeve and thrust collar shall also be checked. Generally the life of sleeve and collar is longer than that of bearing, but sometimes surface of these parts is damaged by foreign matter contained in the pumped liquid. It is advised that sleeve and collar are to be replaced with new ones when these parts have scratched traces on the surface and the traces catch finger nails

Table 7-4. Limit Value of Bearing Wear

Type of Pump	Bearing Position	D - d (*mm*)	L (*mm*)
W002M, W003M	Front (Inducer Side)	0.4	26.0
W004M, L012M	Rear	0.4	26.0
W015D, L032C	Front, Rear	0.4	50.0
L030C, L090C	Front, Rear	0.45	70.0

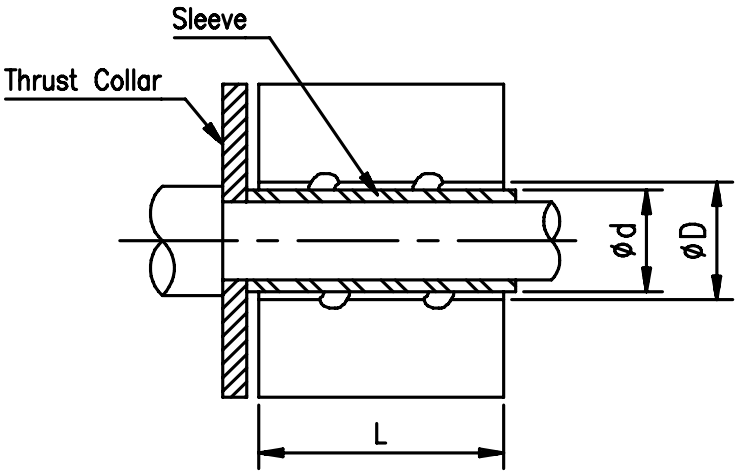


Fig. 7-23. Bearing Wear Limit

Table 7-5. Inspection Points

	Daily Inspection	Monthly Inspection	Periodic Inspection
Objects	Inspect mainly if there is any abnormal operating condition	Inspection, cleaning & maintenance which can be done without disassembling	To repair defects which are found upon disassembling or before
Pressure Gauge	Is specific pressure indicated ?		
Flow Meter	Is specific flow indicated ?		
Ammeter	Is there any over amperage or fluctuation of current ?		
Liquid Leakage	Is there any leakage ?		
Abnormal Noise or Vibration	Is there any ?		
Stator Assembly		Measure insulation resistance Not less than 5 MΩ	Measure insulation resistance before & after disassembly
Casing			Is there any foreign material inside ? Is the mouth ring worn ?
Impeller			Is there any wear damage in the mouth ring ? Is there any foreign material inside ?
Circulation Channels			Are there blocked ?
Bearings			Are there any cracks, scratches, wears or abrasions ?
Shaft Sleeve			Same as above
Thrust Collar			Same as above
Rotor Can			Are there any contact marks or scratches ?
Stator Can			Same as above
Gaskets			Any cracks or breaks ?
TRG		Measure voltage at TRG terminals	Measure voltage of TRG. If necessary, replace bearing.

Table 7-6. Troubles Causes and Countermeasures (1/2)

Troubles	Causes	Countermeasures
No Pumping	Pump has not started due to;	Change to three phase to single phase source
	Valves is not open	Open valve
	Pump is not connected to electric source	Check if wire connections are poorly or incorrectly
	Motor coil is cut	Measure resistance between coils, and if it is cut, send back motor to us for repair work
Total head lacking upon initial operation of new pump	Rotating direction is improper	Correct rotation
	Circuit resistance or actual head is different from plan	Correct as planned or replace pump
	Viscosity or specific gravity is too high	
	Circulation line inside pump is clogged with foreign particles	Remove them
	Voltage drops	Correct so as to have specified voltage
	Cavitation has occurred	Correct suction pipe Get suction liquid level higher
	Liquid has solidified	Remove the solidification
Flow rate drops while in operation	Check all in above section	
	Mouth rings of casing and impeller are worn	Replace it
	Impeller is abraded or damaged	Replace it
	Unexpected rise of viscosity due to liquid temperature's decline	Raise temperature as specified or replace pump
	Piping loss is increased	Clean piping

Table 7-6. Troubles Causes and Countermeasures (2/2)

Troubles	Causes	Countermeasures
Motor stops automatically	Baring have seized due to dry operation	Replace bearings
	Over-load	Check if liquid specification or amount is as per planned, and if not, correct as specified or replace pump
	Over-heat	Check if air bleeding is completed, if circulation line is clogged or if the amount of cooling water is as specified
	Wrong setting of safety device	Reset after inspection
Abnormal abrasion of bearings Line end	Dry operation	Keep the liquid level high enough
	Lubricant is insufficient	Clean circulation passageway
	Slurry is mixed in	Remove the slurry
	Sleeve sliding surface is damaged or rough	Remove the sleeve
	Crystallization of liquid	Remove the crystallization
Abnormal vibration and noise Circulation line0	Cavitation has occurred	Correct so as not to cause cavitation
	Circulation liquid is insufficient	Clean the passageway
	Foreign particle comes into casing	Remove the foreign particle
	Bearings are worn	Replace the bearings
	Poor mountings of pump	Mount the pump securely
	Crystallization of liquid	Remove the crystallization

7-12. Purge pump

1) Motor Connection
Connect the motor to the power supply so that the pump rotates in the rightward direction viewed from the pulley side.

2) Operation

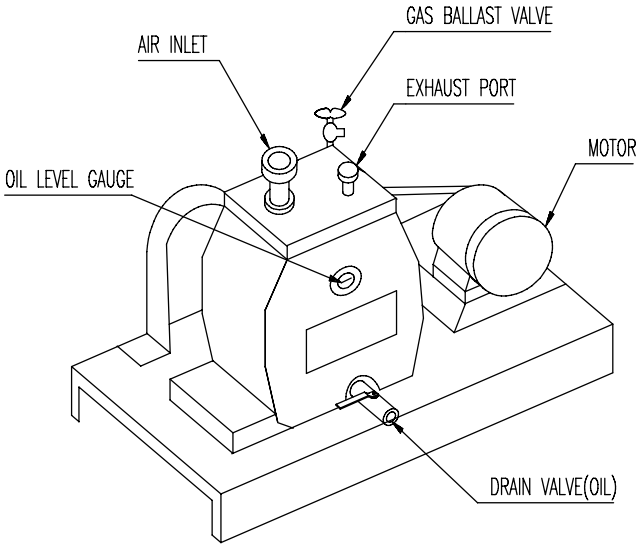


Fig. 7-24. Vacuum Pump Assembly

(1) Check before running

(a) Check the tension of V-belt.
Adjust the tension of V-belt to such extent that the belt can be twisted about 90 degrees when its middle part is picked up between your fingers and twiddled, of the belt is bent about its thickness when pressed with your fingers. The tension control is made by means of the slide base of motor.
(b) Open the gas ballast valve.
(c) Check an oil gauge to confirm that oil is in the pump.
Before the starting, it sometimes happens that the oil is in the cylinder, and the oil level is below the center of oil gauge.
Adjust the oil quantity so that the oil level comes nearly to the center of oil gauge during the operation of the pump. Where the oil quantity is small, remove the cap of the exhaust port and feed oil from here, while in the case of large oil quantity, draw out the oil from the drain.
(d) Use the designated pump oil or the rotary pump oil.

(2) Starting
Close the motor switch to start the pump. When the pump indicates heavy rotation, close the switch intermittently.

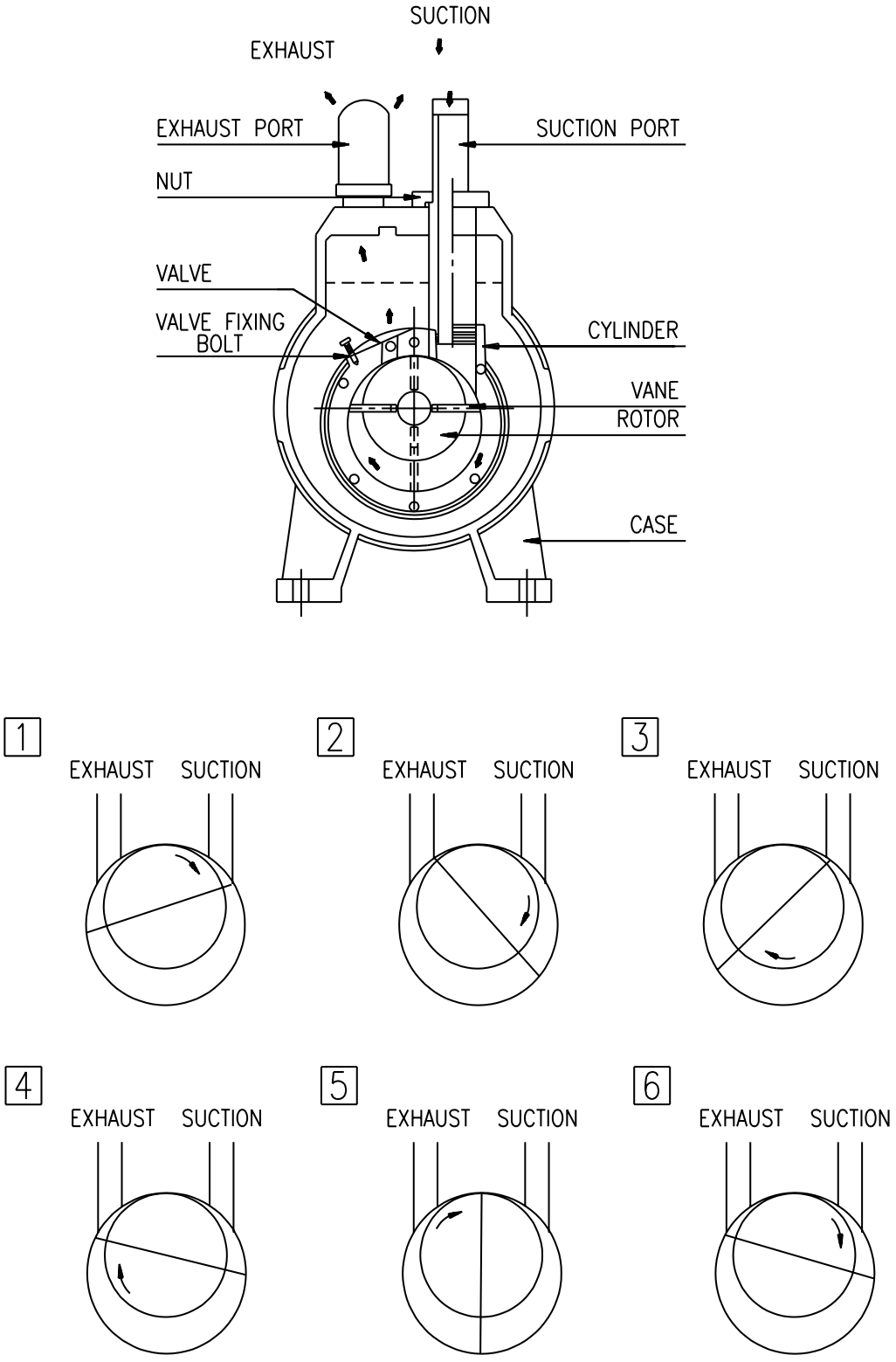


Fig. 7-25. Detail of Vacuum Pump Construction and Vacuuming Operation

(3) Stopping
Cut off the motor switch

(4) Steps to be taken during the power failure
Promptly take the following steps when the pump is suddenly suspended from operation because of power failure or the like.
(a) Close the suction side valve of the vacuum system.
(b) Cut off the motor switch

3) Maintenance

(1) Check the tension of V-belt from time to time, and make adjustment if the belt is prolonged. Ordinary rubber V-belt is damaged by moisture almost in no case, but is affected by oil or gasoline. It is necessary to carefully wipe off dust and dirt from the belt, from time to time.

(2) Pay attention to the quantity and discoloring of oil. Pressure is sometimes low even when the oil is stained. In general, however, the pressure goes up (become worse) in proportion to the degree of stain, and it becomes necessary to replace the oil in an extreme case. When exhausting a certain degree of condensing gas, it is possible to purify the oil by using ballast.

4) Diagnosis of Fault
Take the following steps when the equipment has gone wrong.

Table 7-7. Diagnosis of Fault

Condition	Check Point	Steps to be Taken
The motor alone rotates, but the pump does not run	In the tension of the belt adequate ?	Strain the belt
	Isn't a seizure caused by a foreign abject contained in the pump	Disassemble the machine and make repair
Noise is heard	Isn't the pump oil insufficient ?	Supply the pump oil
	Isn't the exhaust valve in fault ?	Replace the exhaust valve part
	Isn't the blade spring in trouble ?	Replace the blade spring
	Isn't a seizure caused by a foreign object contained in the pump ?	Disassemble the machine and make repair
Pump temperature is abnormally high	Is the tension of belt proper ?	Strain the belt
	Isn't the pump oil insufficient ?	Supply the pump oil
	Isn't a seizure caused by a foreign in the pump ?	Disassemble the machine and make repair
Low Degree of Vacuum	Isn't there any leakage in the equipment ?	Close the suction side vacuum valve, check the degree of vacuum of the pump alone, and stop the leakage.
	Isn't the pump oil stained ?	Replace the pump oil.
	Isn't the exhaust valve in fault ?	Replace the exhaust valve part.

All contents subject to change without prior notice

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