IWAKI WALCHEM
AIR DRIVEN BELLOWS PUMP
FH-40R-W02
INSTRUCTION MANUAL

IWAKI WALCHEM Corporation

INTRODUCTION

Thank you for selecting the FH-40R-W02 Pneumatic Bellows Pump. This pump is designed exclusively for pumping semiconductor grade, high purity liquids.

1. This instruction manual describes proper installation requirements, operating procedure, safety measures, inspection procedure, and troubleshooting. To ensure the safe and efficient use of the pump, please read this manual carefully before handling or operating the pump.

2. Employ full safety measures and precautions since this type of pump handles hazardous liquids such as strong acids.

3. To operate the pump, it is necessary to use a controller with adequate safety and control features and 5-port electromagnetic valve. Read the respective instruction manuals carefully.

Please ensure that the end user gets a copy of this manual for reference.

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SECTION **PAGE**

1 Unpacking and Inspection

Open the package and check that the product conforms to your order. Also check each of the following points. For any problem or inconsistency, contact Iwaki Walchem at once.

1. Check that the model number indicated on the nameplate conforms to the specifications of your order.

2. Check that the pump body and parts have not been accidentally damaged or that any bolts or nuts have not been loosened in transit.

2 Operating Principle

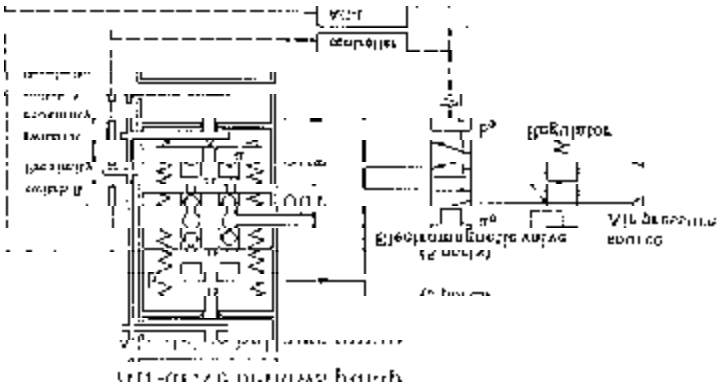


Figure 1

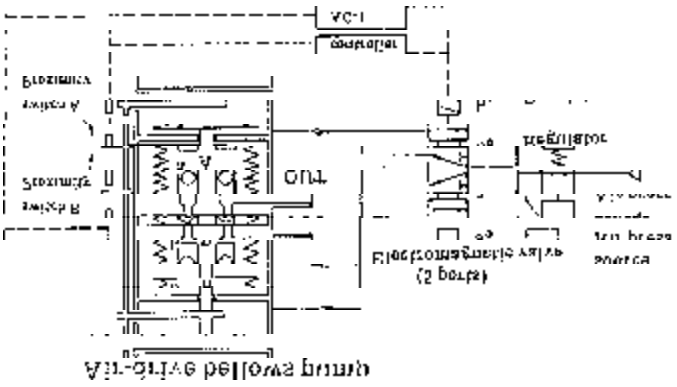


Figure 2

Refer to Figure 1. When pressurized air is supplied to chamber 'a' of the pump, bellows 'A' is compressed and fluid is discharged from the bellows thru the pump head outlet port. Simultaneously, bellows 'B' is extended and fluid is drawn into the bellows thru the pump head suction (inlet) port. Air is being exhausted from pump chamber 'b' during this process. When the 'B' bellows is fully extended, proximity switch 'B' is activated to signal the completion of this stroke to the controller system.

The controller system receives the input signal from proximity sensor 'B' and changes the output signal to the electromagnetic valve to switch it from the a_0 position to b_0 position.

Refer to Figure 2. Once the electromagnetic valve is in the b_0 position, pressurized air is supplied to chamber 'b' of the pump and the process outlined above is reversed. Fluid is discharged from bellows 'B' while bellows 'A' is in its suction stroke and air is exhausted from chamber 'a.' Upon completion of this pump stroke, proximity sensor 'a' is activated and the controller signals the valve to switch from the b_0 position to a_0.

With a constant air supply, this sequence is repeated continuously and the pump achieves a constant flowrate based on installation and operating conditions.

3 Identification Codes

1	2	3	4
FH-	**40**	**R**	**-S**

1. Series code: **FH**: Pump for high temperature liquid

2. Maximum discharge volume: **40**: 11.6 GAL/min (40 L/min)

3. Pump connection port (discharge port/suction port): **R:** 1" PFA tubing

4. Special specifications
   No symbol: Standard specification
   S: Special specification - **W02** Expanded temperature range version

4 Specifications

■ Pump Specifications

	Item	FH-40R-W02
General specifications	Max. discharge volume Note 1	11.6 GAL/min (40 L/min)
	Max. stroke speed	80 spm
	Liquid temp. range	68-320°F (20-160°C)
	Max. supply air pressure	28.6 PSI (2kg/cm²)
	Liquid-contacting material	PTFE/PFA
	Pump connection port	PFA 1" tubing (25 mm O.D. x 22 mm I.D.)
	Supply air connection port diameter	3/8" PT female thread
	Air consumption	50-250 NL/min (1.8-8.8 cfm)
Proximity sensor specification	Type	High frequency oscillation type prox. switch
	Output system	NPN open collector output
	Output capacity	Max. 200 mA
	Line voltage	10-30 VDC
	Protective structure	1P67
	Interelectrode voltage	AC6V ±10%
Leak sensor		

Note 1: The maximum discharge volume is based on pure water at room temperature.

■ Dimensions/Mass

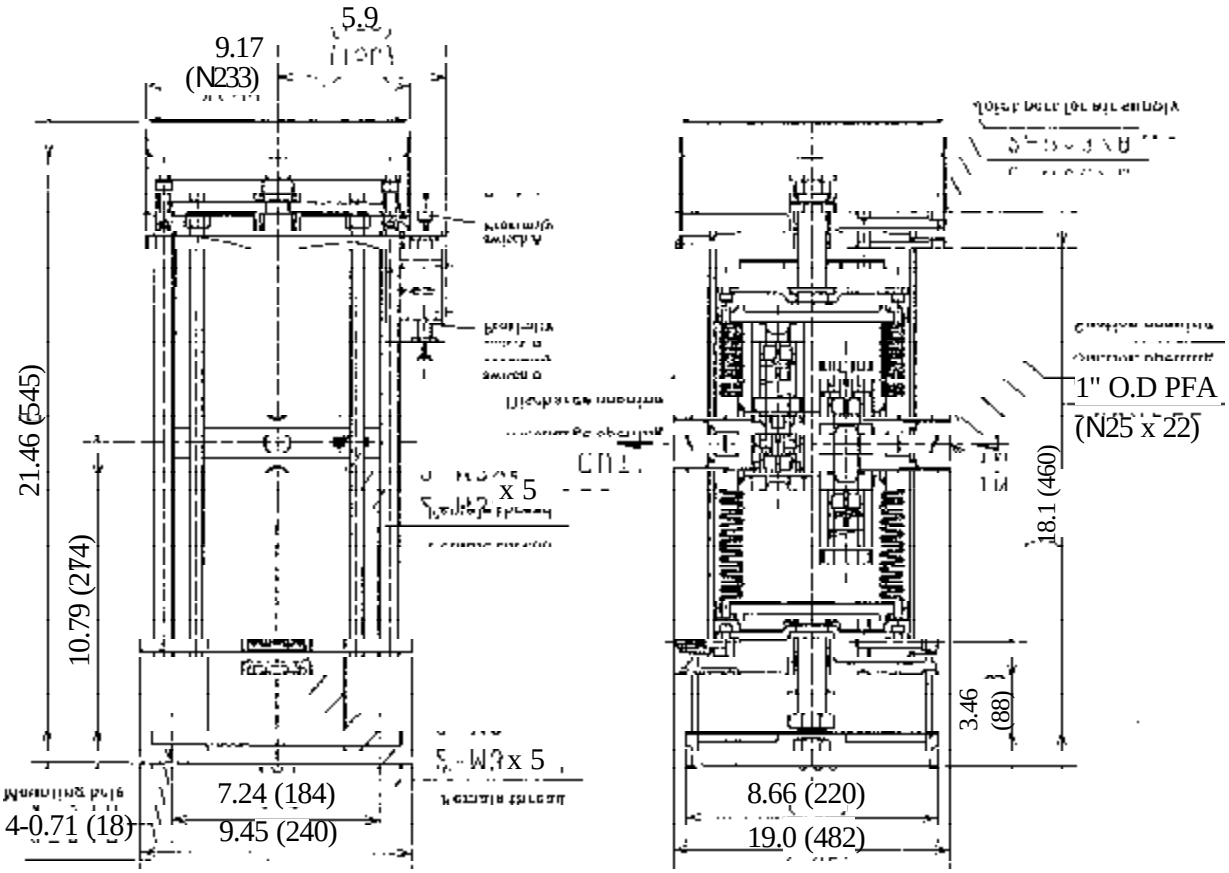


Figure 3

Pump Mass: 48.5 lbs (22 kg)

■ Exploded View and Parts List

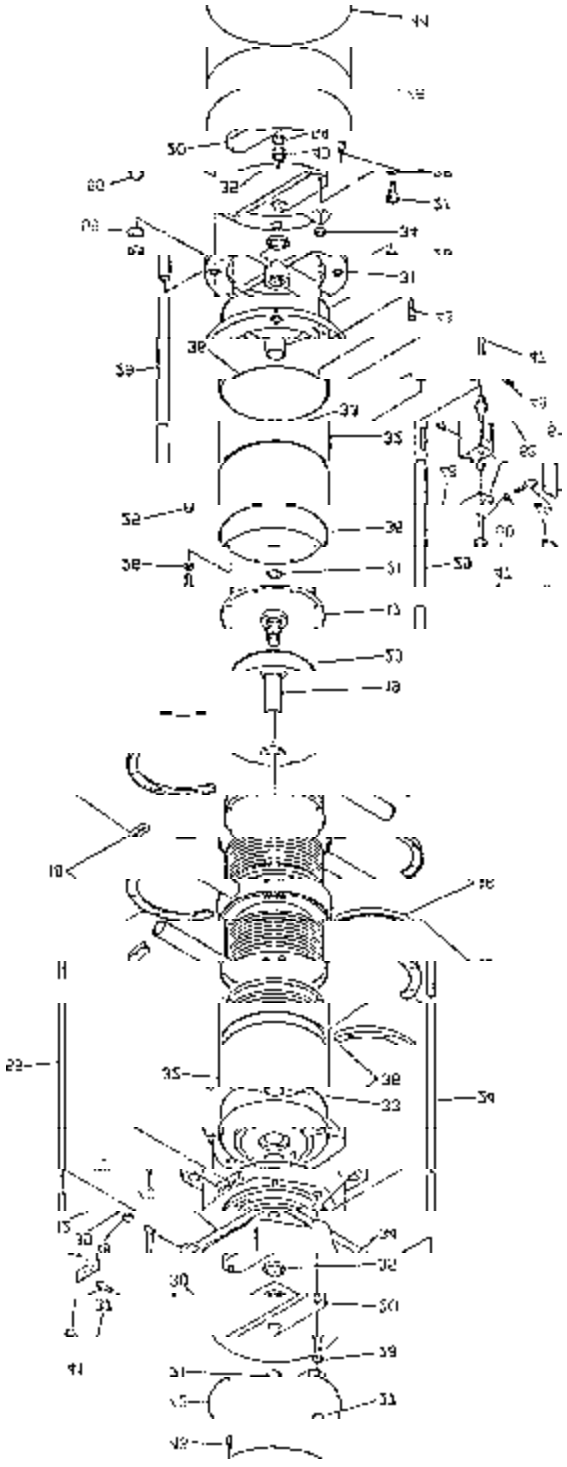


Figure 4

No.	Part Name	Qty	Material	Remarks
1	Pump head	1	PFA/PTFE	TG-70J
12	Electrode bar B	2	SS	
17	Bellows plate	2	SS	
18	Split flange	4	SS	
19	Pump shaft A	2	SS	
20	Arm	2	SS	
21	C-shaped retain ring	4	SS	
22	Oring	2	FKM	
23	Oring	2	FKM	
24	Pump shaft B	2	SS	
25	Hex socket bolt	16	SS	M6x20
26	Spring washer	16	SS	M6
27	Hex socket bolt	4	SS	M8x25
28	Spring washer	4	SS	
29	Shaft cover	2	SS	
30	Cover A	1	AC4C-T6	PTFE coated
31	Cover B	1	AC4C-T6	PTFE coated
32	Cylinder	2	A6063	PTFE coated
33	Bearing A	2	PTFE	
34	Bearing B	4	PTFE	
35	Rod packing	2	FKM	
36	Oring	4	FKM	
37	Electrode bar holder	1	PVC	
38	Gasket B	2	PTFE	
39	Oring	2	FKM	S-10
40	Hex nut	2	SS	M20
41	Hex socket bolt	2	SS	M4x10
42	Plate	1	SS	PTFE coated
43	Small machine screw	6	SS	M3x6
44	Cover C	1	SS	PTFE coated
45	Small machine screw	4	SS	M5x8
46	Small machine screw	4	SS	M3x20
47	Proximity switch	2		15' cord
48	Hex scket stop screw	2	SS	M3x6
49	Holder cover	1	Clear PVC	
50	Switch holder	1	PVC	
51	Detection plate	1	SS	
53	Hex nut	1	SS	M3
54	Stud bolt	4	SS	PTFE coated
55	Cap nut	4	SS	PTFE coated
56	Disc spring	4	SS	PTFE coated

5 Handling Precautions

For reliable pump performance to suit your application needs, full safety measures should be taken for the pump unit and entire system. The following information, including the points to be observed in the handling of the pump, deal with measures to ensure safe operation of the system. Please read the precautions carefully.

To operate this pump, a 5-port solenoid valve and a controller (Iwaki model or host PLC) are required. In addition, to enhance system safety, a quick exhaust valve is recommended.

No.	Points to be Observed	Description
1	Pump stroke speed. Do not run pump above 80spm (40 cycles).	• If air bubbles are sucked through the pump port, the pump is put into a state of air locked operation & the number of strokes rises to an abnormal level. Safety measures should be taken in the system so that the pump does not run at a speed above maximum stroke speed.
2	Supply air pressure should not exceed 28.6 PSI (2kg/cm^2).	• Any fluctuation in pressure of supplied air causes change in discharge. Install a regulating valve to stabilize pressure. • Based on the back-pressure resistance of the filter and plumbing system at temperature, regulate supply air pressure below max. settings for longer life and protection of the bellows. • Maintain the differential pressure (supply air vs. dis charge pressure) below 14 PSI (1 kg/cm2) to maximize pump service life.
3	Liquid temperature range.	• Temp. of liquid must be maintained within the specified temperature range of 68°-320F (20-160°C)
4	Prohibited liquids Caution! The following liquids must not be used: • Liquids that are easily crystallized. • Liquids containing slurry. • Solvent type liquids. • Stripper liquids.	• Service life of the valve & bellows is shortened by liquids that are easily crystallized or contain slurry. Use of such liquids is not recommended. • If solvent type liquid (including naphtha) is used., electrostatic destruction may be generated between fluoroplastic & liquid, eventually producing pinholes. • Some types of stripper liquid may cause cracks in the bellows or piping (PFA) at an early stage. • Consult factory for warranty information for these fluids.
5	When stopping pump operation, first open pump discharge & then shut off supply air pressure.	Warning! Stopping pump without releasing pressure on the pump discharge side may result in bellows deformation due to the force of hydraulic pressure remaining on the pump discharge plumbing.

No.	Points to be Observed	Description
6	Do not suspend pump operation for extended periods with liquid remaining in the pump chamber.	Warning Suspending pump operation for extended periods with liquid remaining inside the pump chamber may allow permeation of gas from the liquid into the air chambers and piping. This may cause corrosion of pneumatic components.To prevent this problem, freshen air in the air chamber to remove permeating gas build-up. (E.G., if pump operation is suspended for 2 to 3 days, run pump for 10 minutes daily to replace air.)
7	Handle proximity sensor cables with care.	When wiring or adjusting sensor, take care not to twist or bend cable excessively as this may cause damage to the switch connection.

■ Safety measures for the entire system

No.	Measure	Description
1	Monitoring operation condition	• Use monitor, etc., to inspect running condition of system daily or periodically.
2	Take advance precautions against pump abnormality and carry out daily and other periodic inspections.	Warning! If bellows are damaged during the pumping operation, dangerous liquid could splash out of the unit, creating a hazardous condition for operator(s) and the facility near the system.
3	Use humidity-free clean instrument-ation air as supply air.	• Supply air mixed with water, oil or dust may the affect smooth and normal functioning of the pump. Excessive water in the pump air chamber section may be detected by a leak detection sensor, leading to an alarm condition..
4	Use appropriate filter for the pump.	• When selecting an appropriate filter, carefully examine the filtering area, grain-blocking capacity and flow rate characteris-tics. Some filters, depending on structure, may have low air bleeding performance and greatly affect capacity. Also pay attention to liquid viscosity, which may significantly influence flow rate.
5	Do not restrict air exhaust port.	Caution! Do not restrict the air exhaust port of the pump and/or pneumatic system, keep exhaust lines as short as possible. The bellows may be deformed as a result of excessive pneumatic pressure. Quick exhaust valves are recommended.
6	Do not supply air to both right & left air supply ports when pump operation is suspended.	Warning! If air is supplied simultaneously to two chambers on right & left sides while pump operation is suspended, bellows are pressurized & will become deformed. • Some types of double solenoid electromagnetic valves cause pressurization of the two air chambers while the valve is not conducting.

■ Liquid Circulation Safety System

In typical semiconductor wet process liquids, a catalyst such as H_2O, O_3 or H_2O_2 is added to the process liquid. The subsequent reaction generates heat and produces extreme gassing of the liquid. Measures should be taken to reduce the amount of gas laden liquid which can enter the pump chambers. Excessive gas can cause an air lock condition for the pump which may increase the pump stroke rate to excessive levels.

For the safe and efficient circulation and feeding of liquid, it is necessary to carry out air elimination and take proper safety measures.

Air elimination technique

When air enters the bellows and the pump is air locked, the pump stroke speed increases. If the increase is excessive, that is, higher than the specified pump stroke speed, stop the pump or carry out air elimination.

Plan A (Bubbles are blocked by means of blocking board)

1. In case of flooded suction system

   A blocking board is set in the overflow tank to separate bubbles from the liquid, thus eliminating the air content.

2. In case of suction lift system

   A blocking board is set in the lower level in the reaction tank. The top of the suction port tube is positioned under the blocking board so that bubbles are not sucked in together with the liquid.

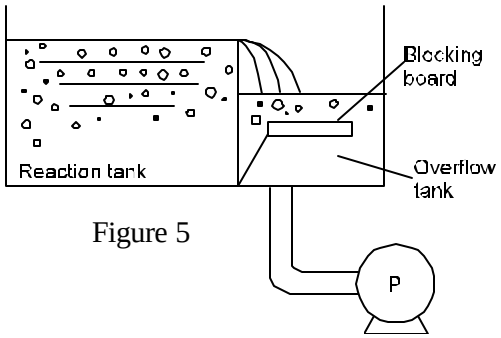


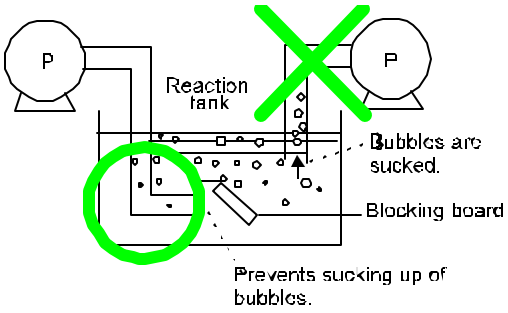
Figure 5

Plan B (Automatic air elimination with auto valve installed)

1. Regardless of the occurrence of air locking, continuous automatic air elimination is executed in the entire system. For example, the air elimination process is activated every 2 minutes after the start-up of the pump by opening the auto valve for 10 seconds.

   Note 1: Some filters have diameters too small for air elimination. Take the diameter into consideration when selecting a filter.

Figure 6



Note 2: Determine the open period of the auto valve on the basis of the system performance.

2. If the conditions under which bubbles are mingled remain the same, an air elimination technique which fits well with such conditions may be applicable. For example, if bubbles are generated only when feeding H202, open the auto valve to carry out air elimination only when H202 is fed.

3. Another technique is to install an air detection sensor in the suction port area, so that the auto valve is automatically opened by a signal sent out from the sensor and the air elimination operation is executed.

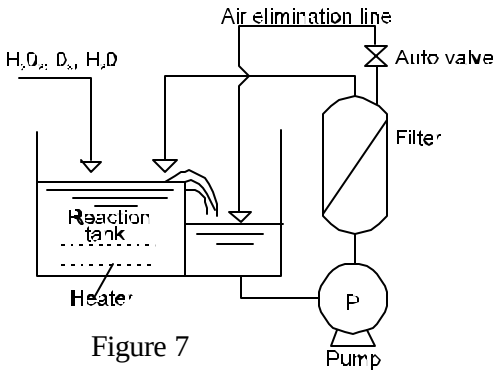


Figure 7

Installing another air detection sensor on the discharge side is effective in preventing air from entering in the event of bellows damage.

System Safety Measures

- Observe the upper limit of the stroke speed.
  Keep the stroke speed within the specified maximum stroke speed of 80 spm (120 cycles).

- Safety measure on exhaust side
  Install a quick exhaust valve to protect the inside of the electromagnetic valve from corrosion by the permeated gas.

- Safety measure in piping
  Install a pulse dampener to reduce the vibration of the discharge side piping.

6 Installation, Piping and Wiring

■ Installation

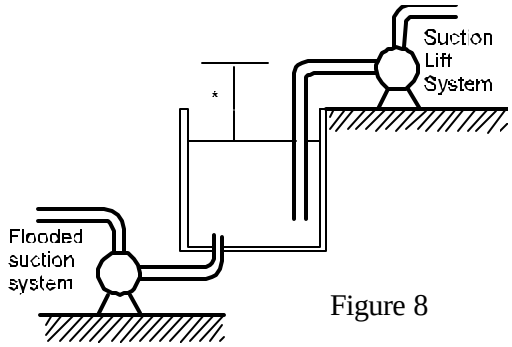


Figure 8

1. Pump installation position
   - In case of flooded suction system set the pump as close to the liquid supply tank as possible.
   - In case of suction lift system set the suction side piping in accordance with the self- priming capacity and as close to the liquid supply tank as possible.

   * Self-priming capacity: 6.4 ft (2m) (water at 70°F)

2. Installation foundation
   Select a flat and rigid foundation (such as a chassis) for installation, to avoid twisting motion or vibration.

3. Direction of pump
   Fasten base of pump firmly to floor of the cabinet. Pump design is vertical with suction and discharge ports 180 degrees apart on center of pump head.

■ Piping

Carry out piping in accordance with the following description.

Piping on liquid supply side and air supply side

The standard tubes for both the discharge and suction ports are PFA tubes. Connect the tubes as described below.

1. Carry out sufficient air blowing or flushing of tubes to get rid of foreign matter inside the tubes, prior to connecting them with the pump.

2. Tube connection should be done such that the extra load of piping is not applied to the pump. Use pipe supports as necessary to prevent the vibration and heat generated along the piping from reaching the pump.

3. The joints on the pipe should be assembled carefully, to prevent liquid leakage, air leakage, and air suction.

4. General couplings purchased in the market may be used in the piping. However, they must be designed to be reliable against leakage in such operations as high-temperature feeding or heat cycle operation.

Piping on liquid supply side

1. Pump port diameters and materials
   The standard material of the pump discharge port and suction port is PFA tube. The applicable tube diameters are as follows.
   * Tube diameters: 1" O.D.
   Use tube fittings with diameters corresponding to those of the tubes. (See the figure on the right.)

   • The diameter of the piping side tube should be larger than those of the discharge and suction ports.

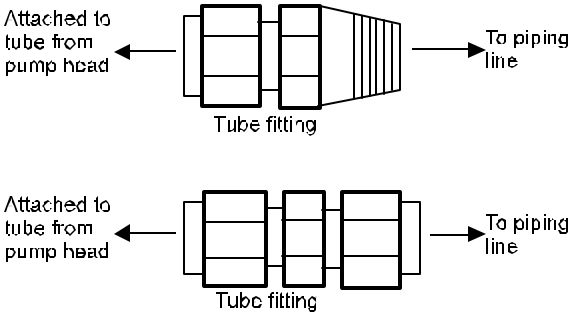


Figure 9

2. The length of the pipe should be as short as possible, to minimize piping resistance. The number of bends, couplings and valves installed along the piping should be minimized, to keep the piping resistance as low as possible.

3. Design the piping to absorb linear expansion and thus prevent thermal stress onto the pump.

Piping on air supply side

1. Diameter of pump connection port.
   The diameter of the connection port on the air supply side is as follows.
   * Connection port diameter: 3/8" PT

   • The diameter of the piping side tube should be larger than those of the pump connection port.

2. Install a relief type regulating valve.

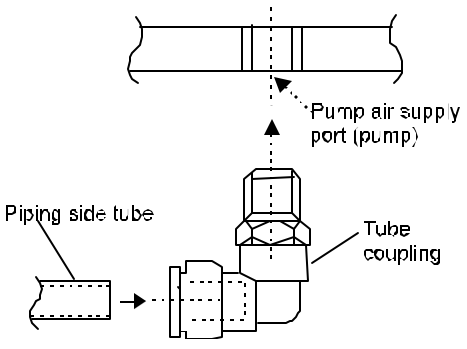


Figure10

Fluctuation of supply air pressure results in fluctuation of the pump stroke as well as discharge volume. Install a regulating valve to maintain the air pressure at a fixed level.

3. Install a safety valve.
   Install a safety valve to prevent the supply air pressure from exceeding 28 PSI.

4. Installation positions of regulating valve and electromagnetic valve.
   Install these valves as close to the pump as possible, in consideration of operating efficiency and pressure loss. Be sure to select valves that meet the air consumption rate of the pump. All pneumatic components should be full port, unrestricted style.

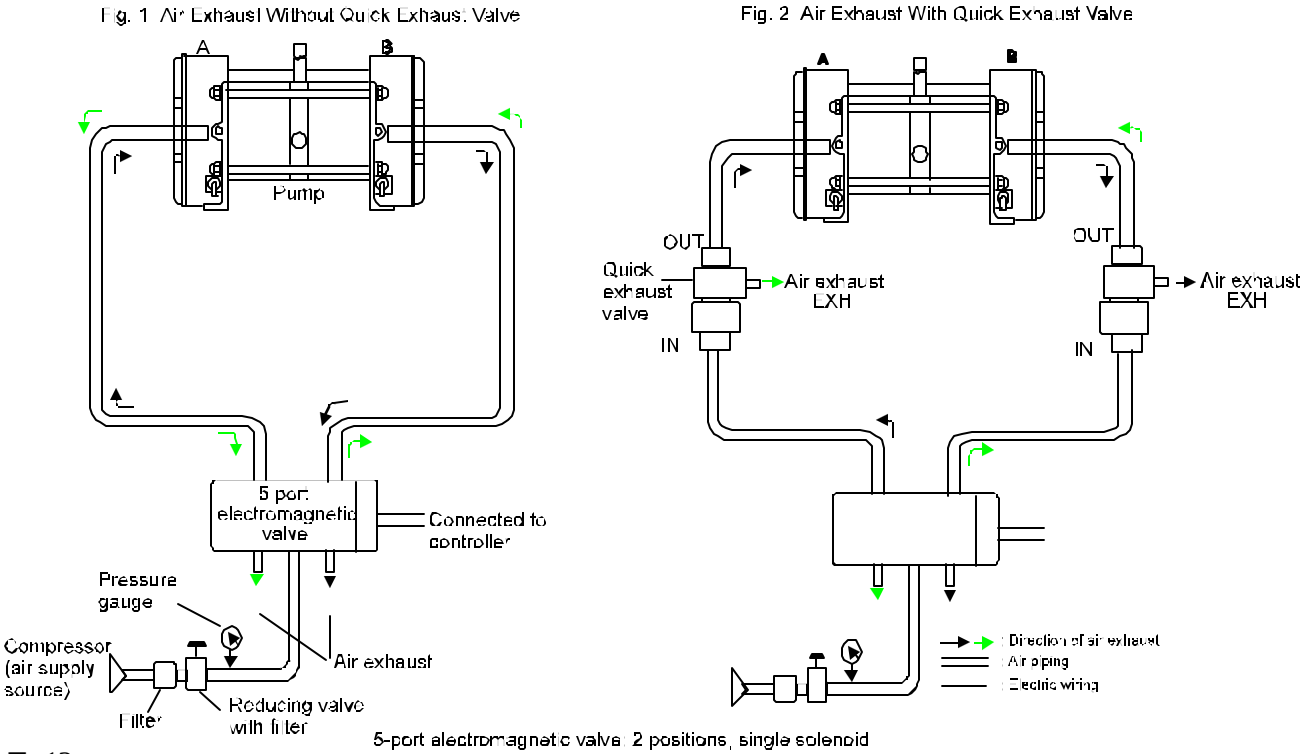
5. Installation of air exhaust port
   The exhaust ports of the air circulation system and the electromagnetic valve must be installed in correct positions so that the exhaust air is released into the open air.

6. Measure to minimize air exhaust
   To minimize the noise of air exhaust, connect the exhaust port with a duct or attach a silencer on the exhaust port.

7. Installation of multiple pumps
   The air consumption of pumps (the total consumption by all the pumps installed) increases in relation to the compressor capacity. The diameter of the pipe must be determined taking into consideration the total number of pumps.

8. Recommended use of quick exhaust valve
   As shown in Figure 1, the air exhausted out of the pump flows out of the system via the exhaust port of the electromagnetic valve.

Figure 11



5-port electromagnetic valve 2 positions, single solenoid

Depending upon the type of liquid applied, some permeated gas may be mixed into the exhaust air. (The inside of the electromagnetic valve may be corroded by such permeated gas, becoming useless to the system.) In such a case, install a quick exhaust valve between the pump and the electromagnetic valve. The air will be exhausted through the exhaust port of the quick exhaust valve, as shown in Figure 2. (A limited amount of air will be exhausted through the electromagnetic valve.)

■ Connection instructions

1. The quick exhaust valve has the directions of IN, OUT, and EXH. (The direction symbols are stamped on the valve.)

* The pump unit itself can be operated without a quick exhaust valve. However, keep air exhaust lines as short as possible with no restrictions.

2. The 5-port electromagnetic valve (or selector valve) has the directions of IN and OUT. (The direction symbols are stamped on the valve.)

3. Use air piping tubes with inner diameters larger than 3/8" I.D. (10mm) for the piping between such devices as the 5-port electromagnetic valve and the regulating valve with filter.

4. The discharge volume of the pump can be adjusted by adjusting the supply air volume which changes the pump stroke speed. The air piping system (composite effective cross-sectional area) must be arranged such that the required air volume is secured.
   - Composite effective cross-sectional area (standard value) S= 19.5mm^2 or larger
   - Composite effective cross-sectional area is calculated by the following equation.

$$\frac{1}{S^2} = \frac{1}{S1^2} + \frac{1}{S2^2} + \cdots + \frac{1}{Sn^2}$$

S = Composite effective cross-sectional area
Si = Effective cross-sectional area of each part

Wiring for 5-port electromagnetic valve

The electromagnetic valve has no polarity. Some types with a built-in surge killer have polarity, which requires special attention in the connection process.

Caution! As a rule, the 5-port electromagnetic valve has no polarity, though there are exceptions. If a 5-port electromagnetic valve with polarity is used, be careful about the +/- polarity in wiring. Note that faulty polarity selection may result in the shorting of the solenoid section of thevalve.

Note: The air piping of the 5-port electromagnetic valve is divided into the 'normal-open' side pipe and 'normal-closed' side pipe. The ‘normal-open’ side should be installed on the proximity switch A side and ‘normal-closed’ on the proximity switch B side. The controller system should be wired accordingly to switch air from chamber 'a' and 'b' in response to signals from the respective proximity sensors. The pump does not run if the above connection is incorrect. To run the pump, interchange the air piping of the 5-port electromagnetic valve or interchange the wires of proximity switches A and B.

■ Wiring instructions

1. Wires

Wires (approximately 1m) of the proximity switch and stud bolts for the leak detection electrode are provided with the pump. However, no other connection wires are attached with the product.

Wire Application	Power Specification
For controller power	115V, 0.24A or above
For connecting 5-port electromagnetic valve & controller	24V, 0.24A or above

A. Extension of electrode wire

Keep the resistance value at 5kohms or below. A resistance greater than the above may make it impossible to detect a conductivity change between the leak detection electrodes. (This is dependent on the controller system.)

B. Wiring of proximity switch

Isolate the wires of the proximity switch from the power line or other high-voltage cable. They should not be installed in the same duct or in the same cable tube, otherwise the switch may malfunction. When extending the wire, if it is not extended beyond 30m, use a wire of 0.3mm^2 or above. If the extension is for more than 30m, use a wire with a conductive resistance of 100 ohms/km or less.

7 Operation and Inspection

During the trial run of the pump, flush the unit and piping at the same time. Following is a description of the operation and adjustment of the pump using the Iwaki AC-1 controller. (For pump operation using the AC-3, FD-1, or SC-I type controller, refer to the instruction manual of the selected controller.)

■ Operation procedure

Pump start-up

1. Turn on the power switch of the controller.

2. Supply air to the pump.
   Open the air supply valve (fully) to supply air. The pump will start operation and the 'Operation indicator' LED (blue) on the controller will start flashing.

Pump stopping

1. Suspend the air supply.
   Release the pump discharge side pressure. Then, close the air supply valve to suspend the air supply.

2. Turn off the power switch of the controller.
   The pump will stop operation and the 'Operation indicator' LED will go out.

■ Adjustment of discharge volume

1. The discharge volume can be adjusted by increasing or decreasing the air supply volume. (The increase or decrease of air supply volume controls the pump stroke speed, thus finally controlling the discharge volume.)

2. Adjustment method
   Control the reducing valve until the desired discharge volume level is reached.

Warning! Never control the stroke rate of the pump by restricting air exhaust. Premature pump failure will result.

■ *Trial run*

Observe the following points when running the pump for the first time after installation.

1. Check repeatedly whether the piping and the wiring are correct. Faulty wiring, with the proximity switch in particular, may cause damage to components.

2. Carefully inspect the joints in the piping as well as the pump unit. If everything is normal, start the trial run.

* Make sure the trial run is done with pure water.

■ Points to be observed when operating pump

If the trial run of the pump has proved the system to be normal, start the actual operation. Pay attention to the following points during operation.

No.	Inspection Point	Remarks
1	Is pump stroke speed at specified level?	Must be 80spm (40 cycles) or below.
2	Is air pressure kept normal?	Must be 28 PSI or less.
3	Is air volume enough?	Use of air reducing valve recommended.
4	Is there is any leakage in sealed section of air piping or liquid piping?	Inspect periodically.
5	Is supply air clean?	Use clean, dry instrumentation air.

8 Causes of Trouble and Troubleshooting

Trouble	Causes	Countermeasures
Pump does not operate.	• Bellows are deformed or damaged (Alarm) • Supply air pressure or air flow rate is reduced. Compressor failure. Air filter is clogged or air leaks from pipe. • Faulty selection of electromagnetic valve. • Faulty wiring or disconnection. • Galling or damage to pump shaft. • Increased discharge pressure in liquid feeding pipe.	▫ Inspect and replace.* ▫ Set back to initial value (Reset). ▫ Inspect & repair or recheck capacity. ▫ Inspect & clean or repair. ▫ Inspect & rearrange wiring. ▫ Inspect & replace. ▫ Inspect & replace filter.
Pump operates but no liquid is discharged.	• Bellows or valve is clogged with foreign matter (such as fragments of wafer, etc.) • Wear of valve and/or valve seat. • Air suction through suction pipe.	▫ Inspect & repair assembly. ▫ Inspect & repair.* ▫ Tighten pipe couplings.
Discharge volume is reduced.	• Supply air pressure or air volume is reduced. Compressor failure Pressure setting of regulatinging valve is incorrect. Air filter is clogged or air leaks from pipe. • Wear of valve or valve seat. • Insufficient NPSHa • Increased discharge pressure • Inside of bellows or valve is clogged with foreign matter.	▫ Set back to initial set value (Reset) or recheck capacity. ▫ Reset pressure. ▫ Inspect & clean or repair. ▫ Inspect & replace. ▫ Inspect suction condition. ▫ Inspect dischargecondition. ▫ Inspect & replace
Liquid leaks	• Insufficient fastening of stud bolts. • Bellows are damaged.	▫ Tighten bolts. ▫ Inspect & replace.*
Excessive air consumption	• Wear of shaft packing.	▫ Replace shaft packing.
Excessive vibration and/or noise.	• Insufficient anchoring of base. • Bellows are deformed.	▫ Fasten anchoring bolts. ▫ Inspect & replace.

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