WATO EX-20/30/35 Anesthesia Machine

Service Manual

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Revision History

This manual has a revision number. This revision number changes whenever the manual is updated due to software or technical specification change. Contents of this manual are subject to change without prior notice. Revision 1.0 is the initial release of the document.

- Revision number: 6.0
- Release time: 2012-11

Preface

Manual Purpose

This manual provides detailed information about the assembling, dissembling, testing and troubleshooting of the equipment to support effective troubleshooting and repair. It is not intended to be a comprehensive, in-depth explanation of the product architecture or technical implementation. Observance of the manual is a prerequisite for proper equipment maintenance and prevents equipment damage and personal injury.

This manual is based on the maximum configuration. Therefore, some contents may not apply to your monitor. If you have any question, please contact our Customer Service Department.

Intended Audience

This manual is geared for biomedical engineers, authorized technicians or service representatives responsible for troubleshooting, repairing and maintaining the anesthesia machines.

Password

A password is required to access different modes within the anesthesia machine.

- Manage Configuration: 1234
- Factory maintenance: 0611

Contents

1 Safety

1.1 Safety Information

⚠ DANGER

- **Indicates an imminent hazard that, if not avoided, will result in death or serious injury.**

⚠ WARNING

- **Indicates a potential hazard or unsafe practice that, if not avoided, could result in death or serious injury.**

⚠ CAUTION

- **Indicates a potential hazard or unsafe practice that, if not avoided, could result in minor personal injury or product/property damage.**

NOTE

- **Provides application tips or other useful information to ensure that you get the most from your product.**

1.1.1 Dangers

There are no dangers that refer to the product in general. Specific “Danger” statements may be given in the respective sections of this manual.

1.1.2 Warnings

⚠WARNING

- **This equipment must be installed by factory authorized engineers and adequate training of its use should be delivered to its user before it is put into use.**
- **There is high voltage inside the equipment. Never disassemble the equipment before it is disconnected from the AC power source.**
- **This equipment can be disassembled by Mindray trained and authorized personnel only.**
- **Be sure of static discharge before disassembling the equipment. Wear antistatic wrist straps or gloves when disassembling the parts labelled with static-sensitive symbolsto avoid damage to the parts.**
- **The equipment must be connected to a properly installed power outlet with protective earth contacts only. If the installation does not provide for a protective earth conductor, disconnect it from the power line.**
- **Dispose of the packaging materials, observing the applicable waste control regulations and keeping it out of children’s reach.**

1.1.3 Cautions

⚠CAUTION

- **Make sure that no electromagnetic radiation interferes with the performance of the equipment when preparing to carry out performance tests. Mobile phone, X-ray equipment or MRI devices are a possible source of interference as they may emit higher levels of electromagnetic radiation.**
- **Before connecting the equipment to the power source, check that the power source conforms to the requirements specified in the Operator’s Manual.**

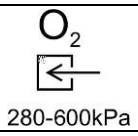
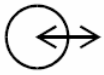
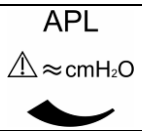
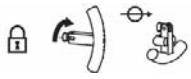
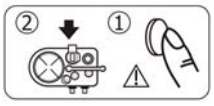
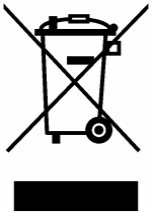
1.1.4 Notes

NOTE

- **Refer to Operator's Manual for detailed operation and other information.**

1.2 Equipment Symbols

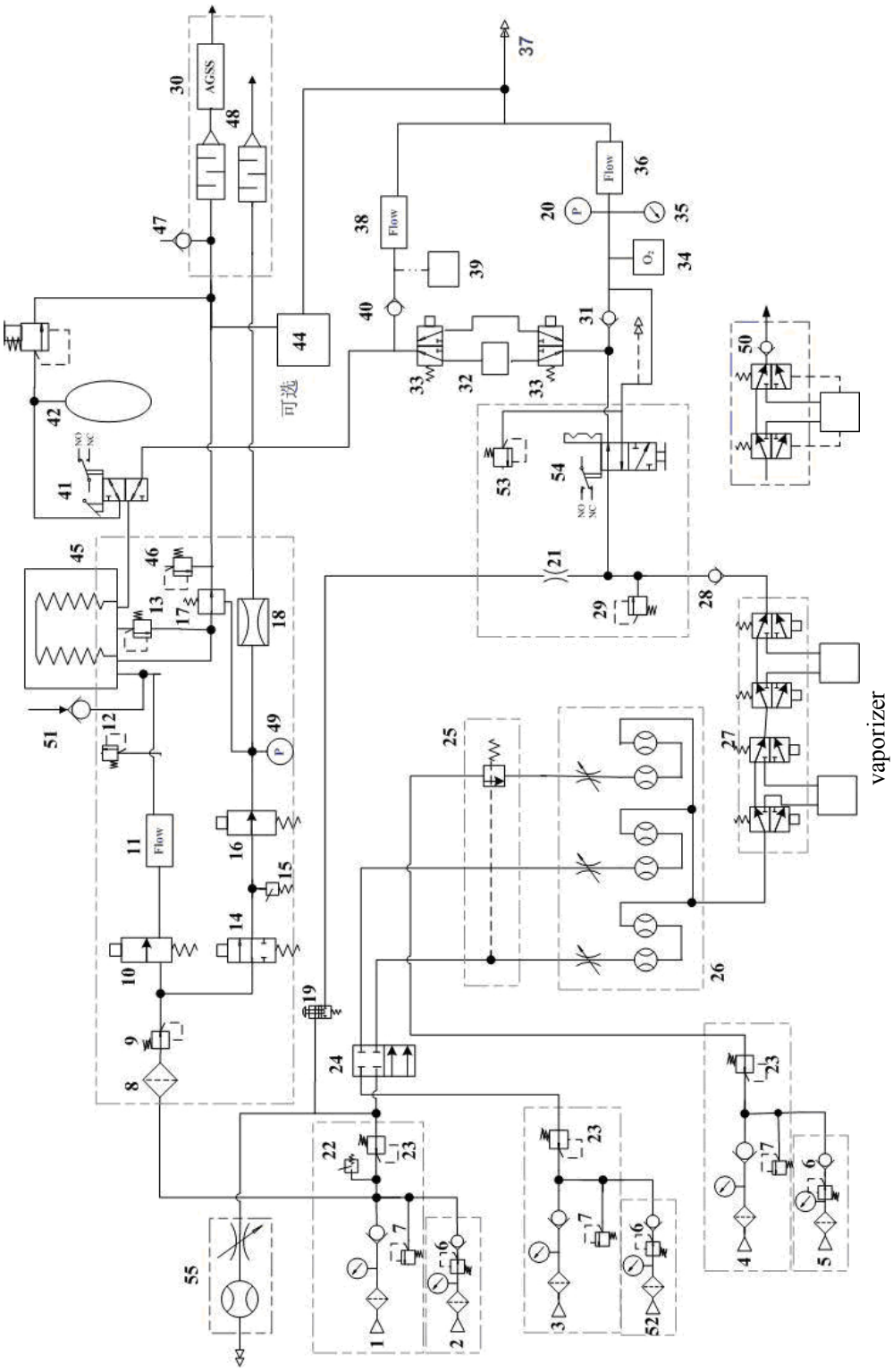
	Attention: Consult accompanying documents (this manual)		Consult Operator's Manual
	Alternating current		Fuse
	Equipotential		Autoclavable
	Pipeline		Not autoclavable
	Standby key		Network connector
	Power On		Power Off
	System On		System Off
	Silence key		MV&TVe alarm off key
	Menu key		O_2 flush button
	ACGO On		ACGO Off
	Bag position/ manual ventilation		Mechanical ventilation
	O_2 sensor connector		Flow control
	Air supply connector		N_2O supply connector

	Cylinder		O_2 supply connector
	Manufacture date		AGSS connector
	Manufacturer		DB9 connector
	APL valve		Vaporizer
	Maximum level of the CO2 absorbent canister		Isolation transformer
	Gas flow direction		Serial number
	Lock the lifting device		Lock or unlock as the arrow shows
	Approximate		Unlock the lifting device
	Max. weight: 30 kg		Upward (Pop-Off valve)
	Disassemble the breathing circuit as shown in the figure		Do Not Crush
	Type BF applied part. Defibrillation-proof protection against electric shock.	AIR DRIVE	Driven by air
	The following definition of the WEEE label applies to EU member states only. This symbol indicates that this product should not be treated as household waste. By ensuring that this product is disposed of correctly, you will help prevent bringing potential negative consequences to the environment and human health. For more detailed information with regard to returning and recycling this product, please consult the distributor from whom you purchased it. * For system products, this label may be attached to the main unit only.		

2 Theory of Operation

2.1 Gas Flow

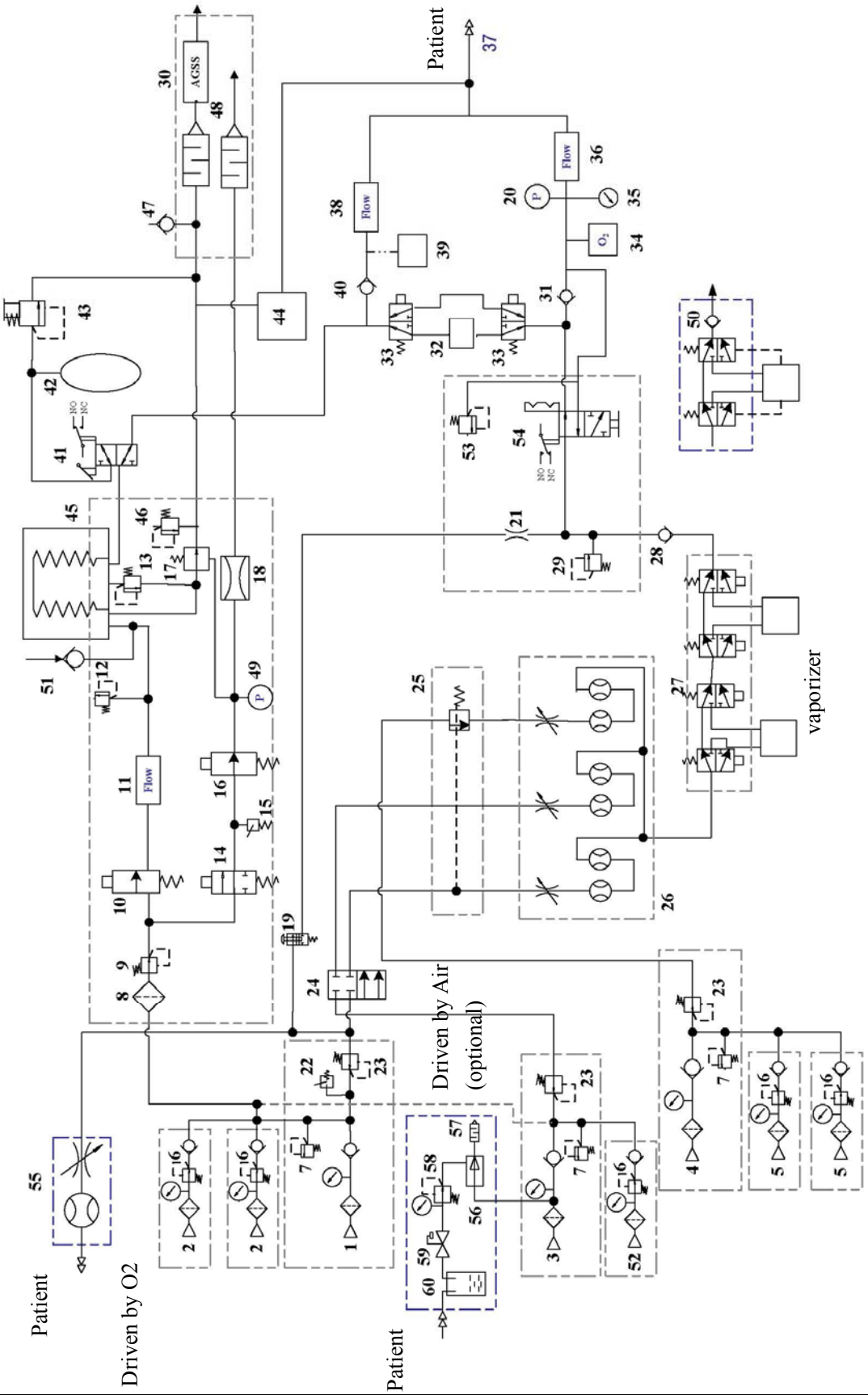
2.1.1 Pneumatic Circuit Diagram(without 4-yoke configuration)



2.1.2 Parts List

1	O2 pipeline connector	29	Pressure relief valve (37.9 kPa)
2	O2 cylinder connector	30	AGSS
3	Air pipeline connector	31	Inspiratory check valve
4	N2O pipeline connector	32	CO2 absorbent canister
5	N2O cylinder connector	33	Bypass
6	Cylinder regulator (400 kPa)	34	O2 sensor
7	Pressure relief valve (758 kPa)	35	Airway pressure gauge
8	Drive gas inlet filter	36	Inspiratory flow sensor
9	Regulator (200 kPa)	37	Patient
10	Inspiratory flow control valve	38	Expiratory flow sensor
11	Inspiratory flow sensor	39	Water collection cup
12	Mechanical pressure relief valve (110 cmH2O)	40	Expiratory check valve
13	Pop-Off valve	41	Bag/mechanical ventilation switch
14	PEEP safety valve	42	Manual bag
15	Drive gas pressure switch (140 kPa)	43	APL valve
16	Proportional PEEP valve	44	Gas monitoring module
17	Expiratory valve	45	Bellows
18	Pneumatic resistor	46	Mechanical pressure relief valve (1 kPa,10 cmH2O)
19	O2 flush button	47	Negative pressure check valve (1 cmH2O)
20	Pressure relief valve	48	Gas reservoir
21	Flow restrictor	49	Pressure sensor
22	O2 supply pressure switch (200 kPa)	50	Single-vaporizer manifold
23	Regulator (200 kPa)	51	Free breathing check valve
24	System switch	52	Air cylinder connector
25	O2-N2O cut-off valve	53	Pressure relief valve
26	Flowmeter module	54	ACGO selector switch
27	Double-vaporizer manifold	55	Auxiliary O2 supply
28	Check valve	/	/

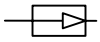
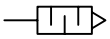
2.1.3 Pneumatic Circuit Diagram(with 4-yoke configuration)



2.1.4 Parts List

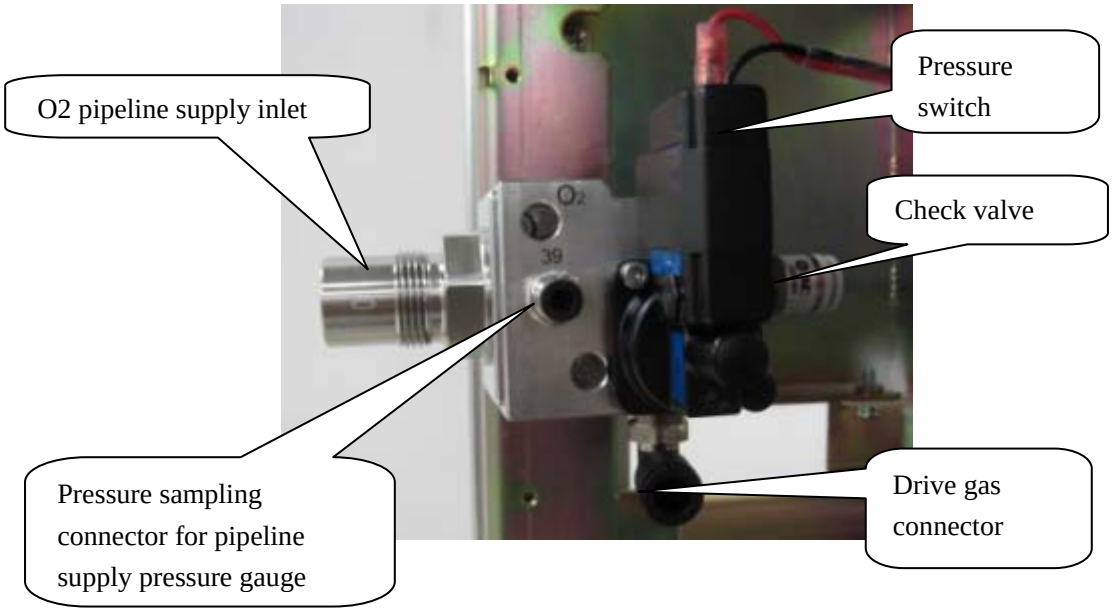
1	O2 pipeline connector	31	Inspiratory check valve
2	O2 cylinder connector	32	CO2 absorbent canister
3	Air pipeline connector	33	Bypass
4	N2O pipeline connector	34	O2 sensor
5	N2O cylinder connector	35	Airway pressure gauge
6	Cylinder regulator (400 kPa)	36	Inspiratory flow sensor
7	Pressure relief valve (758 kPa)	37	Patient
8	Drive gas inlet filter	38	Expiratory flow sensor
9	Regulator (200 kPa)	39	Water collection cup
10	Inspiratory flow control valve	40	Expiratory check valve
11	Inspiratory flow sensor	41	Bag/mechanical ventilation switch
12	Mechanical pressure relief valve (110 cmH2O)	42	Manual bag
13	Pop-Off valve	43	APL valve
14	PEEP safety valve	44	Gas monitoring module
15	Drive gas pressure switch (140 kPa)	45	Bellows
16	Proportional PEEP valve	46	Mechanical pressure relief valve (1 kPa,10 cmH2O)
17	Expiratory valve	47	Negative pressure check valve (1 cmH2O)
18	Pneumatic resistor	48	Gas reservoir
19	O2 flush button	49	Pressure sensor
20	Pressure relief valve	50	Single-vaporizer manifold
21	Flow restrictor	51	Free breathing check valve
22	O2 supply pressure switch (200 kPa)	52	Air cylinder connector
23	Regulator (200 kPa)	53	Pressure relief valve
24	System switch	54	ACGO selector switch
25	O2-N2O cut-off valve	55	Auxiliary O2 supply
26	Flowmeter module	56	Vacuum generator
27	Double-vaporizer manifold	57	Muffler
28	Check valve	58	Adjustable negative pressure gauge
29	Pressure relief valve (37.9 kPa)	59	Floating overfill protection valve
30	AGSS	60	Liquid collection bottle

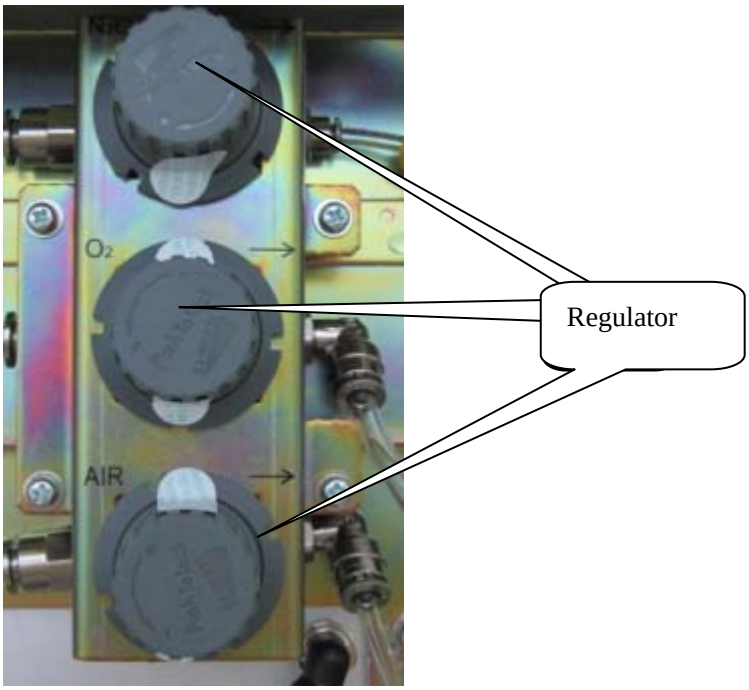
2.1.5 Key to Symbols

	Filter		Regulator
	Pressure gauge		Check valve
	Gas supply connector		Pressure relief valve
	Flowmeter		Flow control valve
	Pressure switch		Flow restrictor
	Vacuum generator		Muffler
	Overfill protection valve		Liquid collection bottle

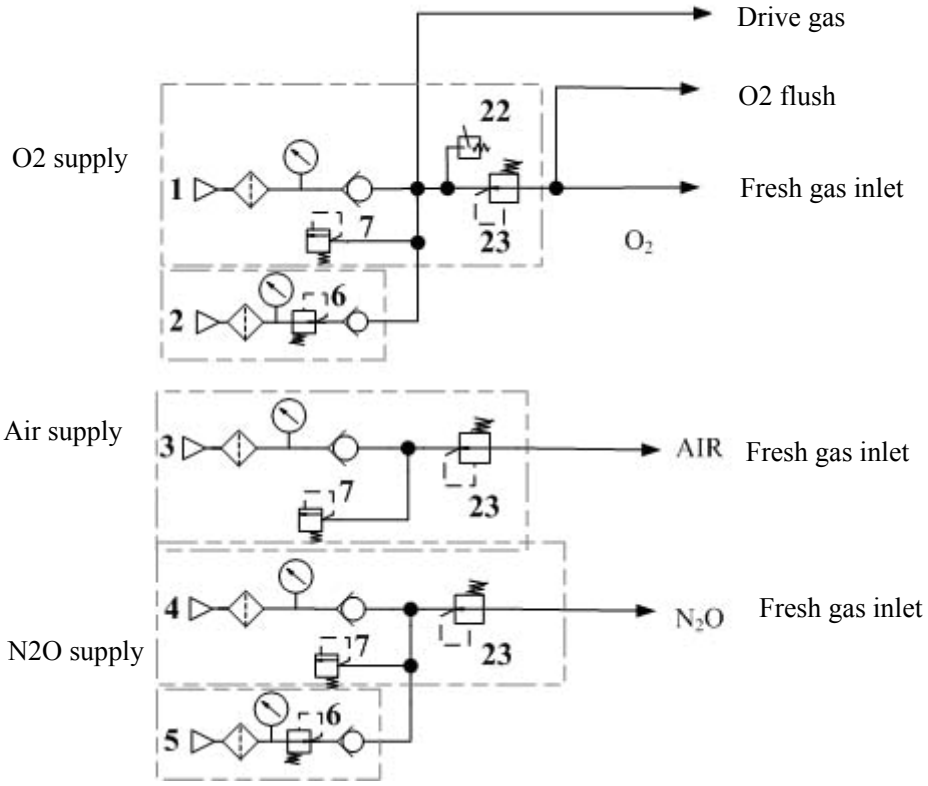
2.1.6 Description

2.1.6.1 Gas Supplies



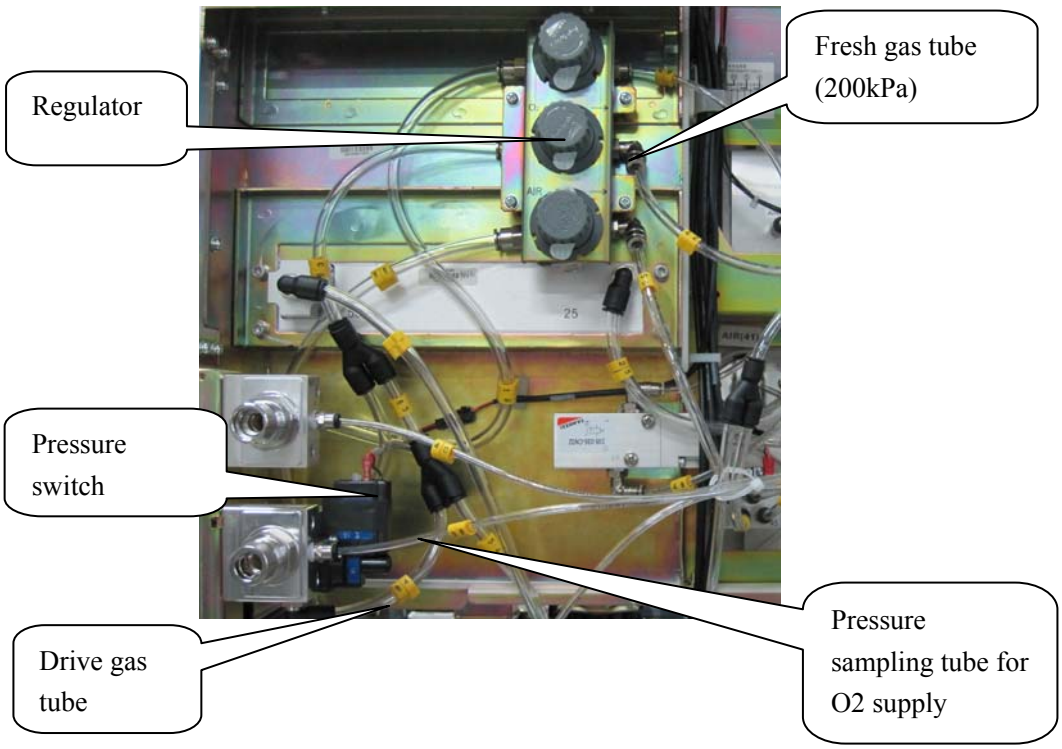


The above picture shows the O2 pipeline supply inlet assembly. The anesthesia machine's pneumatic circuit starts from the gas supplies, which functions to introduce the external pipeline or cylinder gases into the machine. Since the pressure of external gas is very high and the external gas contains foreign substance, regulator, filters and pressure relief valves are available in the supply gas circuit. Also, check valves are equipped in the supply gas circuit to prevent gas from flowing back into the pipeline or cylinder. The following figure shows the supply gas circuit.

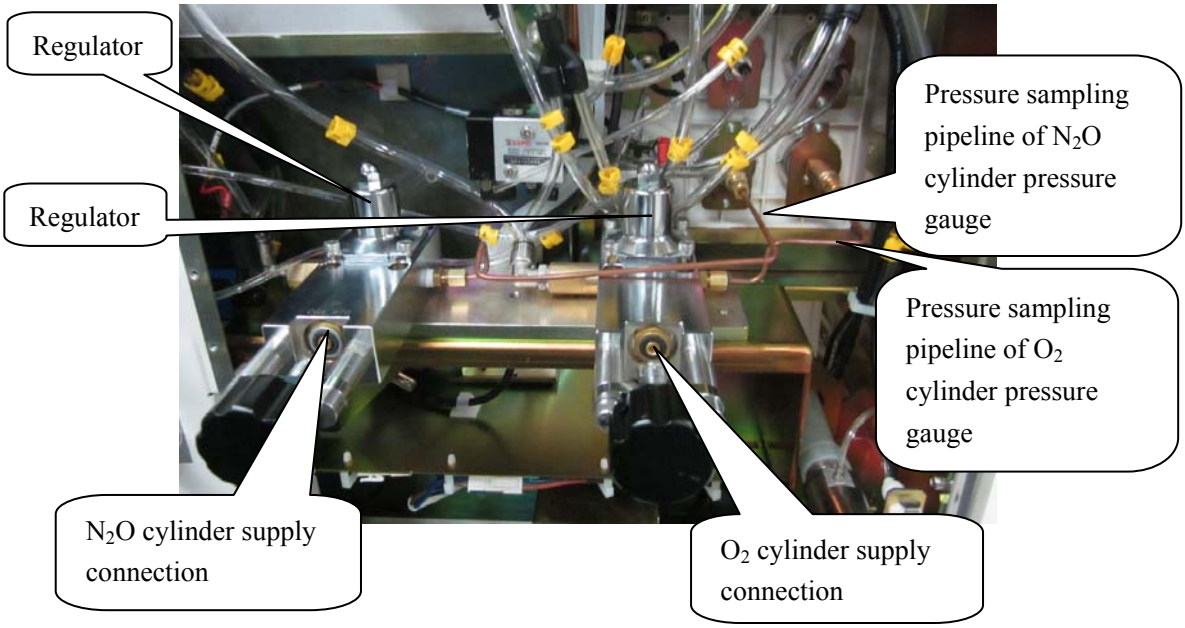


The anesthesia machine has pipeline and cylinder gas supplies available. Pipeline gas supplies, which are O_2, N_2O and Air, go into the pipeline gas supply inlet assemblies through pipeline connectors 1, 4 and 3 respectively. The pipeline pressure ranges between 280 and 600 kPa. Cylinder gas supplies, which are O_2, Air and N_2O, go into the system through cylinder connectors 2, 5 and 52 respectively. The O2, Air and N2O cylinder pressures are 6.9 – 15 MPa, 6.9 – 15 MPa and 4.2 – 6 MPa respectively, which are decreased to approximately 400 kPa through regulator 6. Each connector is clearly marked and designed to prevent misconnection. All connectors have filters and check valves. Color coded gauges show the pipeline and cylinder pressures. Pressure relief valve 7 functions to prevent the supply gas pressure from being too high. It releases excess gas when gas pressure exceeds approximately 750 kPa. Each supply gas is outputted after gas pressure is decreased below approximately 200 kPa through regulator 23. Pressure switch 22 monitors the O2 supply pressure. When O2 supply pressure is less than approximately 200 kPa, the ventilator gives the alarm of O2 supply failure.

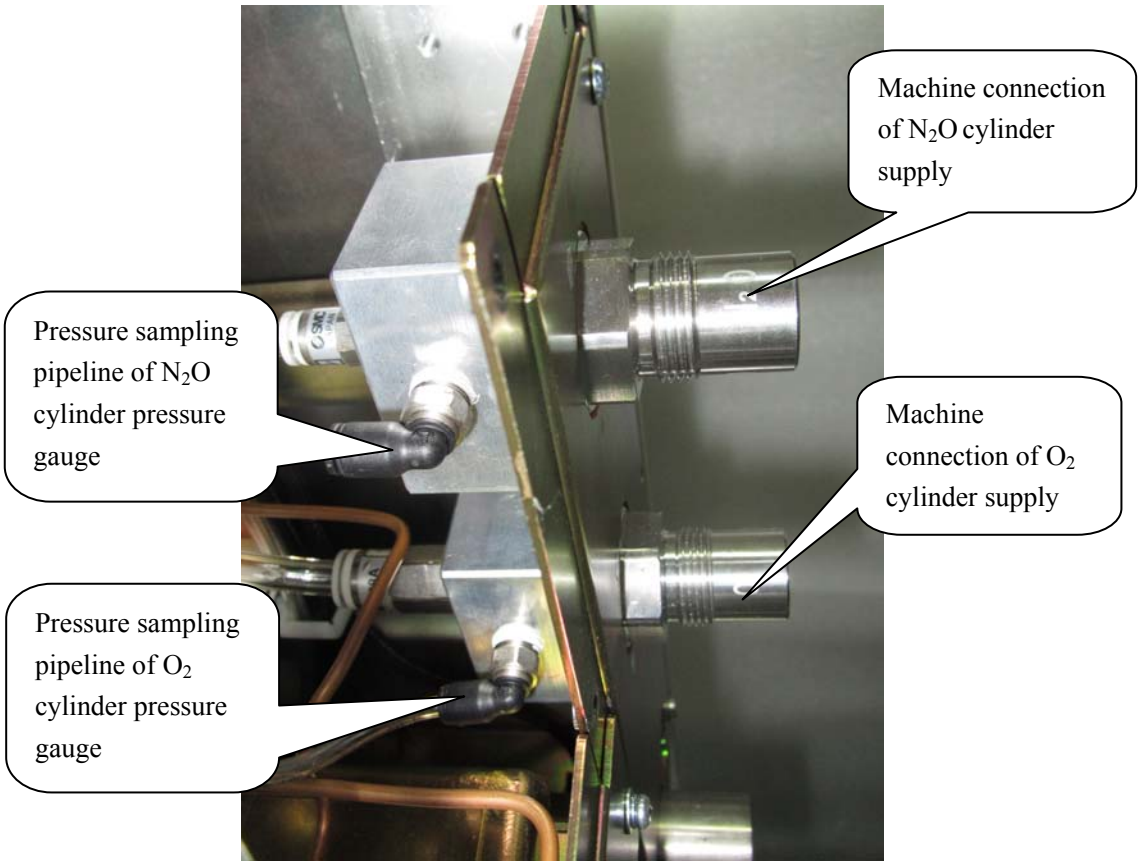
The following picture shows the output connectors of O2 pipeline supply inlet assembly.



The following picture shows the output connector of cylinder supply inlet assembly.

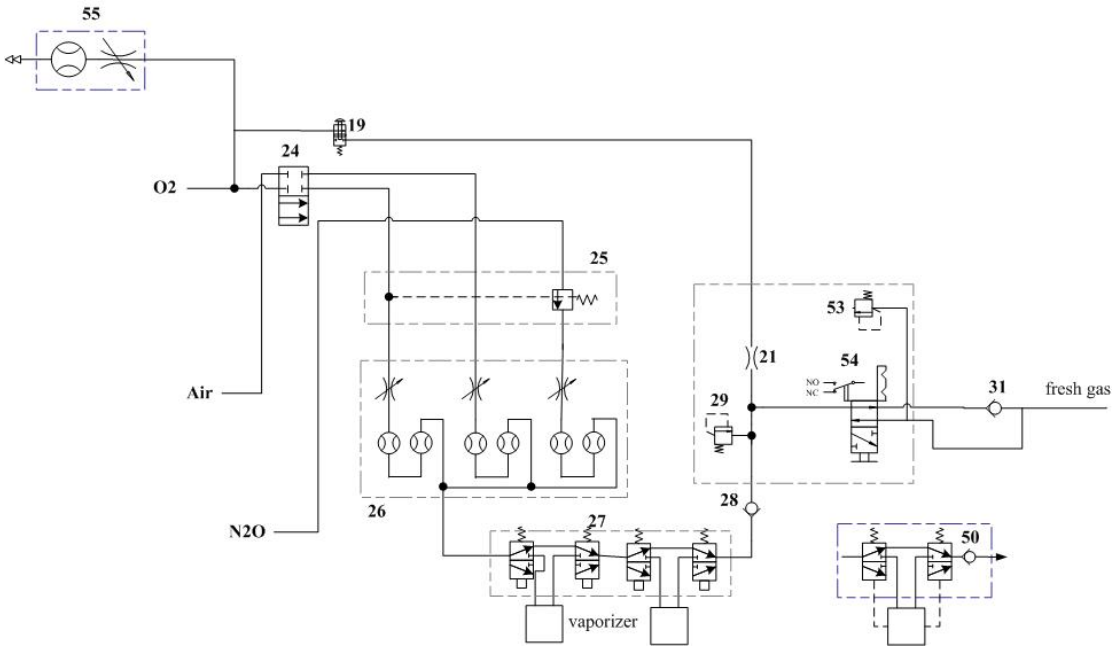


The following picture shows the output connector of cylinder supply inlet assembly of anesthesia machine configured with four yokes.

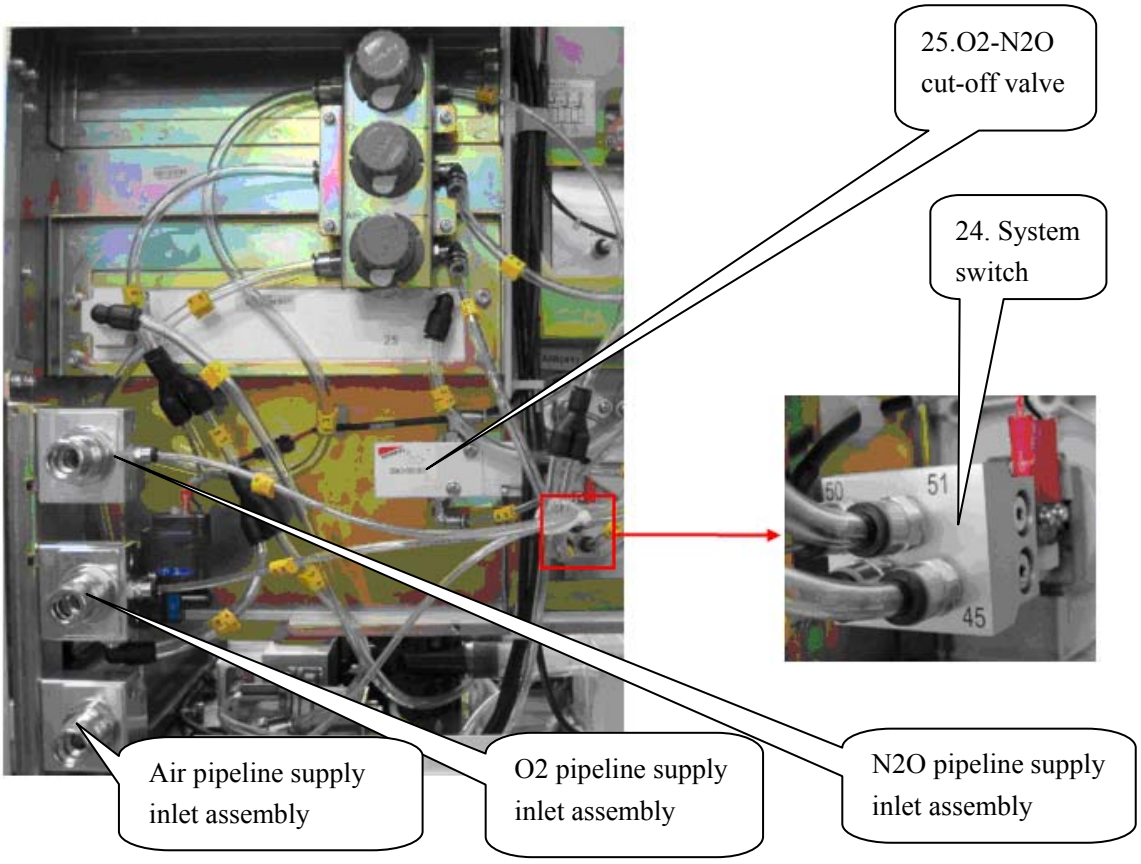


2.1.6.2 Anesthetic Gas Delivery System

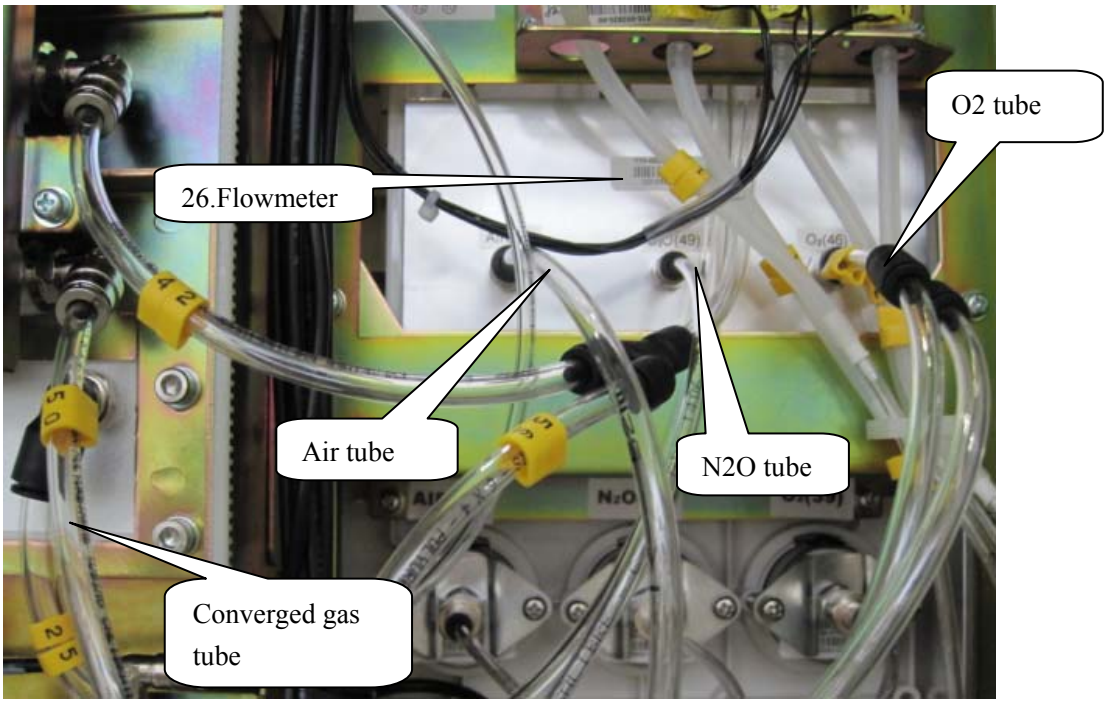
The anesthetic gas delivery system is connected to the gas supplies, anesthetic gas delivery device (vaporizer) and breathing system. N2O, O2 and Air supplies enter the anesthetic gas delivery system and the mixed gas (namely fresh gas) containing these three gases and anesthetic agent and pure O2 (O2 flush) are outputted. The following figure shows the pneumatic circuit of anesthetic gas delivery system.



The following picture takes O2+N2O+Air configuration as an example to illustrate how pipeline supplies are outputted. O2 is divided into two pathways. One pathway of O2 flows into system switch 24 and the other into O2 flush valve 19. N2O flows into O2-N2O cut-off valve 25 and Air into system switch 24.

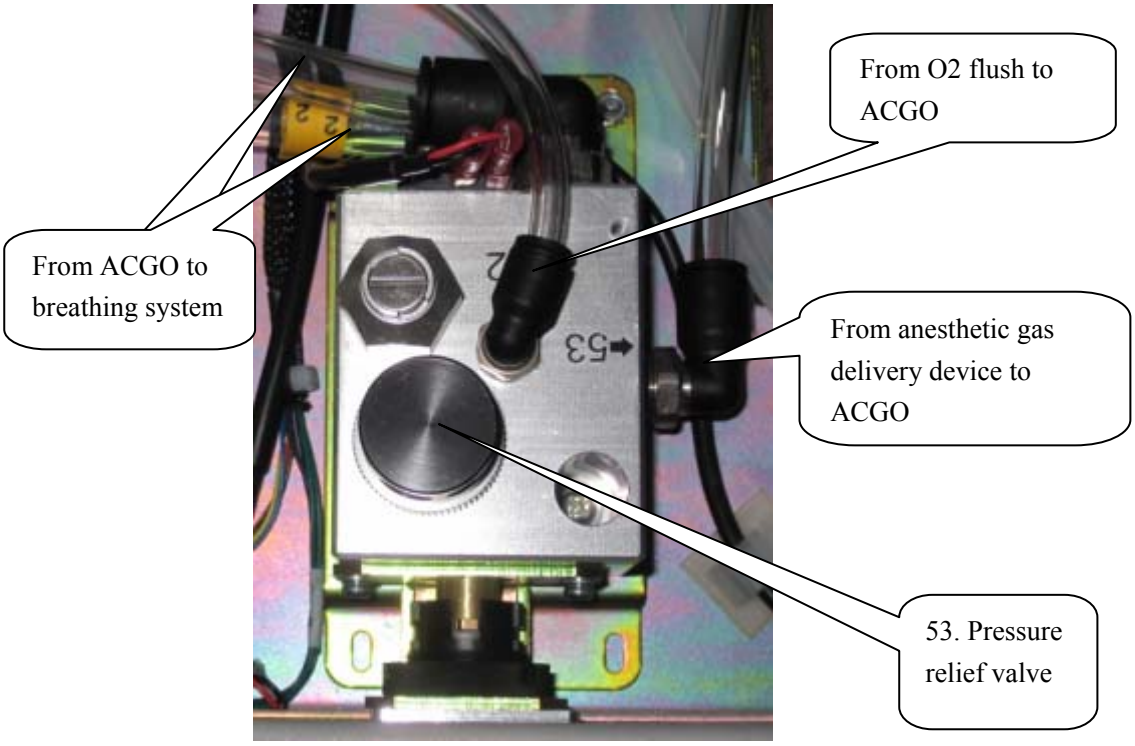


When system switch 24 is turned on, Air enters flowmeter 26. O2 is divided into two pathways. One pathway of O2 flows into flowmeter 26 and the other into O2-N2O cut-off valve 25. If the pressure of O2 vented into O2-N2O cut-off valve 25 is greater than 0.1 MPa, N2O can enter flowmeter 26, as shown below.

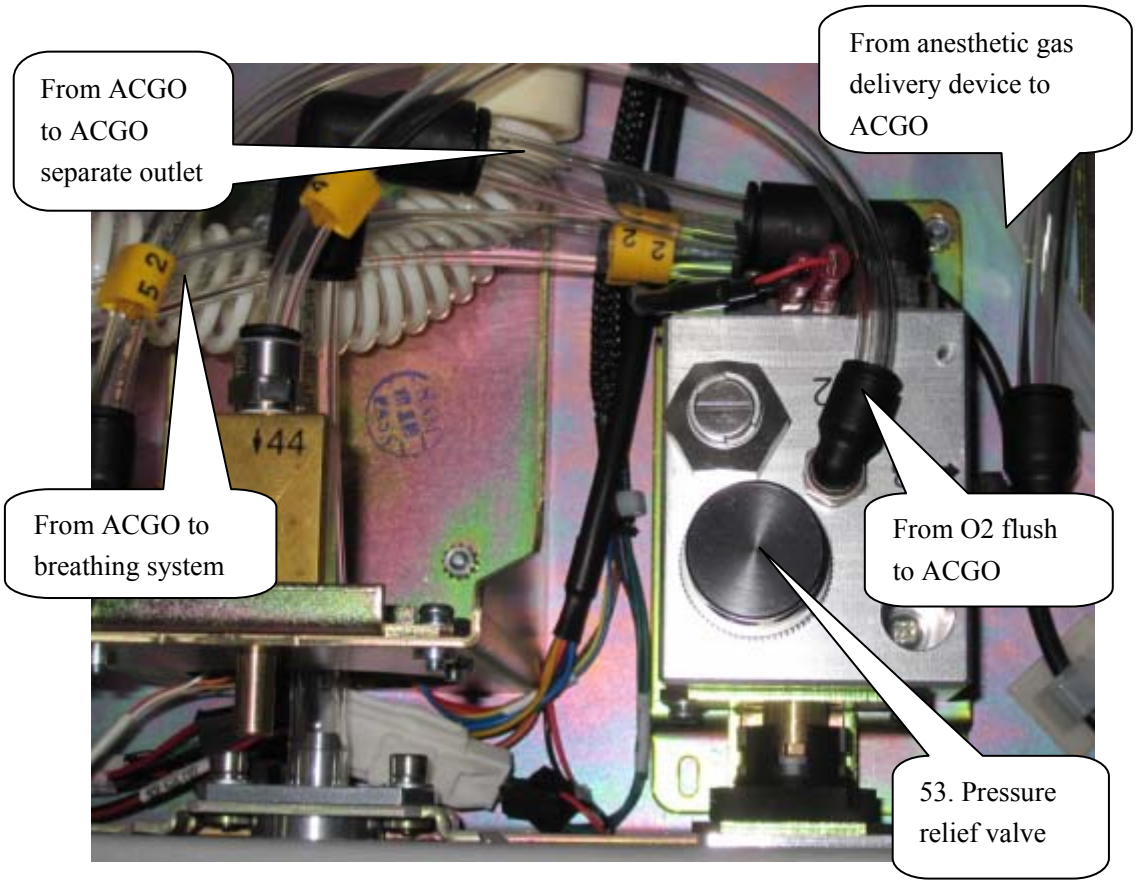


Flowmeter 26 controls gas flows. The gases passing through flowmeter 26 enter the anesthetic gas delivery system (vaporizer) as shown above.

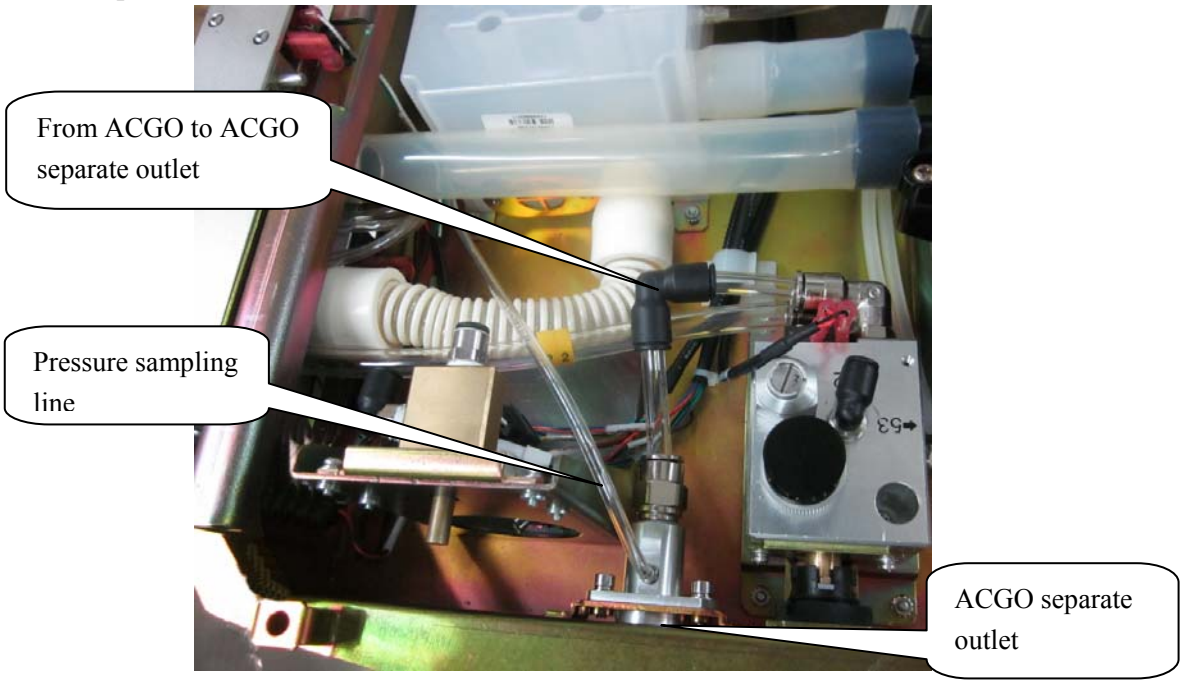
The converged gas entering the anesthetic gas delivery device (vaporizer) is mixed with the anesthetic agent to form fresh gas. The fresh gas then goes from check valve 28 through the ACGO to the breathing system. The flushed O2 also enters the breathing system through the ACGO. Regarding anesthesia machine of this configuration, from the system menu select [**Maintenance**]→[**Factory Maintenance>>**]→enter the required password→[**System Setup**]. Set [**CGO**] to [**SCGO**] in the accessed menu.



The following picture shows the case when a separate ACGO is configured. Regarding anesthesia machine of this configuration, from the system menu select [**Maintenance**]→[**Factory Maintenance>>**]→enter the required password→[**System Setup>>**]. Set [**CGO**] to [**ACGO01**] in the accessed menu.

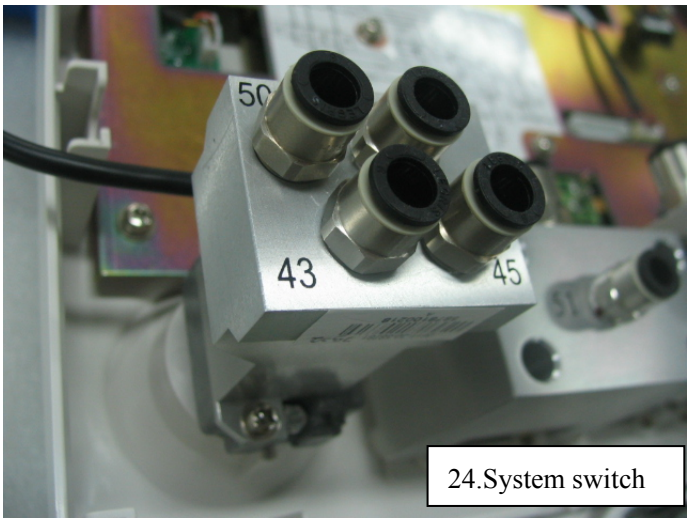


The following picture shows the case when a separate ACGO (with pressure sampling) is configured. Regarding anesthesia machine of this configuration, from the system menu select [**Maintenance**]→[**Factory Maintenance>>**]→enter the required password→[**System Setup>>**]. Set [**CGO**] to [**ACGO02**] in the accessed menu.



When ACGO is turned on, the anesthesia machine stops mechanical ventilation. The fresh gas is directly outputted through the inspiration connector on the breathing circuit. Pressure relief valve 53 on the ACGO prevents pressure at the ACGO port from exceeding 110cmH2O when ACGO is turned on.

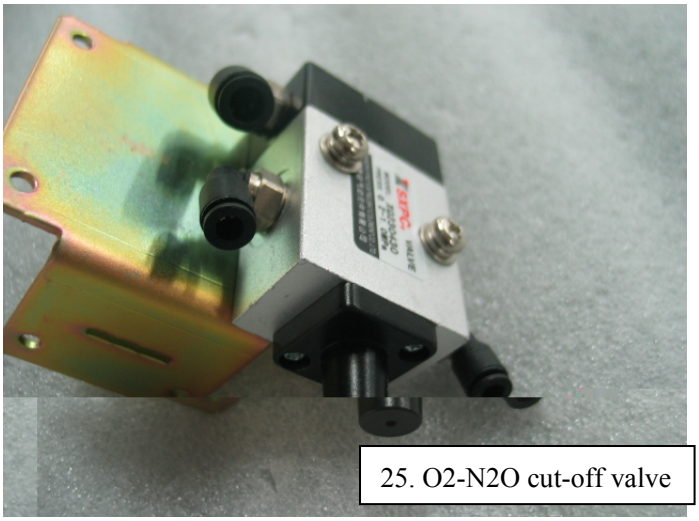
System Switch Assembly



24.System switch

The above picture shows the system switch assembly. Supply gases of Air and O2 go into system switch 24; and Air & O2 flowing into the flowmeter and O2 into the control end of the O2-N2O cut-off valve are outputted. System switch has an electrical outlet which controls the power-on status of the system. When the system switch is turned on, O2 and Air enter the anesthetic gas delivery system and the system is powered on simultaneously. The anesthetic ventilator starts to monitor the status of the system. When the system switch is turned off, O2 and Air cannot enter the anesthetic gas delivery system and the system is powered off.

O2-N2O Cut-off Valve Assembly



25. O2-N2O cut-off valve

The O2-N2O cut-off valve assembly involves material switchover. The picture of the latest real object shall prevail.

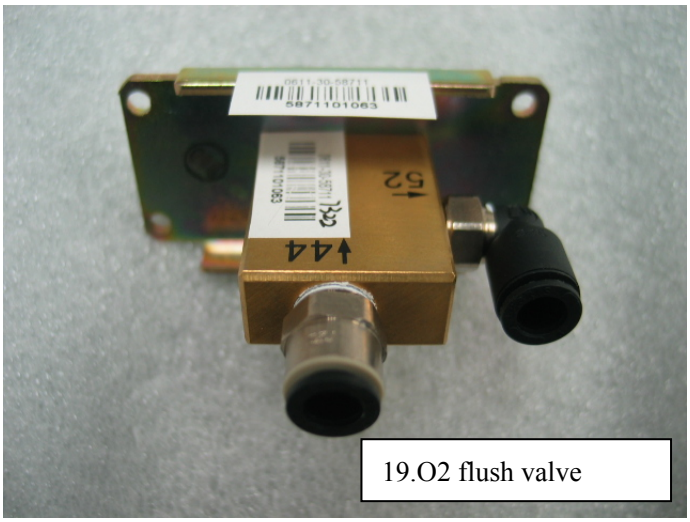
The above picture shows the O2-N2O cut-off valve assembly. O2-N2O cut-off valve 25 is a pneumatically controlled three-way valve. O2 is uploaded to the control end of the O2-N2O cut-off valve to conduct on-off control of N2O. When the O2 supply pressure is less than 0.1 MPa (approximate value), N2O supply is cut off. When the O2 supply pressure is greater than 0.1 MPa (approximate value), N2O supply is switched on. O2-N2O cut-off valve 25 does not affect Air supply.

Flowmeter Assembly

26. Flowmeter

The above picture shows the flowmeter assembly. Flowmeter assembly 26 controls O2, N2O and Air flows and the proportion between O2 and N2O as well to ensure that the gas flows outputted are adjustable within the range of 0 – 10 L/min. O2, N2O and Air enter the low-flow flowmeters and high-flow flowmeters in turn respectively. The low-flow flowmeter displays flow ranging from 0.05 to 1 L/min at the resolution of 0.05 L/min and the high-flow flowmeter displays flow ranging from 1.1 to 10 L/min at the resolution of 0.1 L/min. The flowmeter has integrated an O2-N2O chain linkage which helps keep the O2 concentration not lower than 21% and keep that the minimum O2 concentration is lower than 40% when N2O flow exceeds 1 L/min. Turning flow controls counterclockwise increases the flow and clockwise decreases the flow.

O2 Flush Button Assembly



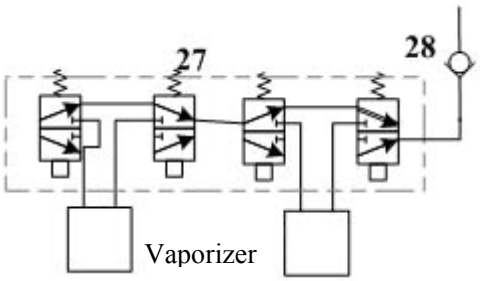
19.O2 flush valve

The above picture shows the O2 flush button assembly. When O2 flush valve 19 is depressed, O2 rushes into the pneumatic circuit which is cut off when the valve is released. The O2 supply gas at 0.2 MPa after regulated goes through the O2 flush valve, the ACGO assembly, and into the breathing system. The O2 flush button assembly is not affected by the system switch. Flushing O2 can be performed as long as O2 supply is normal. The O2 flush valve has a slide valve structure inside which ensures automatic reset each time the valve is depressed and released via the spring.

Vaporizer Manifold

27. Vaporizer manifold

The above picture shows the vaporizer manifold assembly. The anesthetic gas delivery device (vaporizer) is connected to the anesthetic gas delivery system. The mixed gas of N2O, O2 and Air go into the device and the fresh gas containing these three gases and anesthetic agent is finally outputted to the ACGO assembly. The following figure shows the pneumatic circuit of anesthetic gas delivery device (vaporizer).



Double-vaporizer manifold 27 (or single -vaporizer manifold) is integrated with check valve 28 which prevents flushed O2 and fresh gas from flowing back to the vaporizer and impairing the concentration outputted of the anesthetic agent as a result. When a double-vaporizer manifold is used, Selectatec mounting with interlocking function can prevent the user from turning on two vaporizers simultaneously.

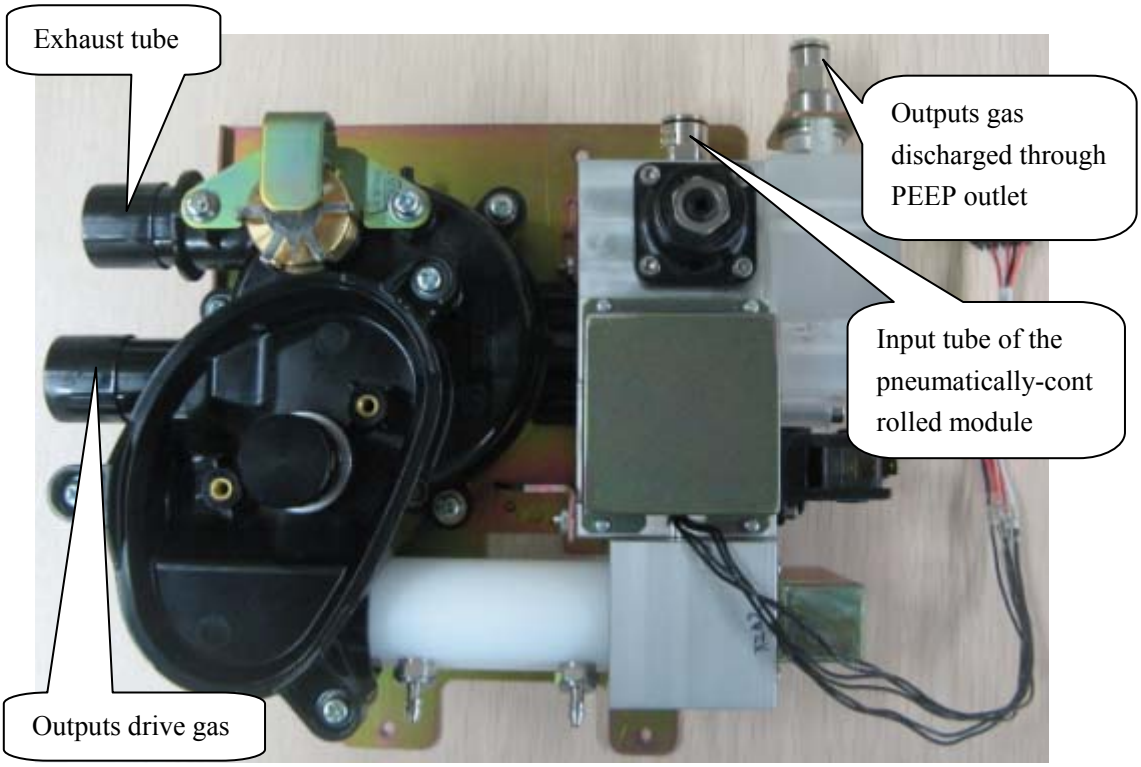
ACGO Assembly

30. ACGO

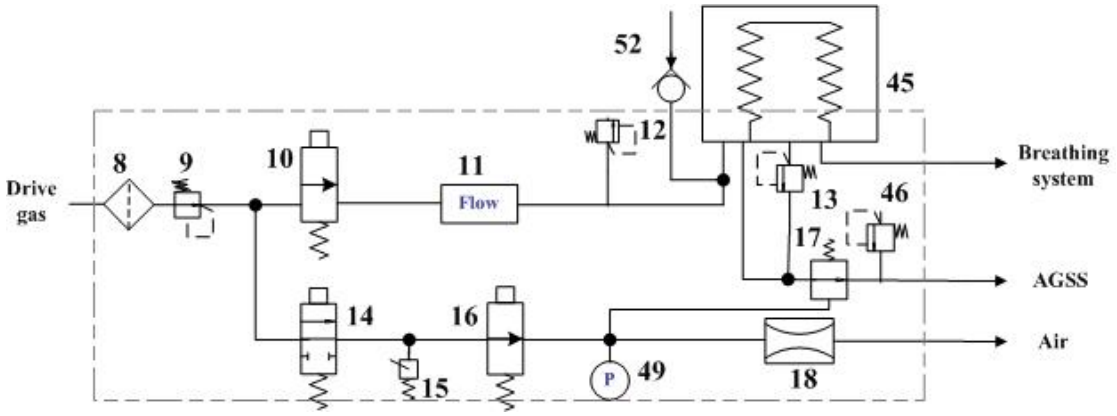
The above picture shows the ACGO assembly. The ACGO assembly includes flow restrictor 21, pressure relief valve 29, ACGO selector switch 54 (three-way valve) and contact switch. Flushed O2 and fresh gas are mixed and enter the ACGO. The outputs include fresh gas provided for the breathing system (when ACGO is turned off) and that provided for the patient (when ACGO is turned on). When ACGO is switched on, the anesthetic ventilator stops working. Pressure relief valve 29 at the front restricts the pressure of flushed O2 and also that of the fresh gas not to exceed 38 kPa (approximate value). Pressure relief valve 53 at the back ensures that the pressure of the gas outputted to the ACGO port does not exceed 110 cmH_2O.

2.1.6.3 Pneumatically-controlled Module of the Anesthetic Ventilator

The pneumatically-controlled module of the anesthetic ventilator provides drive gas for the patient to breathe. O2 (or Air) from the gas supply inlet assembly enters the pneumatically-controlled module and is outputted in three pathways: drive gas entering the breathing system, drive gas discharged through the AGSS outlet and drive gas discharged through the PEEP outlet. The ventilator controls drive gas flow to prevent too high pressure inside the pneumatic circuit from injuring the patient. The following picture shows the gas flow direction and parts concerning the pneumatically-controlled module.



The following figure shows the pneumatic circuit of the pneumatically-controlled module.

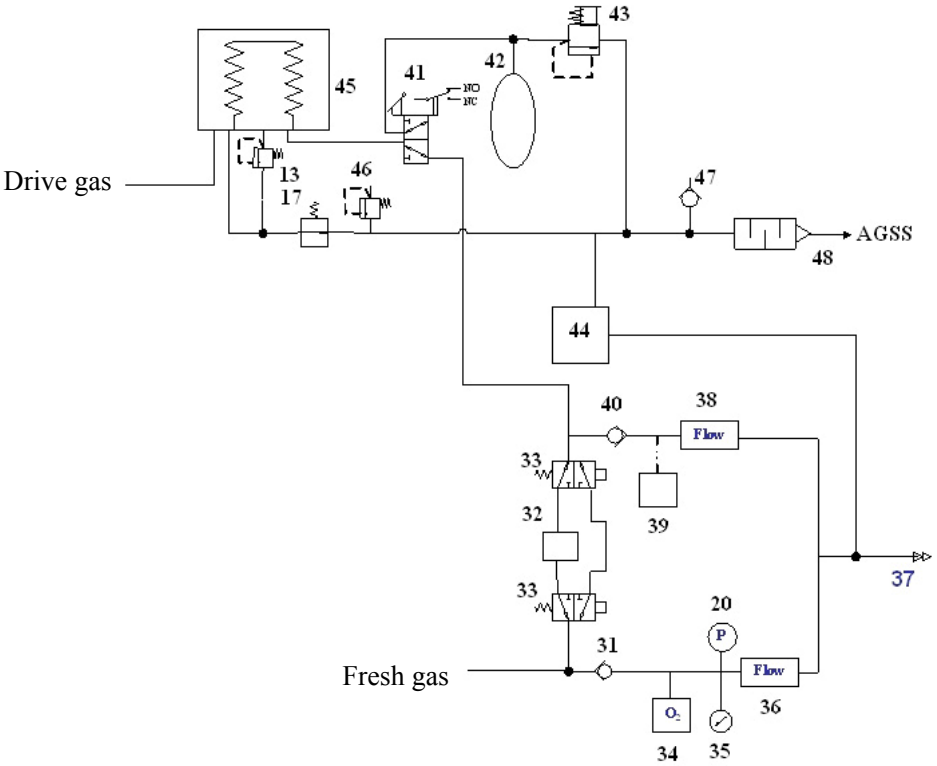


Proportional electromagnetic valve 10 controls inlet gas flow. Filter 8 filters drive gas again. Regulator 9 regulates pressure inside the pneumatic circuit (approximately 0.2 MPa). “11” is a flow sensor of differential pressure type which monitors gas flow in the drive gas circuit. Mechanical overpressure valve 12 ensures that the pressure in the drive gas circuit does not exceed safe pressure. It releases excess gas when gas pressure exceeds 11 kPa. “17” is expiratory valve. During expiration, gas inside the bellows is discharged from this valve. The PEEP function is performed through expiratory valve. “16” is low-flow proportional electromagnetic valve. When it opens, gas is bled from pneumatic resistor 18, forming relatively stable pressure in the pneumatic circuit between “16” and “18”. Such pressure is exerted on the membrane of expiratory valve 17 to form PEEP.

To prevent too high pressure inside the pneumatic circuit from injuring the patient and damaging the equipment, safety valve 14, which is electromagnetic on-off valve, is placed before the gas pathway of the expiratory valve. “15” is a pressure switch. When drive gas pressure is less than approximately 140 kPa, an alarm is triggered. Pressure sensor 49 monitors the pressure at which the expiratory valve closes. Pressure relief valve 46 ensures the tube pressure after the expiratory valve is less than 10 cmH2O.

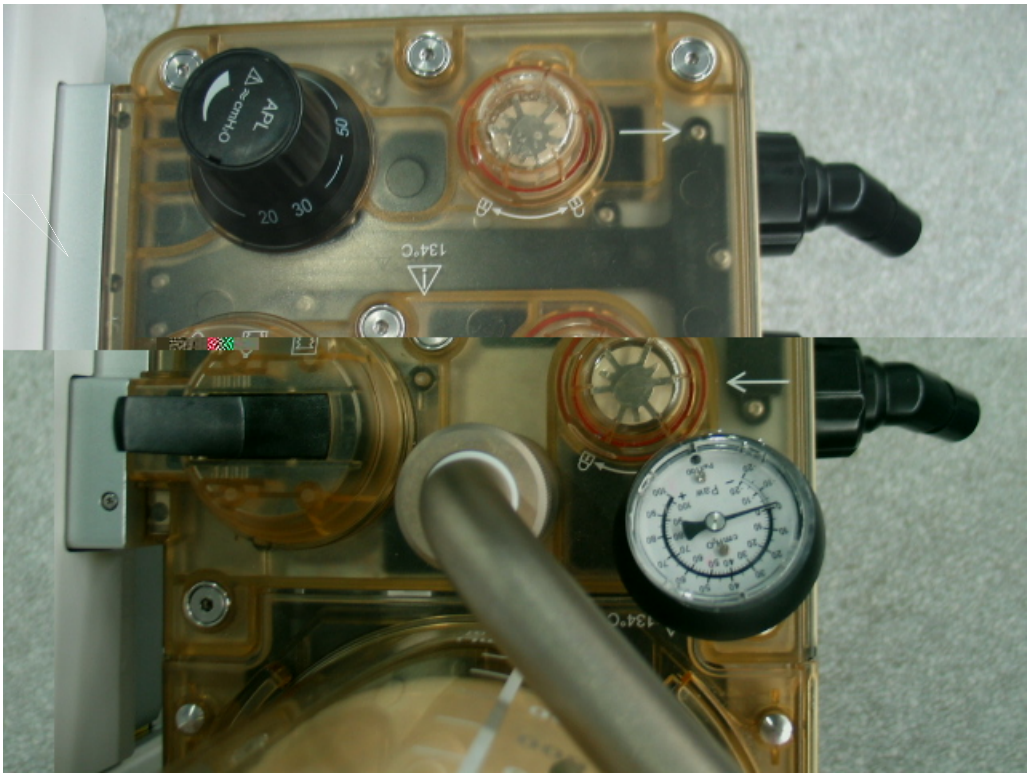
2.1.6.4 Breathing System

The breathing system provides a closed loop for the anesthetic gas. The CO2 in the patient's expired gas can be inspired in the inspiration phase to maintain the temperature and humidity conditions of the patient's expired gas. During inspiration, the drive gas depresses the bag inside the bellows to force the inside gas to enter the patient's lungs. During expiration, the patient's expired gas goes into the bag inside the bellows. CO2 absorbent canister 32 absorbs CO2 the patient expires. The following figure shows the pneumatic circuit of breathing system.



Manual and mechanical ventilation modes are selected through the Bag/vent switch. When manual ventilation is selected, the doctor presses manual bag 42 to supply gas for the breathing system. APL valve 43 adjusts the pressure inside the pneumatic circuit in case of manual ventilation. When mechanical ventilation is selected, the ventilator starts to work. It controls the drive gas to depress the bellows 45 and supply gas for the breathing system as per the selected ventilation mode.

Connected to the anesthesia machine main unit through the circuit adapter, the breathing system is highly integrated with impact structure. Its tubes are all built in except the tube connected to the patient and the O2 cell cable, as shown below.

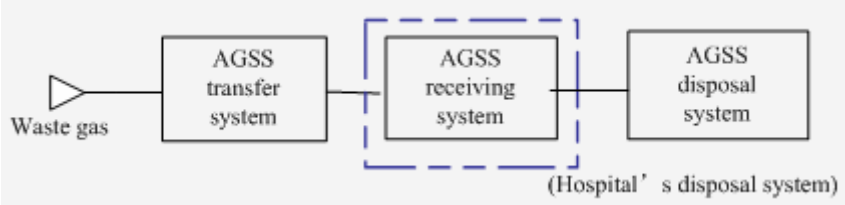


In case of mechanical ventilation, during inspiration, gas flows through Bag/vent switch 41, BYPASS valve 33 or CO2 absorbent canister 32, inspiratory valve 31, O2 sensor 34, and inspiratory flow sensor 36 to the patient. During expiration, gas flows through expiratory flow sensor 38, expiratory valve 40, and Bag/vent switch 41 to the bellows. Pressure sensor 20 monitors the airway pressure.

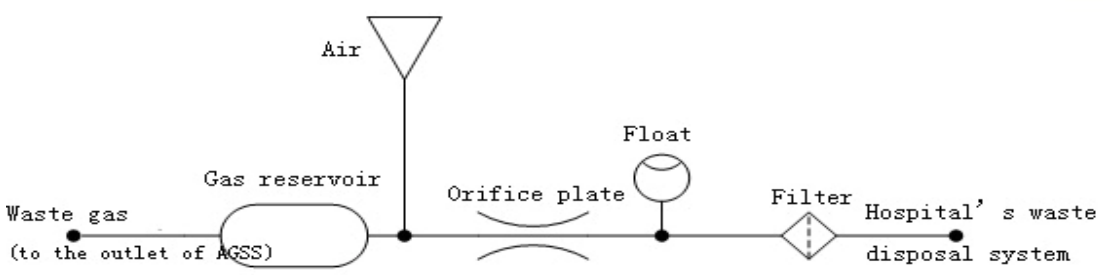
The breathing system is easily disassembled and is autoclavable at 134℃.

2.1.6.5 Anesthetic Gas Scavenging System

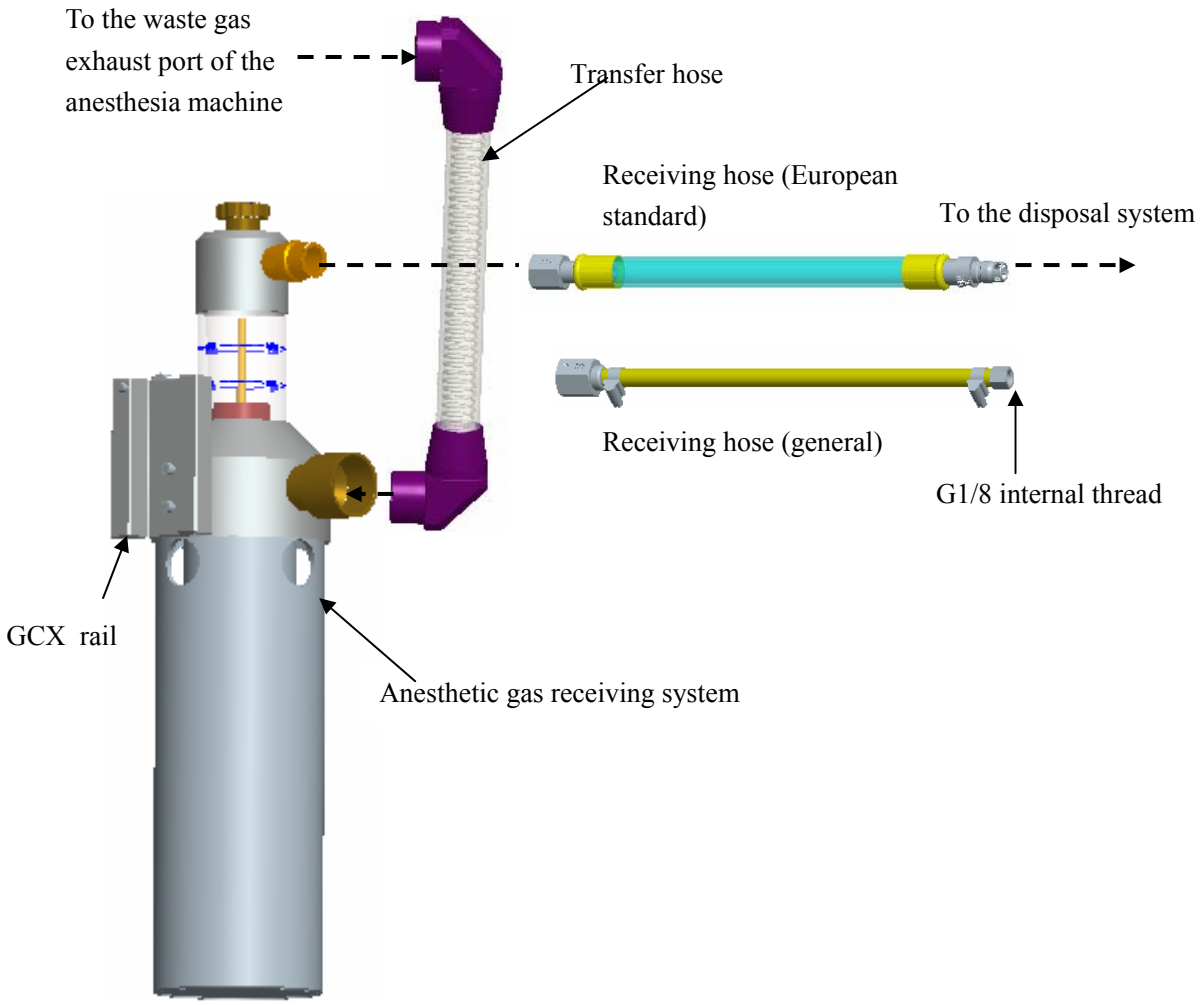
The anesthetic gas scavenging system (AGSS) is composed of AGSS transfer system, AGSS receiving system and AGSS disposal system. Waste gas goes from the exhaust port of the anesthesia machine through the AGSS transfer system and the AGSS receiving system and to the hospital's waste gas disposal system (AGSS disposal system), as shown below.



The following figure shows the operational theory of the AGSS. The throttling holes reduce the effect of negative pressure at the AGSS outlet onto the flow at the entrance. The float helps the user to know if the disposal system meets the requirement for minimum pump rate. The filter filters foreign substance to prevent the disposal system from being occluded. The gas reservoir is connected to the air through pressure compensation openings. When positive or negative pressure occurs inside the gas reservoir, gas is inputted or outputted to ensure pressure balance inside the system.

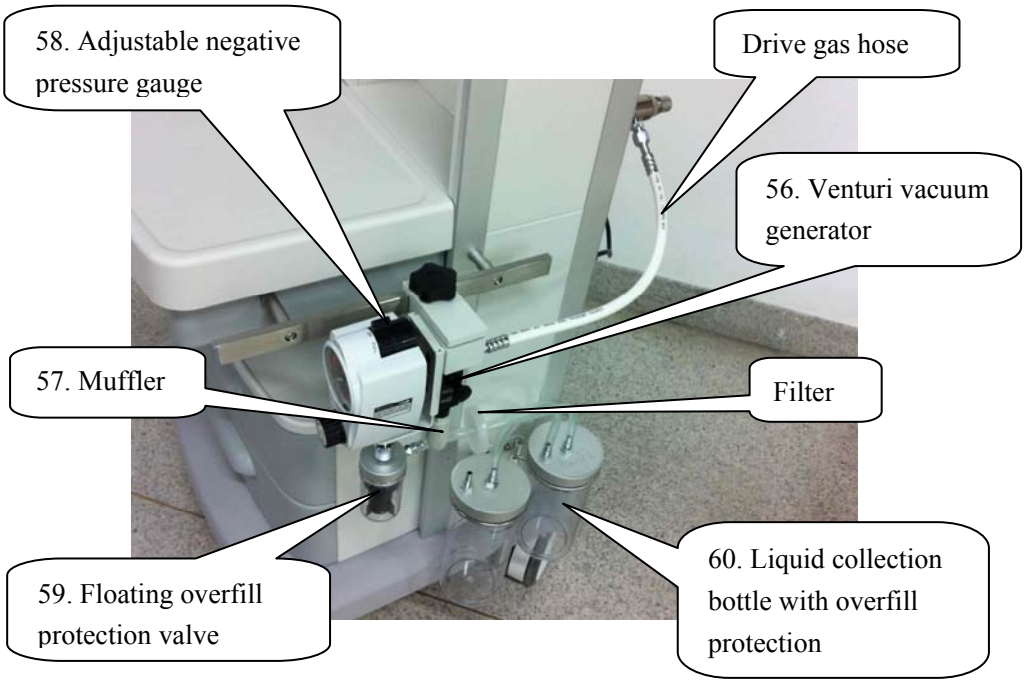


There are high-flow and low-flow configurations of AGSS. The declared flow of low-flow AGSS is 25～50L/min and that of high-flow AGSS is 75～105L/min. The two types of AGSS configuration have same installation structure and vary in the internal structure only. The AGSS is mounted onto the anesthesia machine through GCX rail and is fixed by tightening the hand nut on the GCX rail. Both ends of the transfer hose have 30 mm conical connectors. The inlet is a female 30 mm conical connector and the outlet a male 30 mm conical connector. The anesthetic gas receiving system is connected to the receiving hose through CGA V-5 2220 connector. The receiving hose is connected to the hospital's disposal system through EN ISO 9170-2:2008 connector (applicable to disposed standard EN 737-4：1998 connector). To adapt to the situation that the hospital's disposal system does not have such standard connector, the Appendix provides the receiving hose (general) which does not have connector when connected to the disposal system. Only G1/8 internal thread is provided. You need to install the appropriate connector based on the hospital's disposal system before connection. The following picture shows the AGSS structure and connections.



2.1.6.6 Negative Pressure Suction System

The negative pressure suction system uses pipeline Air or O2 as the drive gas. While the drive gas is discharged from the muffler of Venturi negative pressure generator assembly, negative pressure is produced at the negative pressure regulator according to Venturi theory. The regulated negative pressure can suction the patient's body fluid at the throat. The suctioned body fluid is temporarily kept in the liquid collection bottle. Both liquid collection bottle and negative pressure regulator assembly are integrated with overfill protection device to prevent the patient's body fluid from entering the negative pressure regulator and Venturi negative pressure generator so as to damage the equipment. A filter is also connected to prevent bacteria from contaminating the equipment or from entering the pipeline gas supply.



3 Checkout and Test

⚠WARNING

- **After servicing the equipment or replacing its components, complete all the tests in this section.**
- **Before doing the tests in this section, completely reassemble the equipment and refer to 4 Maintenance and Calibration to do necessary calibrations.**

3.1 System Inspection

NOTE

- **Make sure that the breathing circuit is correctly connected and not damaged.**
- **The top shelf weight limit is 30 kg.**

⚠WARNING

- **Do not leave gas cylinder valves open if the pipeline supply is in use. Cylinder supplies could be depleted, leaving an insufficient reserve supply in case of pipeline failure.**

Make sure that:

1. The equipment is not damaged.
2. All components are correctly attached.
3. The breathing circuit is correctly connected and the breathing tubes are not damaged.
4. The vaporizers are locked in position.
5. The fixing nuts of the negative pressure suction system are fastened.
6. The gas supplies are connected and the pressures are correct.
7. Cylinder valves are closed on models with cylinder supplies.
8. The casters are not loose and the brake(s) is set and prevents movement.
9. Make sure the circuit is locked safely.
10. The power cord is correctly connected. The AC mains indicator and the battery indicator work normally.
11. The anesthesia machine is switched on or off normally.

3.2 Pipeline Tests

⚠WARNING

- **Do not leave gas cylinder valves open if the pipeline supply is in use. Cylinder supplies could be depleted, leaving an insufficient reserve supply in case of pipeline failure.**

1. Disconnect the pipeline supplies and close all cylinder valves. Bleed all the gas inside the machine to let the pressure gauges go to zero. f the gauge fails to go to zero, it indicates that the gauge is faulty.
2. Connect an O2 pipeline supply.
3. Set the system switch to the ⊙ position.
4. Set the flow controls to mid range.
5. Check that the pressure reading on the O2 gauge is within the range of 280 to 600 kPa (if not, adjust the O2 pipeline output pressure). Check that other gauges go to zero.
6. Disconnect the O2 pipeline supply.
7. As O2 pressure decreases, alarms for [**O2 Supply Failure**] and [**Drive Gas Pressure Low**] should occur. The alarm for [**Drive Gas Pressure Low**] occurs only when O2 is the drive gas.
8. Connect other pipeline supplies. Check that the readings on the gauges fall within the range of 280 to 600 kPa.

3.3 Cylinder Tests

NOTE

- **To prevent damage, open the cylinder valves slowly.**
- **After doing the cylinder tests, close all cylinder valves if cylinder supplies are not used.**
- **Turn the flow controls slowly. Do not turn further when the flowmeter indicates the maximum or minimum flow to avoid damaging the control valve.**

This test is not required if cylinders are not configured.

3.3.1 Check the Cylinders are Full

Check the cylinders of the anesthesia machine one by one as follows:

1. Set the system switch to the Ö position and connect the cylinders.
2. Open the valve of the cylinder to be checked. Make sure that the valves of other cylinders are closed.
3. Make sure that the cylinder being checked has sufficient pressure. If not, close the applicable cylinder valve and install a full cylinder.
4. Close the valve of the checked cylinder.

3.3.2 Cylinder High Pressure Leak Test

NOTE

- **For N2O test, turn on the O2 supply after the test is completed. Turn off the N2O main switch first. Turn on the N2O flowmter to ensure that there is no residual N2O and that the N2O pressure gauge returns to zero. Then turn off the O2 supply.**

1. Make sure that the system switch is in the Ö position.
2. Close the auxiliary O2 supply flowmeter if auxiliary O2 supply is configured.
3. Turn all the flow controls fully clockwise (minimum flow).
4. Open the cylinder valve.
5. Record the current cylinder pressure.
6. Close the cylinder valve.
7. Record the cylinder pressure after one minute. There is a leak
   - If the cylinder pressure for drive gas decreases more than 5000 kPa (725 psi).
   - If the cylinder pressure for non-drive gas decreases more than 690 kPa (100 psi).
   - In this case, install a new cylinder gasket and repeat steps 1 through 6. If the leak continues, do not use the system.
8. Repeat ***3.3.2 Cylinder High Pressure Leak Test*** for each cylinder.

3.4 Flow Control System Tests

3.4.1 Without O2 Sensor

NOTE

- **Turn the flow controls slowly. Do not turn further when the flowmeter indicates the maximum or minimum flow to avoid damaging the control valve.**

⚠WARNING

- **If N2O is available and flows through the system during this test, use a safe and approved procedure to collect and remove it.**
- **Incorrect gas mixtures can cause patient injury. If the O2-N2O Link system does not supply O2 and N2O in the correct proportions, do not use the system.**

To do the flow control system tests:

1. Connect the pipeline supplies or slowly open the cylinder valves.
2. Turn all flow controls fully clockwise (minimum flow).
3. Set the system switch to the ⊙ position.
4. Connect the AC power source if battery capacity shortage occurs. Do not use the system if other ventilator failure alarm occurs.
5. Set the flow controls to mid range. Check that the flowtube float moves smoothly.
6. Test the Link system with N2O flow increasing:

   a. Turn the O2 and N2O flow controls fully clockwise (minimum flow).

   b. Turn the N2O flow control only.

   c. Increase the N2O flow gradually as shown in the table. Make sure that the O2 flow must be greater than the minimum limits.

   d. If the N2O flow is set crossing the limit, before continuing the test, turn the O2 flow control clockwise till the N2O flow decreases to the preset value.

Step	**N2O flow (L/min)**	**O2 flow (L/min)**
1	0.6	≥0.2
2	1.5	≥0.5
3	3.0	≥1.0
4	7.5	≥2.5

7. Test the Link system with O2 flow decreasing:

   a. Set the N2O flow to 9.0 L/min.

   b. Set the O2 flow to more than 3 L/min.

   c. Slowly turn the O2 flow control clockwise to set the N2O flow to the rates shown in the table. Make sure that the O2 flow must be greater than the minimum limits.

   d. If the O2 flow is set crossing the limit, before continuing the test, turn the N2O flow control counterclockwise till the N2O flow increases to the preset value.

Step	N2O flow (L/min)	O2 flow (L/min)
1	7.5	≥2.5
2	3.0	≥1.0
3	1.5	≥0.5
4	0.6	≥0.2

8. Cut off the N2O pipeline supply or close the N2O cylinder valve. Turn the O2 and N2O flow controls counterclockwise respectively and turn on the O2 and N2O flowmeters. Make sure that there is no residual gas in the N2O pathway and the pressure gauge in the N2O pathway goes to zero. Then turn the O2 and N2O flow controls clockwise respectively and make sure that the O2 and N2O flows are at the minimum.
9. Disconnect the O2 pipeline supply or close the O2 cylinder valve.
10. Set the system switch to the ⏻ position.

3.4.2 With O2 Sensor

Do as described in ***3.9.2Test the O2 Concentration Monitoring and Alarms*** before testing. To do the flow control system tests:

1. Connect the pipeline supplies or slowly open the cylinder valves.
2. Turn all flow controls fully clockwise (minimum flow).
3. Set the system switch to the ⊙ position.
4. Connect the AC power source if battery capacity shortage occurs. Do not use the system if other ventilator failure alarm occurs.
5. Set the flow controls to mid range. Check that the flowtube float moves smoothly.

⚠WARNING

- **During steps 6 through 7, the O2 sensor used must be correctly calibrated and the Link system must be kept in working status.**

6. Test the Link system with N2O flow increasing:

   a. Turn the O2 and N2O flow controls fully clockwise (minimum flow).

   b. Turn the N2O flow control only.

   c. Increase the N2O flow gradually and the O2 flow should increase accordingly. The measured O2 concentration must be ≥25% through the full range.

7. Test the Link system with O2 flow decreasing:

   a. Set the N2O flow to 9.0 L/min.

   b. Set the O2 flow to more than 3 L/min.

   c. Slowly turn the O2 flow control clockwise and the N2O flow should decrease accordingly. The measured O2 concentration must be ≥25% through the full range.

8. Cut off the N2O pipeline supply or close the N2O cylinder valve. Turn the O2 and N2O flow controls counterclockwise respectively and turn on the O2 and N2O flowmeters. Make sure that there is no residual gas in the N2O pathway and the pressure gauge in the N2O pathway goes to zero. Then turn the O2 and N2O flow controls clockwise respectively and make sure that the O2 and N2O flows are at the minimum.

9. Disconnect the pipeline supply or close the cylinder valve.

10. Set the system switch to the ⏻ position.

3.5 Vaporizer Back Pressure Test

⚠WARNING

- **Use only the Selectatec series vaporizers. Make sure that the vaporizers are locked when doing the test.**
- **During the test, the anesthetic agent comes out of the fresh gas outlet. Use a safe and approved procedure to remove and collect the agent.**
- **To prevent damage, turn the flow controls fully clockwise (minimum flow or OFF) before using the system.**

Before the test, make sure that the vaporizers are correctly installed.

1. Connect the O2 pipeline supply or open the O2 cylinder valve.
2. Turn the O2 flow control and set the O2 flow to 6 L/min.
3. Make sure that the O2 flow stays constant.
4. Adjust the vaporizer concentration from 0 to 1%. Make sure that the O2 flow must not decrease more than 1 L/min through the full range. Otherwise, install a different vaporizer and try this step again. If the problem persists, the malfunction is in the anesthesia system. Do not use this system.
5. Test each vaporizer as per the steps above.

NOTE

- **Do not perform test on the vaporizer when the concentration control is between "OFF" and the first graduation above "0" (zero) as the amount of anesthetic drug outputted is very small within this range.**

3.6 O2 Flush Test

3.6.1 In Mechanical Ventilation Mode

1. Connect the O2 pipeline supply or cylinder.
2. Set the Bag/vent switch to the mechanical ventilation position.
3. Set the system switch to the ⏻ position or set the system to Standby.
4. Plug the patient connection using a test plug.
5. Turn off ACGO (if ACGO is configured).
6. Let the bellows completely collapse.
7. Press and hold the O2 flush button O_2+. Measure the time required for fully inflating the bellows.
8. Repeat the operation (opening patient connection to collapse the bellows) at least twice.
9. Check that the bellows is fully inflated within 1 to 3 seconds.

3.6.2 In Manual Ventilation Mode

1. Set the Bag/vent switch to the bag position.
2. Set the system switch to the ⏻ position or set the system to Standby.
3. Plug the patient connection using a test plug.
4. Connect a 3 L or 1 L bag to the bag arm or manual bag port.
5. Turn off ACGO (if ACGO is configured).
6. Let the bag completely collapse.
7. Turn the APL valve to 75 cmH2O.
8. Press and hold the O2 flush button O_2+. Calculate the time required for the reading on the pressure gauge to reach 10 cmH2O.
9. Repeat the operation (open patient connection and press the bag to completely collapse the bag) at least twice.
10. Check that
    - The 3 L bag is fully inflated within 3 to 6 seconds.
    - The 1 L bag is fully inflated within 1 to 3 seconds.

3.7 Breathing Circuit Tests

⚠WARNING

- **Objects in the breathing circuit can stop gas flow to the patient. This can cause injury or death. Make sure that there are no test plugs or other objects in the breathing circuit. Make sure that there are no test plugs or other objects in the breathing circuit.**
- **Do not use a test plug that is small enough to fall into the breathing circuit.**

1. Make sure that the breathing circuit is correctly connected and not damaged.
2. Make sure that the check valves in the breathing circuit work correctly:
   - ◆ The inspiratory check valve opens during inspiration and closes at the end of inspiration, and remains closed during expiration.
   - ◆ The expiratory check valve opens during expiration and closes at the end of expiration, and remains closed during inspiration.

3.7.1 Bellows Test

1. Set the system to Standby.
2. Set the Bag/vent switch to the mechanical ventilation position.
3. Set all flow controls to minimum.
4. Connect the Y piece on the breathing tube to the leak test plug to occlude the outlet of the Y piece..
5. Push the O_2 flush button to fill the bellows, which rises to the top.
6. Make sure that the pressure reading on the airway pressure gauge must not increase to more than 15 cmH_2O
7. Release the O2 flush button and the bellows should not fall. If it falls, it indicates that the bellows assembly has a leak. You need to reinstall the bellows.

3.7.2 Breathing System Leak Test in Manual Ventilation Mode

NOTE

- **Perform leak test again each time after servicing the anesthesia machine, replacing the components, or re-connecting the tubes.**
- **Before performing breathing system leak test, make sure that there is no alarm of pressure monitoring channel failure on the screen.**

The test aims to check if the pneumatic circuit has leaks in manual ventilation mode. Test items include APL valve, check valve, sodalime canister, patient tubes, flow sensors and their connectors.
There are two methods available for breathing system leak test in manual ventilation mode. One is by software auto test and the other by manual test.

3.7.2.1 Software Auto Test

There are two ways available to enter the software auto test screen.
Way 1: Push the [**Maintenance**] key to enter the maintenance menu. Select [**Factory Maintenance>>**] and enter the required password to enter the factory maintenance menu. Select [**System Setup**] and switch on leak test in the system setup menu. Then restart the machine. Select [**Continue**] on the startup selftest result screen to enter the manual leak test screen.
Way 2: Make sure that the system is Standby. If not, press the ⏻ key and select [**Ok**] from the pop-up menu to enter Standby. Push the [**Maintenance**] key to enter the maintenance menu. Select [**System Leak&Compliance Test**] to enter manual leak test screen.

To do the manual leak test:

1. Make sure that the system is Standby. If not, press the ⏻ key and select [**Ok**] from the pop-up menu to enter Standby.
2. Set ACGO to patient circuit (if ACGO is configured).
3. Insert the Y piece into the test plug.
4. Install the manual bag.
5. Turn the APL valve to 75 cmH2O.
6. Turn all flow controls to zero.
7. Set the bag/vent switch to the bag position.
8. Push the O_2 flush button to let the pressure fall between 25 and 35 cmH2O on the airway pressure gauge.
9. Select [**Continue**] to start manual leak test.
10. When the manual leak test is completed, the screen for manual leak test result is switched to automatically, prompting the manual leak test result.
    - ◆ “Pass” is displayed if the manual leak test is passed.
    - ◆ “Fail” is displayed in red if the manual leak test is failed.

3.7.2.2 Manual Test

To do the breathing system leak test in manual ventilation mode:

1. Make sure that the system is Standby. If not, press the ⏻ key and select [**Ok**] from the pop-up menu to enter Standby.
2. Set ACGO to patient circuit (if ACGO is configured).
3. Set the bag/vent switch to the bag position.
4. Connect the manual bag to the manual bag port.
5. Turn the APL valve control to fully close the APL valve (75 cmH_2O).
6. Turn the O_2 flow control to set the O_2 flow to 0.15 to 0.2 L/min.
7. Close the breathing system at the patient connection.
8. Push the O_2 flush button to let the pressure increase to approximately 30 cmH_2O on the airway pressure gauge.
9. Release the O2 flush button. A pressure decrease on the airway pressure gauge indicates a leak. Look for and repair the breathing system leak.

3.7.2.3 Commonly-encountered Problems and Recommended Actions

The following table lists the commonly-encountered problems and recommends actions for breathing system leak test in manual ventilation mode.

Failure description	Possible cause	Recommended action
Software auto leak test is failed.	1. The reading on the drive gas pressure gauge indicates drive gas pressure low (lower than 200 kPa) and the alarm of [**Drive Gas Pressure Low**] is produced.	Replace or connect gas supplies and make sure that the drive gas pressure is at 280 to 600 kPa.
	2. The bag/vent switch is not set to the bag position.	Set the bag/vent switch to the mechanical ventilation position.
Manual circuit is leaky.	1. The Y piece on the breathing tube is not connected to the test plug. 2. The APL valve is not turned to the maximum pressure. 3. The manual bag port is not occluded with test lung. 4. The CO2 absorbent canister is not installed in place.	Check the pneumatic connections and do the test again strictly following the operation instructions.

3.7.2.4 Definitions of Error Information during Breathing System Leak Test in Manual Ventilation Mode

During the leak test, many abnormal factors or operations may result in breathing system manual circuit leak test failure. The following table lists the definitions of various abnormal factors. If the breathing system leak test fails, the relevant error code will be recorded in the service logbook.

S/N	Cause	Description	Error code
1	The user cancels the command.	/	0000 0001
2	The bag/vent switch is in vent position.	/	0000 0002
3	ACGO is ON.	/	0000 0004
4	O2 supply pressure is low.	/	0000 0008
5	The airway pressure sensor has an error.	The zero point of airway pressure sensor is not within the range of 0~1200(AD).	0000 0010
6	The airway pressure is not sufficient.	Before the test, the airway pressure in the circuit is less than 18cmH2O	0000 0020
7	Pressure drops drastically.	Pressure drops by more than 10cmH2O.	0000 0040

NOTE

- **If there is indeed a leak, check the pneumatic circuit system for leakage and troubleshoot the problems as described in 5.3Pneumatic Circuit System Problems.**
- **After leak failure is troubleshot, do the leak test again and make sure the test is passed.**

3.7.3 Breathing System Leak Test in Mechanical Ventilation Mode

NOTE

- **Perform leak test again each time after servicing the anesthesia machine, replacing the components, or re-connecting the tubes.**

The test aims to check if the pneumatic circuit has leaks in mechanical ventilation mode. Test items include bellows, drive gas circuit, CO2 absorbent canister, patient tubes, flow sensors and their connectors.

3.7.3.1 Test Procedures

NOTE

- **Breathing circuit leak test must be performed when the system is Standby.**
- **Before doing the breathing circuit leak test, make sure that the breathing circuit is correctly connected and the breathing tubes not damaged.**
- **Before doing the breathing system leak test, make sure that the drive gas pressure is sufficient and the screen does not have alarms of flow sensor failure or pressure monitoring channel failure. During the leak test, make sure that the test procedures are strictly followed.**
- **During the leak test, selecting [Cancel] will stop the ongoing leak test. To continue the test, you must select [Continue] to start the leak test again.**

To do the breathing system leak test in mechanical ventilation mode:
To do the breathing system leak test in mechanical ventilation mode:

1. Make sure that the system is Standby. If not, press the ⏻ key and select [**Ok**] from the pop-up menu to enter Standby.
2. Set ACGO to patient circuit (if ACGO is configured).
3. Connect the Y piece on the breathing tube to the leak test plug to occlude the outlet of Y piece.
4. Turn all flow controls to zero.
5. Make sure that the bag/vent switch is set to the position.
6. Push the O_2 flush button to fill the bellows, bellows rising to the top.
7. Select the [**Maintenance**] shortcut key and select [**System Leak&Compliance Test**] to enter the manual leak test screen. Select [**Skip**] to enter the auto leak test screen. Select [**Continue**] to start the breathing system leak test and compliance test in mechanical ventilation mode. Typically, the test requires 3 to 5 minutes.
8. When the leak test is completed, the screen for auto leak&compliance test result is switched to automatically, prompting the system leakage and system compliance test result.

   1) If the leakage is less than or equal to 200 ml/min, it indicates that the system has good airtightness. The actual leakage is displayed in green.

   2) If the leakage is between 200 and 1000 ml/min (including 1000 ml/min), it indicates that the system has some leakage. The actual leakage is displayed in red.

   3) If the leakage is greater than 1000 ml/min, it indicates that the system has significant leakage. “>1000 ml/min” is displayed in red.

   4) “Fail” is displayed directly when the leak test cannot be executed or the leakage is too serious.

5) If the tube compliance is displayed in green numerics, it indicates that the tube compliance measured value is within the reasonable range. If tube compliance measurement is failed because the leakage exceeds 200 ml/min or due to other reason, the failure message is displayed directly.

9. If the leak test is passed, it indicates that leakage of mechanical ventilation circuit is within 0.2 L/min and the system has good airtightness. If the leak test is failed, it indicates that the leakage of mechanical ventilation circuit exceeds 0.2 L/min and the leak test screen prompts the user to do the following checking:

   1) If the Y-shaped tube is sealed;

   2) If the bellows rises to the top of the bellows housing;

   3) If the O2 sensor is installed;

   4) If the sampling port is occluded;

   5) Select Retry to do the test again and select Override to enter Standby.

Check following the above steps. Select Retry to do the test again. If the leak test is still failed, overhaul the machine.

NOTE

- **In case of leak test failure, check all of the possible leak sources, including bellows, breathing system tubes and CO2 absorbent canister. Check that they are correctly connected and their connectors are not damaged.**
- **If there is indeed a leak, check the pneumatic circuit system for leakage and troubleshoot the problems as described in 5.3Pneumatic Circuit System Problems.**
- **After leak failure is troubleshot, do the leak test again and make sure the test is passed.**

3.7.3.2 Commonly-encountered Problems and Recommended Actions

The following table lists the commonly-encountered problems and recommends actions for breathing system leak test in mechanical ventilation mode.

Failure description	Possible cause	Recommended action
Leak test failure is prompted immediately after [**Start**] is selected (typically, the leak test requires at least 3 minutes).	The bag/vent switch is set to the bag position and the message [**Manual Vent.**] is prompted.	Set the bag/vent switch to the mechanical ventilation position.
	The reading on the drive gas (O2) pressure gauge indicates drive gas pressure low (lower than 200 kPa) and the alarm of [**Drive Gas Pressure Low**] is produced.	Replace or connect gas supplies and make sure that the drive gas pressure is at 280 to 600 kPa.
	The ACGO switch is turned on and the screen displays prompt message of ACGO.	Turn off the ACGO switch.
The airway pressure does not drop during the test but test failure is prompted.	Fresh gas is not turned off.	Turn off the fresh gas.
During leak test, the pressure indicated by the airway pressure gauge fails to reach 30 cmH2O.	1. Before the leak test, the bellows is not fully inflated. 2. The Y piece on the breathing tube is not connected to the test plug. 3. The bellows housing is not properly installed. 4. The CO2 absorbent canister is not installed in place.	Check the pneumatic connections and re-install the pneumatic circuit.
During leak test, the pressure indicated by the airway pressure gauge reaches 30 cmH2O but then falls rapidly.	1. The bellows housing may not be installed properly. 2. The expiratory valve assembly is leaky. 3. The circuit is not tightly connected to the circuit adapter. 4. The connection between the sampling line of the sensor and the board is leaky.	Check the pneumatic connections and re-install the pneumatic circuit.
After the leak test, the alarm of [**Ventilator Hardware Error 11**] occurs.	Control of safety valve by the auxiliary control board fails.	Restart the machine. Verify if the safety valve is controllable by using the safety valve control command of the monitor board.

Failure description	Possible cause	Recommended action
After the leak test, the alarm of [**PEEP Safety Valve Failure**] occurs.	Control of safety valve by the monitor board fails.	If the safety valve is damaged, replace the safety valve. If the safety valve is in good condition, it indicates that the auxiliary control board or the main control board is faulty regarding the control path of the safety valve. Check the connecting lines or replace the faulty board.

3.7.3.3 Definitions of Error Information during Breathing System Leak Test in Mechanical Ventilation Mode

During the leak test, many abnormal factors or operations may result in breathing system manual circuit leak test failure. The following table lists the definitions of various abnormal factors. If the breathing system leak test fails, the relevant error code will be recorded in the service logbook.

S/N	Cause	Description	Error code
1	The user cancels the command.	/	0000 0001
2	The bag/vent switch is in bag position.	/	0000 0002
3	ACGO is ON.	/	0000 0004
4	The drive gas pressure is low.	/	0000 0008
5	The airway pressure sensor has an error.	The zero point of airway pressure sensor is not within the range of 0~1200(AD).	0000 0010
6	The flow sensor has an error.	/	0000 0020
7	Pressure rise time is too long.	The longest time for pressure to rise to the specified pressure threshold 30cmH2O (+5cmH2O) exceeds 30s.	0000 0040
8	Pressure drops drastically.	Pressure is less than 18cmH2O.	0000 0080
9	Leakage is too large.	Leakage exceeds 1000ml/min.	0000 0100

NOTE

- **In case of leak test failure, check the machine for leakage and roughly assess the amount of leakage by using the following methods.**
  - Method 1: In the default VCV mode, stop fresh gas supply. If the bellows rises to the top each time, it indicates that the machine is not leaky. Otherwise, the machine is leaky. Gradually increase fresh gas. The amount of fresh gas when the bag rises to the top at each expiration can be roughly calculated as the amount of leakage.
  - Method 2: During leak test, observe the airway pressure gauge. A period of time (about 30 s) belongs to pressure holding stage after the airway pressure rises. If the airway pressure gauge shows that airway pressure is gradually falling, it indicates that the machine is leaky. Slowly increase fresh gas until airway pressure stops falling. The amount of the then fresh gas can be calculated as amount of leakage.
- **If there is indeed a leak, check the pneumatic circuit system for leakage and troubleshoot the problems as described in 5.3Pneumatic Circuit System Problems.**
- **After leak failure is troubleshot, do the leak test again and make sure the test is passed.**

3.7.4 APL Valve Test

1. Make sure that the system is Standby. If not, press the ⏻ key and select [**Ok**] from the pop-up menu to enter Standby.
2. Set the Bag/vent switch to the bag position.
3. Connect the manual bag to the manual bag port.
4. Connect the Y piece on the breathing tube to the leak test plug on the manual bag port.
5. Turn the APL valve control to let the pressure of APL valve stay at 30 cmH_2O.
6. Push the O2 flush button to inflate the manual bag.
7. Make sure that the reading on the airway pressure gauge is with the range of 25 to 35 cmH_2O.
8. Turn the APL valve control to the SP position.
9. Set the O_2 flow to 3 L/min. Turn any other gases off.
10. Make sure that the reading on the airway pressure gauge is less than 5 cmH_2O.
11. Push the O_2 flush button. Make sure that the reading on the airway pressure gauge does not exceed 10 cmH2O.
12. Turn the O_2 flow control to set the O_2 flow to minimum. Make sure that the reading on the airway pressure gauge does not decrease below 0 cmH_2O.

3.8 Pressure Relief Valve Test

This test can be performed if ACGO is configured.

Perform the pressure relief valve test by using the following tools:

- Anesthesia machine calibration device (quantity:1)
- Circuit adapter test fixture (quantity:1)
- Injector (100 ml) (quantity:1)
- Φ6 silicone tube (quantity:2)
- PU tube (6X300) (quantity:1)
- Y piece (quantity:1)

Test procedures:

1. Turn the system switch off. Close all flow regulators. Turn on ACGO.
2. Pull out the patient circuit. Mount the circuit adapter test fixture onto the circuit adapter.
3. Connect the pressure sensor connector (positive pressure end) on the anesthesia machine calibration device and the injector (before mounting, pull out the push rod of the injector to the graduation of 100 ml) connector to two connectors of the Y piece through two Φ6 silicone tubes. Connect the third connector of the Y piece to No.8 connector on the circuit adapter test fixture through the PU tube (6X300), as shown below.

4. Push in the push rod of the injector to cause the pressure reading on the anesthesia machine calibration device to rise slowly (note to push in the rod at uniform and slow velocity to control the time required for the pressure reading to slowly rise to 100 cmH2O more than 10 s). Continue pushing the push rod at uniform velocity until the rod stops. During the course of pushing in the injector's push rod, the pressure reading on the anesthesia machine calibration device tends to be stable after the tested pressure relief valve is opened. The pressure reading on the anesthesia machine calibration device after the tested pressure relief valve is open should be within 100 to 125 cmH2O. Otherwise, the test is failed. In this case, you need to replace the pressure relief valve assembly (BOM number: 0621-30-69662).

3.9 Alarm Tests

3.9.1 Prepare for Alarm Tests

1. Connect a test lung or manual bag to the Y piece patient connection.
2. Set the Bag/vent switch to the  position.
3. Set the system switch to the  position.
4. Set the system to Standby.
5. Set the ventilator controls as follows:
   - Ventilation mode: select [**Vent Mode**] and then [**VCV**].
   - [**TV**]: 500 ml.
   - [**Rate**]:12 BPM.
   - [**I:E**]: 1:2.
   - [**Plimit**]: 30 cmH_2O.
   - [**PEEP**]: OFF.
   - [**TIP:TI**]: OFF.
6. Push the O_2 flush button to fill the bellows, which rises to the top.
7. Turn the O_2 flow control to set the O_2 flow to 0.5 to 1 L/min.
8 Press the  key and select [**Ok**] from the pop-up menu to exit Standby.
9. Make sure that:
   - The ventilator displays the correct data.
   - The bellows inflates and deflates normally during mechanical ventilation.

3.9.2 Test the O_2 Concentration Monitoring and Alarms

NOTE

- **This test is not required if O_2 sensor is not configured.**

1. Set the Bag/vent switch to the  position.
2. Remove the O_2 sensor and make sure that the sensor measures approximately 21% O_2 in room air.
3. Select [**Alarm Setup**] and then [**Ventilator >>**]. Set the FiO_2 low alarm limit to 50%.
4. Make sure that a low FiO_2 alarm occurs.
5. Set the FiO_2 low alarm limit to a value less than the measured FiO_2 value and make sure that the alarm cancels.
6. Put the O_2 sensor back in the circuit.
7. Select [**Alarm Setup**] and then [**Ventilator >>**]. Set the FiO_2 high alarm limit to 50%.
8. Connect the manual bag to the manual bag port. Push the O_2 flush button to fill the manual bag. After two to three minutes, make sure that the sensor measures approximately 100% O_2.
9. Make sure that a high FiO_2 alarm occurs.
10. Set the FiO_2 high alarm limit to 100% and make sure that the alarm cancels.

3.9.3 Test the Low Minute Volume (MV) Alarm

1. Make sure that MV alarm is turned on.
2. Select [**Alarm Setup**] and then [**Ventilator >>**]. Set the MV low alarm limit to 8.0 L/min.
3. Make sure that a low MV alarm occurs.
4. Select [**Alarm Setup**] and then [**Ventilator >>**]. Set the MV low alarm limit to the default.

3.9.4 Test the Apnea Alarm

1. Connect the manual bag to the manual bag port.
2. Set the Bag/vent switch to the  position.
3. Turn the APL valve control to set the APL valve to the minimum position.
4. Inflate the manual bag to make sure that a complete breathing cycle occurs.
5. Stop inflating the manual bag and wait for at least 20 seconds to make sure that the apnea alarm occurs.
6. Inflate the manual bag to make sure that the alarm cancels.

3.9.5 Test the Sustained Airway Pressure Alarm

1. Connect the manual bag to the manual bag port.
2. Turn the O_2 flow control to set the O_2 flow to minimum.
3. Turn the APL valve control to set the APL valve to 30 cmH_2O position.
4. Set the Bag/vent switch to the  position.
5. Push the O_2 flush button for approximately 15 seconds. Make sure that the sustained airway pressure alarm occurs.
6. Open the patient connection and make sure that the alarm cancels.

3.9.6 Test the High Paw Alarm

1. Set the Bag/vent switch to the  position.
2. Select [**Alarm Setup**] and then [**Ventilator >>**].
3. Set the Paw low alarm limit to 0 cmH_2O and Paw high alarm limit to 5 cmH_2O.
4. Make sure that a high Paw alarm occurs.
5. Set the Paw high alarm limit to 40 cmH_2O.
6. Make sure the high Paw alarm cancels.

3.9.7 Test the Low Paw Alarm

1. Set the Bag/vent switch to the  position.
2. Select [**Alarm Setup**] and then [**Ventilator >>**].
3. Set the Paw low alarm limit to 2 cmH_2O.
4. Disconnect the manual bag from the Y piece patient connection.
5. Wait for 20 seconds. View the alarm area and make sure that a low Paw alarm occurs.
6. Connect the manual bag to the manual bag port. Push the O2 flush button to fill the bellows, bellows rising to the top.
7. Make sure the low Paw alarm cancels.

3.10 AGSS Inspection

3.10.1 Check the Float

Install the AGSS and connect the gas supplies. Check if the float floats off and is between the MAX and MIN levels. If the float fails to be between the MAX and MIN levels by turning the flow adjustment knob at the top of AGSS, or if the float is tacky or damaged, re-install the AGSS or replace the float.

NOTE

- **Do not block the AGSS pressure compensation openings during the inspection.**

If the float fails to float off, the possible reasons are:

1. The float is tacky or stuck to the guide bar. Invert the AGSS and check if the float moves up and down freely. If not, clean where the float and guide bar meet to remove possible foreign substance. Replace the float or guide bar when necessary.
2. The filter screen inside the top cove may be occluded. Remove the filter screen as described below and check if the filter screen is occluded.

a. Turn the top cover counterclockwise to separate it from the sight glass. Remove the filter screen.

b. Shake dust and foreign substance from the removed filter screen until satisfactory clean effect is achieved.

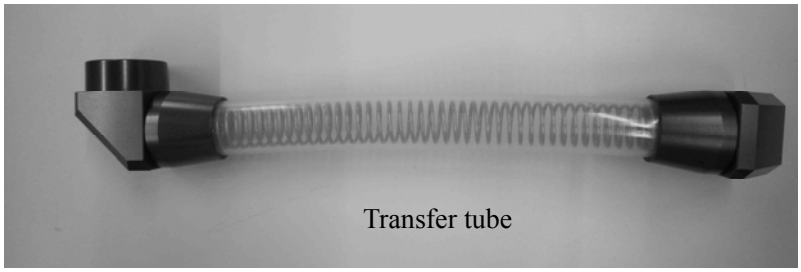
3. The waste gas disposal system is not working or the pump rate is less than the AGSS normal working flow. Check if the waste gas disposal system reaches the pump rate range which the AGSS declares, which is 25 to 50 L/min for low flow AGSS and 75 to 105 L/min for high flow AGSS.

3.10.2 Check the Transfer Tube and Active Scavenging Tube

1. Disconnect the tubes from other components.

   Check the transfer tube and its connectors for damage.

   Check if the transparent silicone hose for damage.

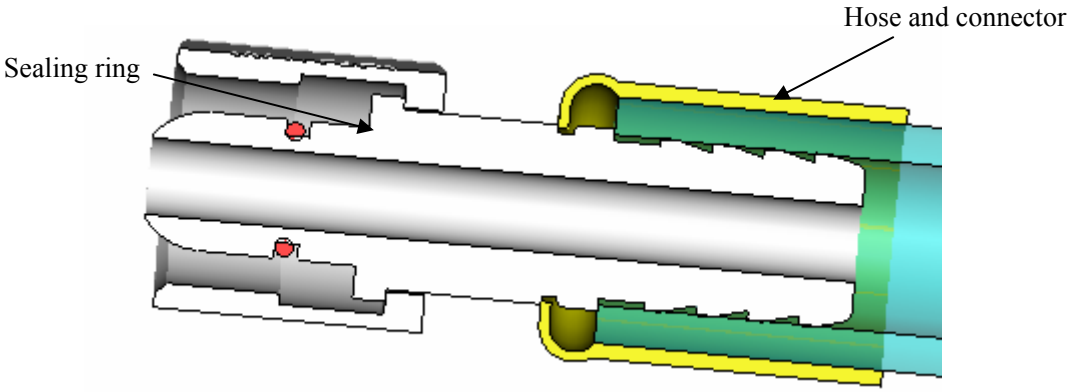

Transfer tube

2. Check the receiving hose regarding the following three aspects:

   a. The receiving hose and its connectors for damage.

   b. If the connections between the receiving hose and its connectors are loose.

   c. The sealing ring for damage.



If any damage or loose connection is detected, replace the corresponding part.

3.11 Negative Pressure Suction Inspection

3.11.1 Check the Tube Connections of Liquid Collection Bottle

1. Check if the tubes are correctly connected following the connection diagram printed on the liquid collection bottle. If not, the overfill protection device cannot work normally.
2. Check if the tubes are inserted in place. If not, leakage may occur, resulting in failure to reach negative pressure of 40 kPa.

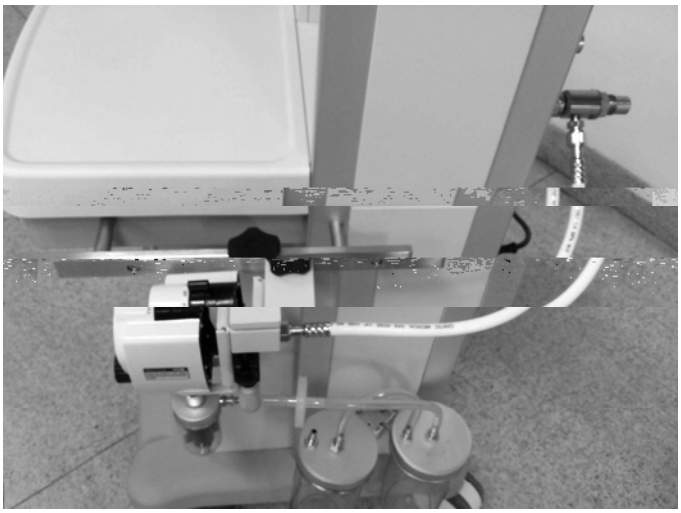
3.11.2 Check the Negative Pressure

1. Read the reading on the Air pipeline pressure gauge on the front side of the anesthesia machine and make sure that the pipeline supply gas pressure is within the normal pressure range.
2. Set the swapping switch on the negative pressure regulator to REG position.
3. Set the switch of Venturi negative pressure generator to ON position.
4. Occlude the patient connection outlet of suction tube with hand.
5. Check if the reading on the negative pressure regulator is greater than 40 kPa. If it is less than 40 kPa, check the following:

   a. Increase the pressure at the rear end of negative pressure regulator clockwise.

   b. Rotate counterclockwise to remove the muffler. Shake dust and foreign substance from the muffler.

   c. Occlusion can occur after the filter is used for a long time. Replace the filter and do the test again.



3.12 Power Failure Test

1. Connect the anesthesia machine to the AC power source. Both AC power LED should come on. If the AC power LED is not lit, check the fuse and power board.
2. Set the system switch to the ⊙ position.
3. Unplug the power cord with the system turned on. The message [**Battery in Use**] is displayed. Meanwhile, the AC power LED is extinguished.
4. Reconnect the AC power. The prompt message disappears. The AC power LED is illuminated.

3.13 Electrical Safety Inspection

NOTE

- **Perform electrical safety inspection after servicing or routine maintenance. Before the electrical safety inspection, make sure all the covers, panels, and screws are correctly installed.**
- **The electrical safety inspection should be performed once a year.**

3.13.1 Auxiliary Electrical Outlet Test

Verify the mains voltage is present at each auxiliary outlet when the anesthesia machine is connected with power.

3.13.2 Electrical Safety Inspection Test

1. Perform protective earth resistance test:

   a. Plug the probes of the analyzer into the protective earth terminal and equipotential terminal of the AC power cord.

   b. Test the earth resistance with a current of 25 A.

   c. Verify the resistance is less than 0.1ohms (100 mohms).

   d. Plug the probes of the analyzer into the protective earth terminal of the AC power cord and the protective earth terminal of any auxiliary outlet. Repeat steps b and c.

   e. If the resistance is larger than 0.1ohms (100 mohms) but less than 0.2ohms (200 mohms), disconnect the AC power cord and plug the probe that is previously plugged in the protective earth terminal of the AC power cord into the protective earth contact of the power outlet. Repeat steps a to d.
2. Connect the compressor, if configured, to the auxiliary electrical outlet.
3. Perform the following earth leakage current tests:
   - normal polarity;
   - reverse polarity;
   - normal polarity with open neutral; and
   - reverse polarity with open neutral.
4. Verify the maximum leakage current does not exceed 500 μA (0.5 mA) in the first two tests. While for the last two tests, verify that the maximum leakage current does not exceed 1000 μA (1 mA).

NOTE

- **Make sure the safety analyzer is authorized by certificate organizations (UL, CSA, or AMAI etc.). Follow the instructions of the analyzer manufacturer.**

3.13.3 Electrical Safety Inspection Form

<table>
<tr><td colspan="4">Location:</td><td colspan="2">Technician:</td></tr>
<tr><td colspan="4">Equipment:</td><td colspan="2">Control Number:</td></tr>
<tr><td colspan="3">Manufacturer:</td><td>Model:</td><td colspan="2">SN:</td></tr>
<tr><td colspan="4">Measurement equipment /SN:</td><td colspan="2">Date of Calibration:</td></tr>
<tr><td colspan="4">INSPECTION AND TESTING</td><td>Pass/Fail</td><td>Limit</td></tr>
<tr><td>1</td><td colspan="3">Auxiliary mains socket outlets</td><td></td><td></td></tr>
<tr><td>2</td><td colspan="2">Protective Earth Resistance</td><td>Ω</td><td></td><td>Max 0.1 Ω</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Earth Leakage</td><td>Normal condition(NC)</td><td>____μA</td><td></td><td rowspan="2">Max:
NC: 500μA
SFC: 1000μA</td></tr>
<tr><td>Single Fault condition(SFC)</td><td>____μA</td><td></td></tr>
</table>

For periodically performance, all the test items included in the ELECTRICAL SAFETY INSPECTION FORM shall be performed. The following table specifies test items to be performed after the equipment is repaired with main unit disassembled.

When neither power supply PCBA, transformer nor patient electrically-connected PCBA is repaired or replaced	Test items: 1, 2
When power supply PCBA or transformer is repaired or replaced	Test items: 1, 2, 3

4 Maintenance and Calibration

⚠WARNING

- **When it comes to test and maintain the equipment, make sure that the patient is disconnected from the equipment.**
- **The equipment may have been used on patients carrying infectious diseases. Before testing or maintaining the equipment, wear sterile rubber gloves to reduce the risk of being infected.**
- **When the equipment to be maintained contains blood or other secretion, clean, disinfect and sterilize the equipment by strictly following the control and safety handling procedures for infectious diseases.**

4.1 Equipment Maintenance

To ensure the long-term reliability and stability of the anesthesia machine, periodical maintenance of the equipment and replacement of its parts must be performed by authorized service personnel. For details about parts replacement, refer to*6Repair* and Disassembly Periodical parts replacement can be carried out every year or every three years. Make records of the parts that have been replaced before the periodical replacement.

NOTE

- **These schedules are the minimum frequency based on typical usage of 2000 hours per year. You should service the equipment more frequently if you use it more than the typical yearly usage.**
- **To avoid equipment damage or personal injury, replace the parts which need to be replaced periodically even if they are not worn or damaged when the due date arrives.**

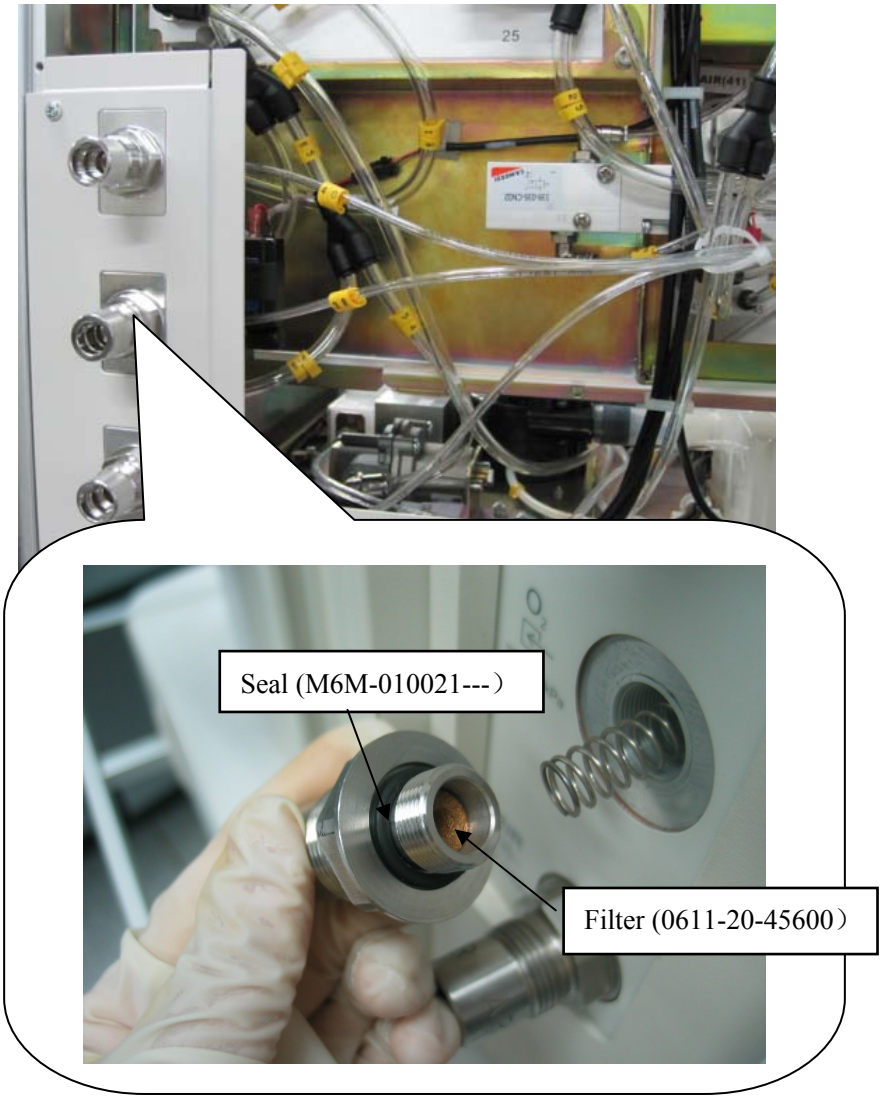
4.1.1 One-year Replaceable Parts

List of one-year service package (0621-30-78479):

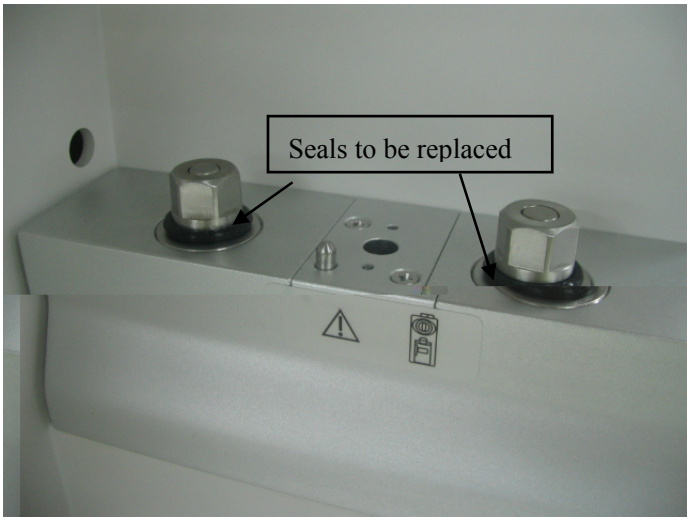
SN	P/N	Description	Qty
1	0611-20-45600	Gas supply inlet filter	3
2	M6M-010021---	Seal for gas supply inlet assembly	3
3	M6M-010014---	Seal for vaporizer manifold	4
4	M6M-010031---	Seal for valve cover	2
5	M6M-010033---	Valve seal	2
6	M6M-010058---	Seal for bag arm	2
7	M6M-010038---	Seal for water collection cup	1
8	049-000154-00	Sealing cushion for CO2 absorbent canister outlet	1
9	0601-20-78842	Sealing component for CO2 absorbent canister	1
10	M6M-010051---	Seal for CO2 absorbent canister support	1
11	M6M-010063---	Seal for pressure sampling connector	4
12	M6M-010006---	Seal for fresh gas and ACGO	2
13	M6M-010058---	Seal for drive gas and APL discharge	2
14	0601-20-78848	Seal for bellows housing	1
15	049-000049-00	Bellows	1
16	0030-10-13077	Seal for axis of Bag/vent switch	2
17	0601-20-78840	BYPASS large sealing cushion	1
18	049-000415-00	Sealing cushion at the outlet (20L)	1
19	049-000416-00	Sealing cushion for CO2 absorbent canister(20L)	1
20	049-000422-00	Sealing cushion for adapter plate (20L)	1

4.1.1.1 Parts Replacement

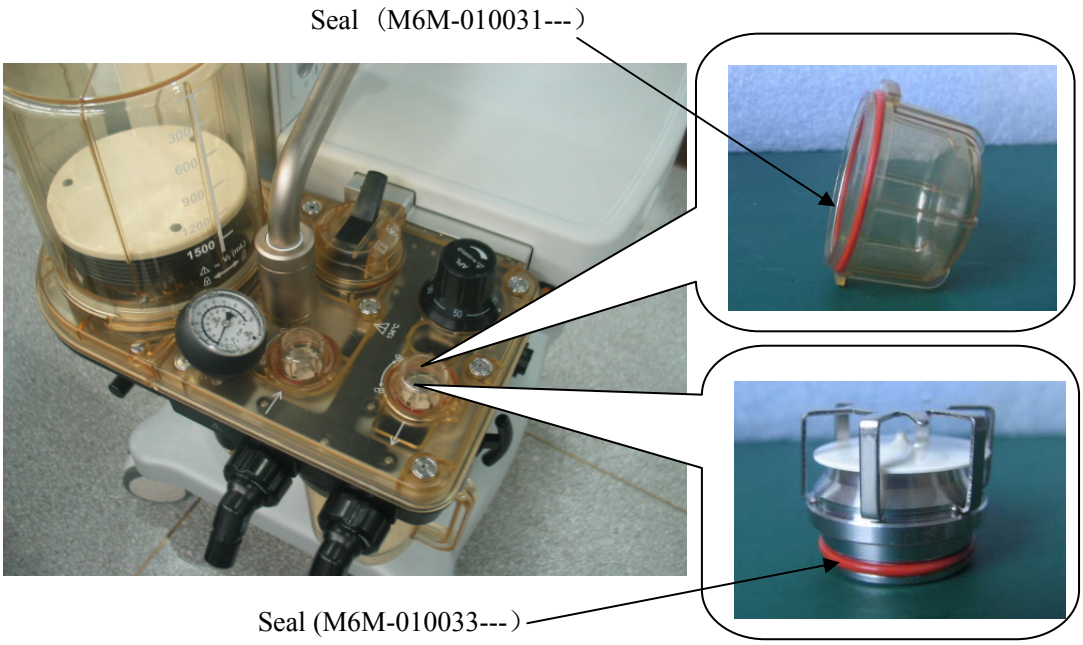
1. As required, replace the gas supply inlet filter (0611-20-45600) and seal for gas supply inlet assembly (M6M-010021---) every 12 months. Unscrew the gas supply inlet counterclockwise using a wrench to disassemble the gas supply inlet assembly as shown below (take O2 supply inlet as an example).



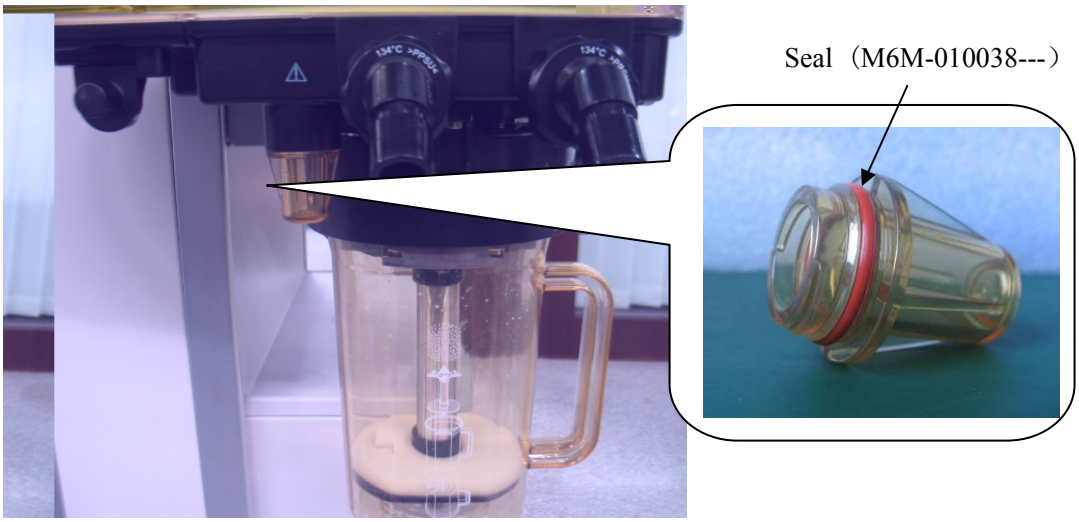
2. As required, replace the seals (M6M-010014---) where vaporizer manifold connectors meet the vaporizers every 12 months



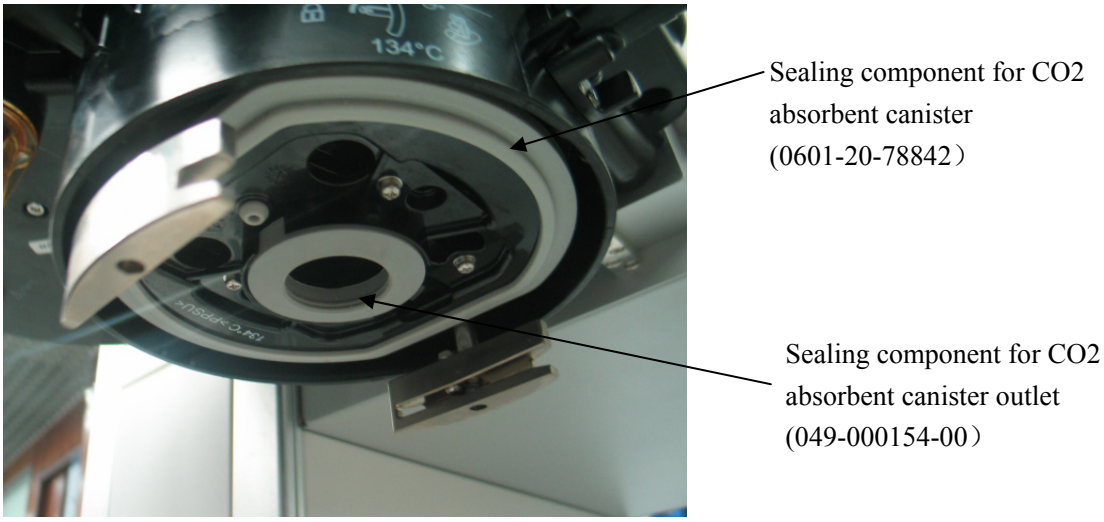
3. As required, replace the seal for valve cover (M6M-010031--) and valve seal (M6M-010033---) every 12 months.



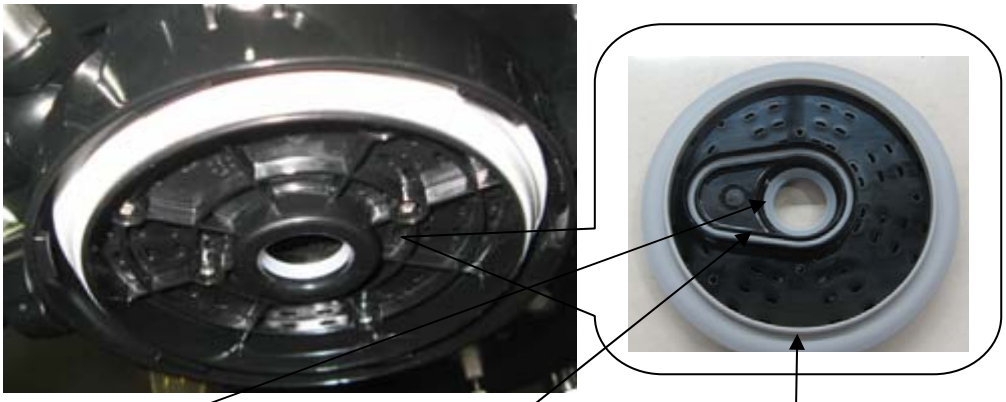
4. As required, replace the seal for water collection cup (M6M-010038---) every 12 months.



5. For WATO EX-25/30/35 anesthesia machine, as required, replace the sealing component for CO2 absorbent canister outlet (049-000154-00) and sealing component for CO2 absorbent canister (0601-20-78842) every 12 months.



For WATO EX-20 anesthesia machine, replace the sealing component for CO2 absorbent canister outlet (049-000415-00), sealing cushion for CO2 absorbent canister (049-000416-00) and sealing cushion for adapter plate (049-000422-00).

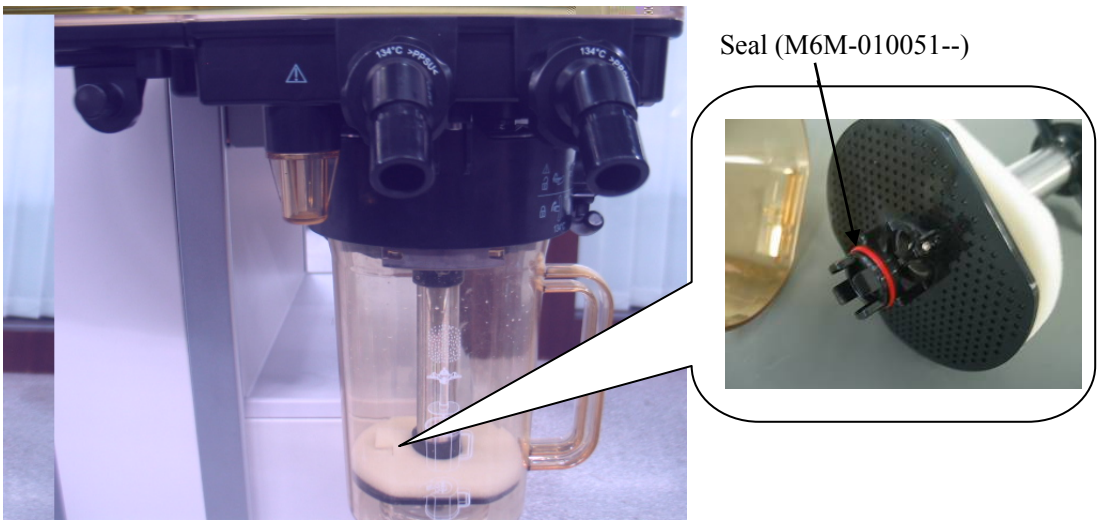


Sealing cushion for adapter plate (049-000422-00)

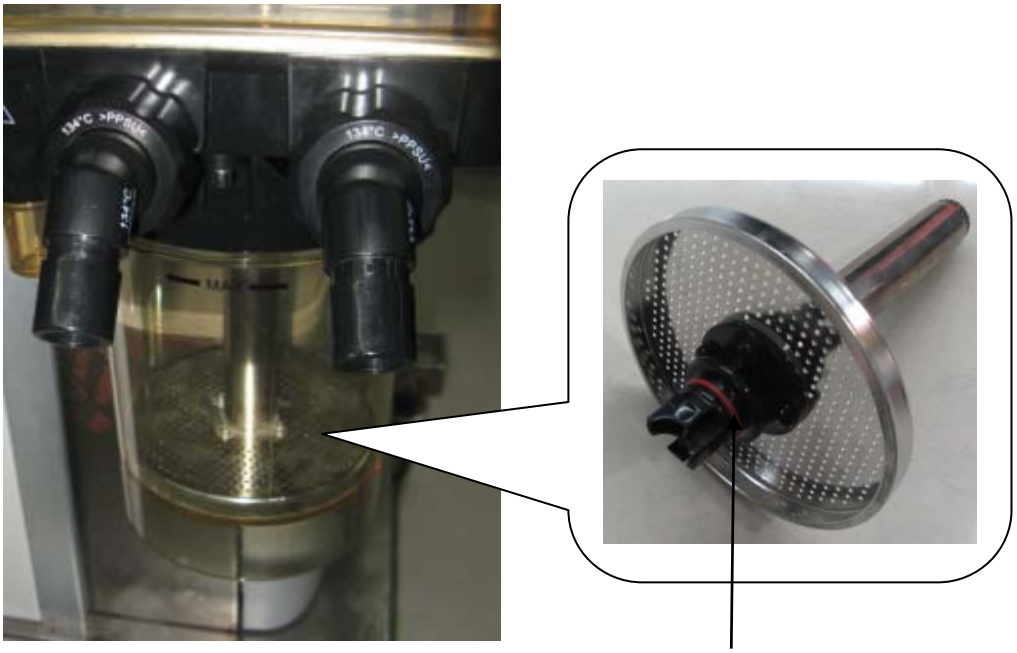
Sealing cushion for CO2 absorbent canister (049-000416-00)

Sealing component for CO2 absorbent canister outlet (049-000415-00)

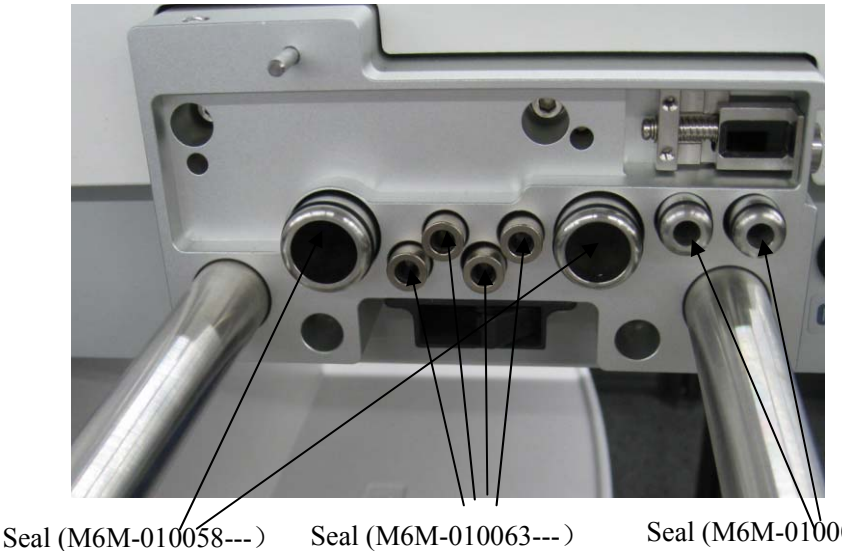
6. For WATO EX-25/30/35 anesthesia machine, as required, replace the seal for CO2 absorbent canister support (M6M-010051--) every 12 months.



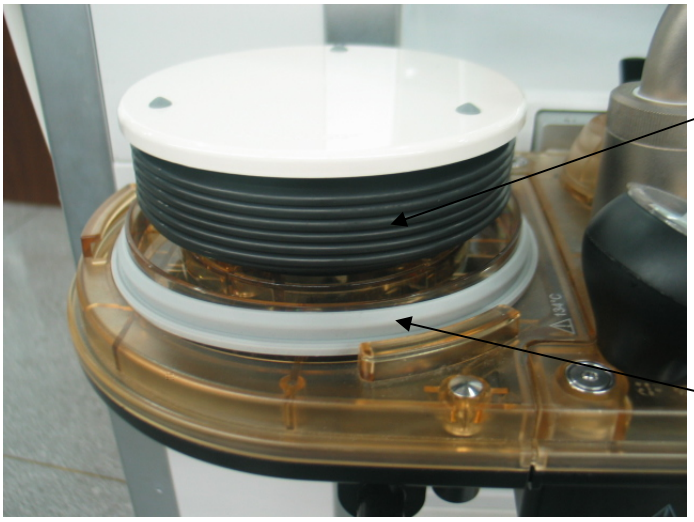
For WATO EX-20 anesthesia machine, replace the seal for CO2 absorbent canister support (M6M-010051--) every 12 months.



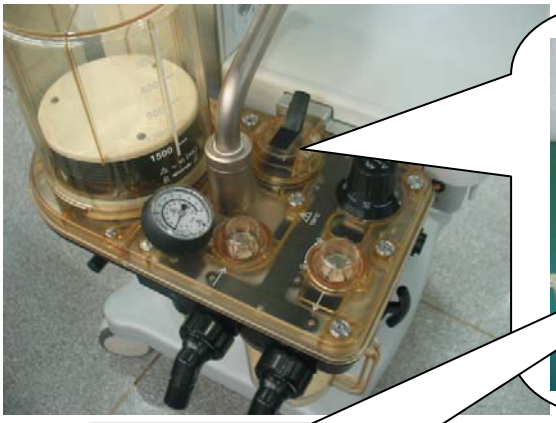
7. As required, replace the seal for pressure sampling connector (M6M-010063---), seal for fresh gas and ACGO (M6M-010006---), seal for drive gas and APL discharge (M6M-010058---) every 12 months.

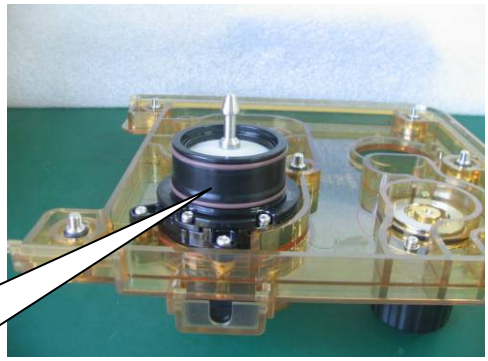


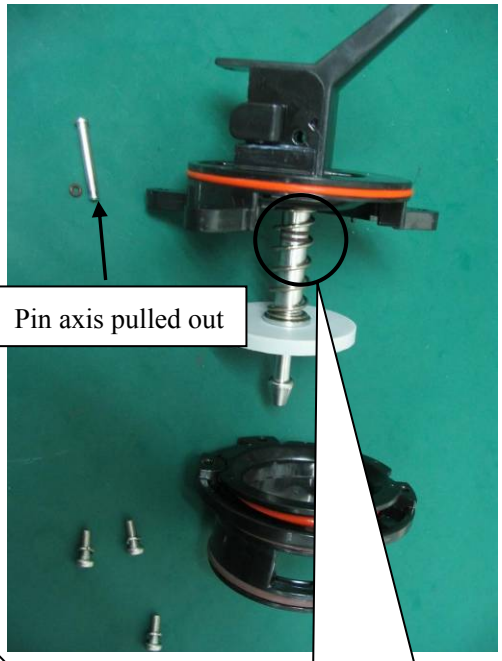
8. As required, replace the seal for bellows housing (0601-20-78848) and bellows (0601-10-69901) every 12 months.

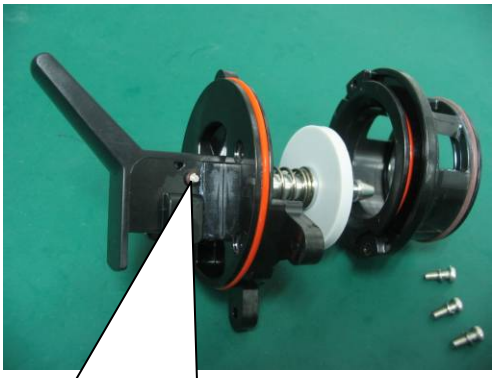


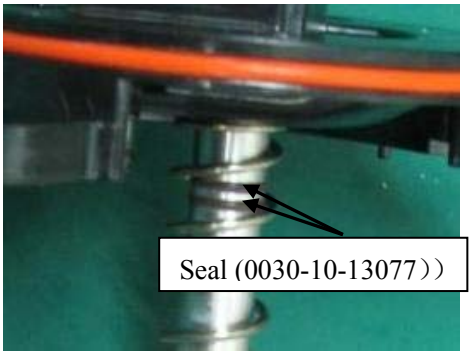
9. As required, replace the seal for axis of Bag/vent switch (0030-10-13077) every 12 months. For details, refer to *6Repair* and Disassembly**.**



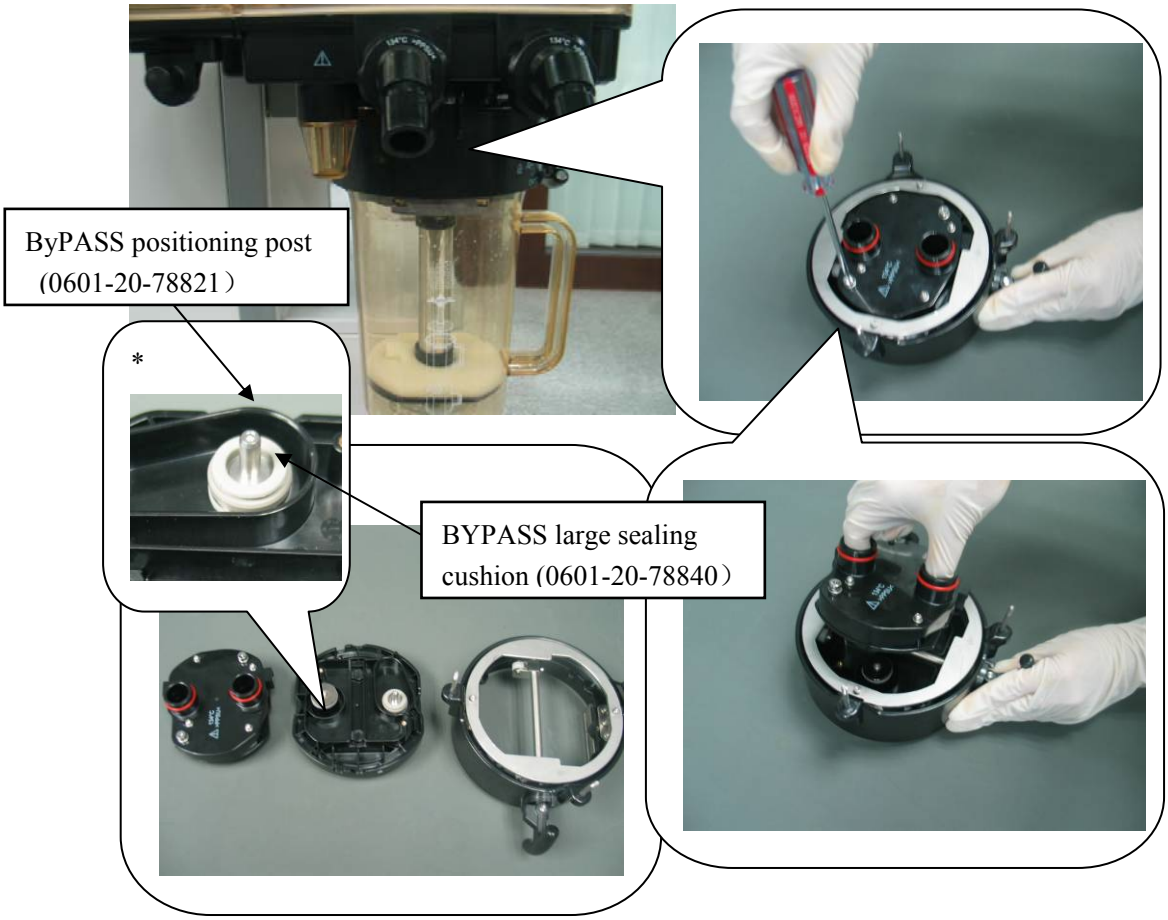








10. For WATO EX-25/30/35 anesthesia machine, as required, replace the BYPASS large sealing cushion (0601-20-78840) every 12 months. If the BYPASS large sealing cushion needs to be replaced, apply threadlocker Loctite® 243(A90-000060---) to the threads of the ByPASS positioning post (0601-20-78821) when a new BYPASS large sealing cushion is to be assembled. For WATO EX-20 anesthesia machine, this step is not required.



4.1.1.2 Checkout and Test of the Anesthesia Machine

Perform the following maintenance procedures every 12 months:

1. System inspection (refer to 3.1).
2. Pipeline test (refer to 3.2).
3. Cylinder test (refer to 3.3).
4. Flow control system test (refer to 3.4).
5. Vaporizer back pressure test (refer to **3.5**).
6. O2 flush test (refer to 3.6).
7. Breathing circuit test (refer to 3.7).
8. Pressure relief valve test (refer to 3.8).
9. Alarm test (refer to 3.9).

10. AGSS inspection (refer to 3.10).
11. Power failure test (refer to 3.12).
12. Electrical safety test (refer to 3.13).
13. Flow sensor calibration (refer to 4.3.2).
14. O2 sensor calibration (refer to 4.3.5).
15. APL valve accuracy adjustment (refer to 0).
16. Low pressure leak test (refer to steps 1 through 8 of "4.Leak test of all pipelines on the circuit adapter" in 5.3.4.2Leak Test of Low-pressure Pneumatic Circuit System).

4.1.2 Three-year Replaceable Parts

List of three-year service package (0621-30-78480):

SN	P/N	Description	Qty
1	M05-010001-06	Lithium battery Li-ion 11.1V4400mAh LI23S001A	1
2	M05-010R03---	Cell battery Lithium 3V35mAh D12.5*2.0	1

4.2 System Test

Before the anesthesia machine at the client end is maintained, some routine tests are required to check if the current status of the anesthesia machine is normal. The following table lists the routine tests.

SN	Test item	Functional description	Test interval
1	Check the mechanical ventilation mode	1. Check if mechanical ventilation is provided normally and if an alarm occurs. 2. Check if the preset values of pressure and TV are same to the measured values. 3. Check if the pressure measured by the pressure sensor is same to that indicated by the airway pressure gauge and if the TV measured by the flow sensor is same to that indicated by the graduation on the bellows housing. 4. Roughly judge if the breathing system has a significant leak by observing how much fresh gas is compensated and observing if the bellows collapses.	After each service or at the time of return visit
2	Breathing system leak test in mechanical ventilation mode	1. Check the pneumatic circuit in mechanical ventilation mode for leaks, including bellows, drive gas circuit, CO2 absorbent canister, patient tubes, flow sensors and their connectors. 2. Check the control effectiveness of main control board and auxiliary control board over PEEP safety valve. 3. Check the monitoring effectiveness of auxiliary control module over airway pressure and PEEP path pressure.	After each service or at the time of return visit

SN	Test item	Functional description	Test interval
3	Breathing system leak test in manual ventilation mode	Check the pneumatic circuit in manual ventilation mode for leaks, including APL valve, check valve, CO2 absorbent canister, patient tubes, flow sensors and their connectors.	After each service or at the time of return visit
4	Check the sensors' zero points	Check if the zero points of all the flow sensors and pressure sensors inside the machine are within the normal range so as to determine when to replace the monitor board.	After each service or at the time of return visit
5	Check the flow sensor accuracy	1. Check if the measurements made by the flow sensors inside the machine are the same. 2. Check if the measurement made by any flow sensor inside the machine is accurate. 3. Check the effectiveness of flow calibration (factory) result.	After each service or at the time of return visit
6	Check the pressure sensor accuracy	1. Check if the measurements made by the pressure sensors inside the machine are the same. 2. Check if the measurement made by any pressure sensor inside the machine is accurate. 3. Check the effectiveness of pressure calibration (factory) result.	After each service or at the time of return visit

4.2.1 Check the Mechanical Ventilation Mode

NOTE

- **The main function of the anesthesia machine is to provide breathing support—mechanical ventilation which complies with the doctor's settings to the patient. The tests in this section are performed aiming to ensure that the machine is able to provide normal mechanical ventilation.**
- **The tests can help to judge if the machine operates normally.**

4.2.1.1 Check Volume Control Ventilation

NOTE

- **Volume control ventilation (VCV) is the standard ventilation mode of the anesthesia machine and also the most basic mechanical ventilation mode.**

To check volume control ventilation:

1. Make sure that the supply pressure is normal and that the tubes in the breathing circuit are correctly connected as required for mechanical ventilation. Connect a 2 L bag, which is used as the test lung, to the Y piece in the patient circuit.
2. Set the Bag/vent switch to the mechanical ventilation position.
3. Select VCV as the ventilation mode.
4. Adjust total amount of fresh gas to 0.5 L/min.
5. Set the following combinations of TV and Rate respectively: 300 ml and 15 BPM, 600 ml and 15 BPM, 900 ml and 15 BPM, 1200 ml and 15 BPM. Set others to the defaults. Record the displayed TVe and Ppeak values, and the peak pressure reading on the airway pressure gauge in each setting stabilized status.
6. Judge if the above measured data meet the following conditions:
   - TV control and measurement are normal: the displayed TVe value should be within the range of TV setting X (1±10%) ml.
   - Circuit leak is within the acceptable range: the bellows can reach the top of the bellows housing each time and the lowest graduation on the bellows housing which the bellows falls to each time corresponds to approximately TV setting.
   - Pressure measurement is normal: the Ppeak measured value is close to the peak pressure reading on the airway pressure gauge. The error should not exceed 2 cmH2O.
   - No other ventilation failure occurs: the Paw and flow waveforms are displayed normally and no technical alarms occur.

If the above test requirements are not met, perform subsequent checks and do the test again.

NOTE

- **If any errors are detected during the ventilation test, perform troubleshooting as per 5 Troubleshooting and do the test again until the system is normal.**

4.2.1.2 Check Pressure Control Ventilation

NOTE

- **Pressure control ventilation is one of the basic mechanical ventilation modes of the anesthesia machine. It is configured depending on user selection and machine type. If the anesthesia machine under test is not configured with this mode, this test is not required.**

To check pressure control ventilation:

1. Make sure that the supply pressure is normal and that the tubes in the breathing circuit are correctly connected as required for mechanical ventilation. Connect a 2 L bag, which is used as the test lung, to the Y piece in the patient circuit.
2. Set the Bag/vent switch to the mechanical ventilation position.
3. Select pressure control ventilation as the ventilation mode.
4. Adjust total amount of fresh gas to 0.5 L/min.
5. Set the following combinations of Pinsp, Rate and PEEP respectively: (10 cmH2O, 15 BPM, OFF), (15 cmH2O, 12 BPM, 5 cmH2O), (20 cmH2O, 10 BPM, 8 cmH2O). Set others to the defaults. Record the displayed Ppeak and PEEP values, and maximum and minimum readings on the airway pressure gauge in each setting stabilized status
6. Judge if the above measured data meet the following conditions:
   - ◆ Pressure control and measurement are normal: the displayed Ppeak value should be within the range of Pinsp setting ±2 cmH2O.
   - ◆ Circuit leak is within the acceptable range: the bellows can reach the top of the bellows housing each time.
   - ◆ Pressure measurement is normal: in one breathing cycle, the Ppeak measured value should be close to the maximum reading on the airway pressure gauge (with error not exceeding 2 cmH2O) and the displayed PEEP value close to the minimum reading on the airway pressure gauge (with error not exceeding 1 cmH2O).
   - ◆ No other ventilation failure occurs: the Paw and flow waveforms are displayed normally and no technical alarms occur.

If the above test requirements are not met, perform subsequent checks and do the test again.

NOTE

- **If any errors are detected during the ventilation test, perform subsequent checks and do the test again until the system is normal.**

4.2.2 Breathing System Leak Test in Mechanical Ventilation Mode

For details, refer to 3.7.3Breathing System Leak Test in Mechanical Ventilation Mode.

4.2.3 Breathing System Leak Test in Manual Ventilation Mode

For details, refer to *3.7.2Breathing* System Leak Test in Manual Ventilation Mode.

4.2.4 Check the Sensor Zero Point

NOTE

- **The zero point A/D value of the airway pressure sensor and PEEP pressure sensor should fall within the normal range of 400 to 800.**
- **The zero point A/D value of the inspiratory flow sensor, expiratory flow sensor and built-in ventilator flow sensor should fall within the normal range of 50 to 1800.**
- **If the zero point of the pressure sensor has an error, in ventilation status, the baseline of the Paw waveform is not at the zero point and a great deviation occurs between pressure control and measurement.**
- **If the zero point of the inspiratory/expiratory flow sensor has an error, in ventilation status, the baseline of the flow waveform is not at the zero point and a great deviation occurs between TV control and measurement.**
- **If the zero point A/D value of any sensor is outside of the normal range, it cannot be corrected. The monitor board must be replaced.**

To check the sensor zero point:

1. Turn off all fresh gases and position the Y piece connector in the patient circuit to the air.
2. Make sure that the system is Standby. Select [**Maintenance**] → [**Factory Maintenance >>**] → [**Diagnostic Test >>**] → [**Display A/D Channels >>**] → [**Ventilator >>**] to access the [**Display A/D Channels—Ventilator**] menu.
3. Make sure that the actual measured value of each sensor is “0” (zero). Record the zero point A/D value of each sensor and judge if the zero point falls with the normal range. If not, replace the monitor board.

4.2.5 Check the Flow Sensor Accuracy

NOTE

- **If a great deviation of TV measured value occurs, test the measurement accuracy of flow sensors so as to determine whether to perform flow calibration again.**

To check the measurement accuracy of flow sensors:

1. Make sure that the circuit, test device (or other flow measurement device) and breathing tubes are connected in serial, similar to tubes connection in flow calibration. For details, refer to***4.3.2Flow Calibration (factory)***.
2. When the system is Standby, select [**Maintenance**] → [**Factory Maintenance >>**] → [**Diagnostic Test >>**] → [**Valves—Test Tool >>**] to access the [**Valves—Test Too**l] menu.
3. Set PEEP safety valve to [**ON**].
4. Set the D/A value of the PEEP valve to above 1500 and ensure that the pressure at which the expiratory valve closes is above 30 cmH2O.
5. Increase the D/A value of the inspiratory valve, causing the measured flow of the anesthesia machine test device to fall within the following ranges respectively: (3±0.5) L/min, (10±1) L/min, (20±1) L/min, (30±2) L/min, (60±3) L/min. Record the measured flows of the inspiratory flow sensor, expiratory flow sensor and ventilator flow sensor to which each setting corresponds.
6. Make sure that the deviation between the measured data of the inspiratory flow sensor, expiratory flow sensor or ventilator flow sensor, and that of the anesthesia machine test device must not exceed 1 L/min or 5% of the measured value of the test device, whichever is greater. Otherwise, refer to ***4.3.2Flow Calibration (factory)*** to perform flow calibration again.
7. If anesthesia machine test device is unavailable, you can execute steps 1 through 5 to test the accuracy of flow sensors. The deviation between the measured data of the inspiratory flow sensor or expiratory flow sensor, and that of the ventilator flow sensor must not exceed 1 L/min or 5% of the measured value of the ventilator flow sensor, whichever is greater. Otherwise, refer to ***4.3.2Flow Calibration (factory)*** to perform flow calibration again.

4.2.6 Check the Pressure Sensor Accuracy

NOTE

- **Generally, measurement deviations do not easily occur to pressure sensors. However, in case of maintaining or replacing the monitor board, three-way valve assembly, or expiratory valve assembly, you need to perform pressure calibration and check the flow sensors accuracy so as to confirm the effectiveness of calibration.**

To check the measurement accuracy of pressure sensors:

1. Make sure that the pressure sampling line and test device (or other pressure measurement device) are connected in parallel, similar to tubes connection in pressure calibration. For details, refer to ***4.3.3Pressure Calibration (factory).***
2. When the system is Standby, select [**Maintenance**] → [**Factory Maintenance >>**] → [**Diagnostic Test >>**] → [**Valves—Test Tool >>**] to access the [**Valves—Test Tool**] menu.
3. Set PEEP safety valve to [**ON**].
4. Increase the D/A value of the PEEP valve, causing the measured pressure value of the anesthesia machine test device to fall within the following ranges respectively: (5±1) cmH2O, (20±1) cmH2O, (50±1) cmH2O, (70±2) cmH2O, (90±2) cmH2O. Record the measured pressure values of the airway pressure sensor and PEEP pressure sensor to which each setting corresponds.
5. Make sure that the deviation between the measured data of the airway pressure sensor or PEEP pressure sensor, and that of the anesthesia machine test device must not exceed 1 cmH2O or 2% of the measured value of the test device, whichever is greater. Otherwise, refer to ***4.3.3Pressure Calibration (factory)*** to perform pressure calibration again.

4.3 System Calibration

NOTE

- **Perform the corresponding calibration if any test item of the system test about measurement accuracy is failed.**

The anesthesia machine provides the function of monitoring volume, pressure, FiO2, CO2 concentration, AG concentration etc. When these measured values have great deviations, it is very likely that measurement offset occurs to the relevant measurement parts. In this case, you need to perform calibration again. After equipment service, such as replacing the monitor board, expiratory valve assembly or three-way valve assembly, you need to calibrate the flow sensors or pressure sensors.
The following table lists the possible calibration items and calibration time.

SN	Calibration item	Functional description	Calibration time
1	Flow calibration (user)	Calibrate the flow sensors of the breathing system.	1. The TV measurement deviation is great (more than 10% compared with the setting value) after the flow sensors in the patient circuit have been used for a long time. 2. The flow sensor in the patient circuit is replaced.
2	Flow calibration (factory)	Calibrate the flow sensors and inspiratory valve of the anesthesia machine.	1. The expiratory valve assembly is replaced. 2. The monitor board is replaced. 3. The deviation between the measured value of the ventilator flow sensor and that of the flow measurement device exceeds more than 5% of the reading or 1 L/min, whichever is greater.
3	Pressure calibration (factory)	Calibrate the pressure sensors and PEEP valve of the anesthesia machine.	1. The monitor board is replaced. 2. The expiratory valve assembly is replaced. 3. The deviation between the measured value of the machine's pressure sensor and that of the standard pressure gauge exceeds more than 2% of the reading or 1 cmH2O, whichever is greater.
4	Pressure and flow zeroing (factory)	Calibrate the deviation from zero point of the monitor board and auxiliary monitor board.	Flow or Paw waveforms deviates from the baseline.

SN	Calibration item	Functional description	Calibration time
5	O2 sensor calibration (user)	Calibrate the accuracy of O2 sensor at 21% and 100% O2.	1. The measured value of the O2 sensor has a great deviation. The deviation exceeds 3% both in Air and pure O2. 2. The O2 sensor is replaced. 3. The monitor board is replaced.
6	CO2 calibration (factory)	Calibrate to cause the module to work more accurately.	The measurement deviation of the module exceeds the specified accuracy range.
7	AG calibration (factory)	Calibrate to cause the module to work more accurately.	The measurement deviation of the module exceeds the specified accuracy range.

Select [**Maintenance**] → [**Factory Maintenance >>**]. Enter the required password to access the [**Factory Maintenance**] menu, where you can perform the following calibrations and settings.

4.3.1 Flow Calibration (user)

NOTE

- **The measurements performed by the flow sensors may be affected by the environment where the sensors are used. After the sensors have been used for a long time, great deviations may occur to the measurement results and tidal volume control as well. This problem can be fixed through flow sensor calibration.**
- **When replacing sensors or after re- installing sensors, you need to calibrate flow sensors again.**
- **Before calibration, perform leak test of the breathing system in mechanical ventilation mode first and make sure that the test is passed.**
- **During calibration, make sure that the drive gas pressure is kept above 0.3 MPa. Failure to do so may lead to calibration failure.**

This calibration is only intended for the flow sensors in the breathing circuit. The inspiratory flow sensor and expiratory flow sensor in the breathing system are calibrated through the built-in flow measurement reference.
After the inspiratory flow sensor and expiratory flow sensor have been used for several months, for example, three months after calibration, great deviations (more than 10% compared with the setting value) may occur to tidal volume measurement due to sensor ageing or environmental factors. Or, the user replaces flow sensors. In this case, you need to re-calibrate flow sensors. For details about user flow calibration, refer to the corresponding section in the Operator's Manual.

NOTE

- **If measurement deviations are not corrected after multiple flow sensor calibrations, the user is recommended to replace the flow sensor and then perform calibration. If the problem persists, factory maintenance is necessary. After the problem is fixed, perform calibration and system test.**

4.3.2 Flow Calibration (factory)

NOTE

- **Factory flow calibration is necessary in case of replacing the monitor board, expiratory valve assembly or three-way valve assembly.**
- **When a great deviation is detected between the measured value of the built-in flow sensor and that of the standard flow measurement device, you need to perform factory flow calibration.**

This calibration is intended for the flows sensors in the breathing circuit, ventilator flow sensor, and also inspiratory valve. The standard flow measurement device is used to calibrate the flow sensors and inspiratory valve.

4.3.2.1 Preparations

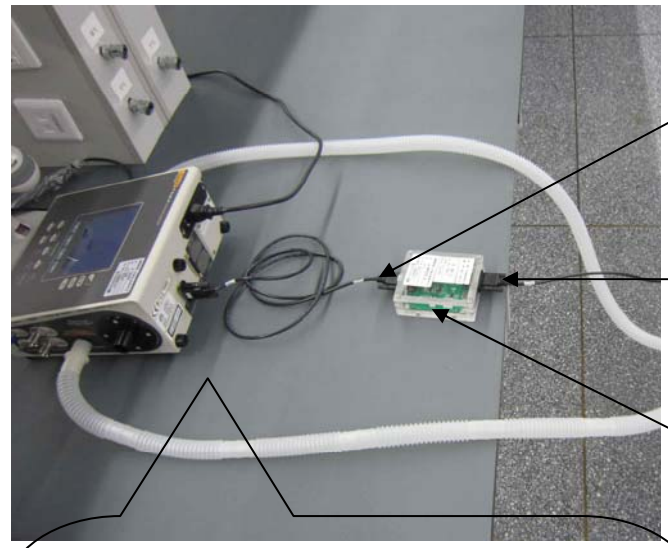
NOTE

- **Make sure that the tubes are not leaky when connected.**
- **Do not move or press the tubes during calibration.**
- **Before calibration, make sure that no sensor or valve related technical alarms occurred.**
- **During calibration, make sure that the drive gas pressure is kept above 0.3 MPa. Failure to do so may lead to calibration failure.**

1. Before calibration, perform leak test of the breathing system in mechanical ventilation mode. Perform calibration after the leak test is passed. For procedures about leak test, refer to ***3.7.3Breathing System Leak Test in Mechanical Ventilation Mode.***
2. Remove the folding bag from the bellows and reinstall the bellows housing.
3. Remove the water collection cup beside the sodalime canister assembly in the breathing system.
4. Connect the anesthesia machine calibration device to the power source.
5. WATO series anesthesia machines support Fluke VTPlus and PF300 for flow calibration.

■ Connectors and settings related to Fluke VTPlus are shown below.

(1) Connect Fluke VTPlus to the power source. The following pictures show the connectors on Fluke VTPlus.



RS232 connection line at the end of calibration device (VT Plus)

(2) Connect Fluke VTPlus to anesthesia machine. The related connectors are shown below.

Connection line at the end of anesthesia machine

(3) Set up Fluke VTPlus as follows:

a. Gas setup: select Setup. Select Setting->ENTER->GasSettings->MODIFY->Gas Type->O2->BACK->BACK.

b. Zeroing setup: select Setup. Select Setting->ENTER->Zero Mode->Manual->BACK->BACK.

c. Serial port mode setup: select Setup. Select Setting->System->Enter->Serial Mode ->OTIS Ctrl->BACK->BACK.

d. After setting up VTPlus, calibration enters serial port mode screen.

■ Connectors and settings related to PF300 are shown below.

Connect calibration communication line RS232

Gas outlet of high flow channel

Gas outlet of low flow channel

Gas inlet of low flow channel

Button for low flow channel

Button for high flow channel

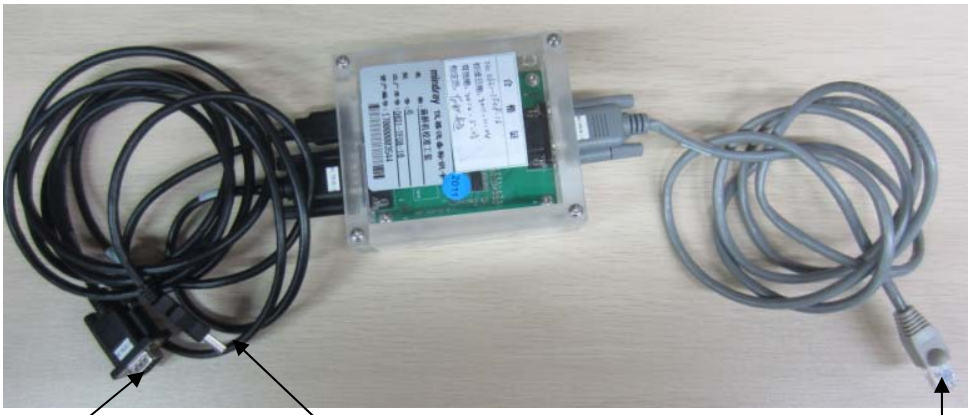
Gas inlet of high flow channel

(1). Start PF300 to enter startup screen. Push the green button under “Menu” in the lower right corner of the screen to enter Menu screen. Push the green button (the second green button from the left) under “Zero” on the screen to pop up the zeroing screen. Zeroing is completed automatically.

NOTE

- **When zeroing the PF300, make sure that there is no gas flow through the PF300, or remove the hose at the gas inlet of PF300.**
- **Air compressor flow calibration is not supported due to the response speed of PF300.**
- **When selecting a channel for calibration, after connecting the tubes, make sure that the button corresponding to the channel is depressed already and the red indicator light is lit.**

(2). Connect the RS232 communication port of PF300 to the communication port of the anesthesia machine calibration device through dedicated communicated line. The following picture shows the PF300 calibration communication line.



Connect anesthesia machine calibration port

USB port. Connect the USB port of anesthesia machine or computer to power the calibration fixture board

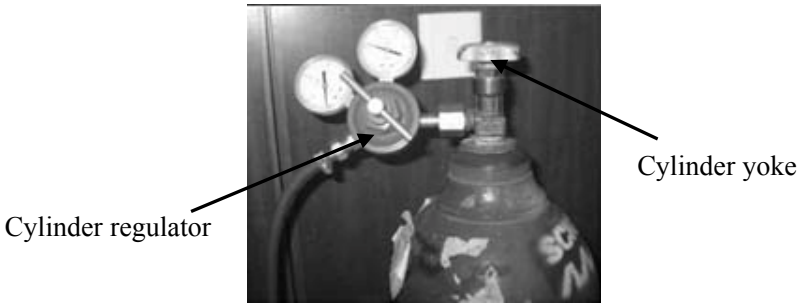
Connect PF300. Except this connection line, other parts are same to Fluke VTPlus.

(3). Perform gas setup of the PF300 as follows:

Select “Menu” button on the startup screen. Select Gas Type/Standard→Select→Gas Type set to Air/O2-Man. Set O2 Concentr to 100%. Set Gas Standard to ATP→BACK →BACK to return to the startup screen.

4.3.2.2 Calibration Procedures

1. Before calibration, make sure that the supply gas pressure is sufficient. If cylinder supply is used, turn up the cylinder yoke (not cylinder regulator) enough before calibration so as to ensure that the pressure reading on the O2 pressure gauge stays above 0.3 MPa. If pressure falls, turn up the cylinder yoke further.



2. Turn off all fresh gases. Connect the inspiratory and expiratory ports of the anesthesia machine using a short tube, as shown below.

3. Make sure that the anesthesia machine is in standby mode. Select to enter factory flow calibration screen. Select the [**Maintenance**] shortcut key → [**Factory Maintenance >>**] → enter the required password → [**Factory Cal. >>**] → [**Flow Cal.**].
4. After entering the calibration screen, select the calibration device in the pull-down menu, such as VTPlus and PF300. Select [**Flow Cal.**] to start calibration.
5. After the screen for connecting the calibration device appears, connect the anesthesia machine and calibration device into a circuit. Select [**Continue**]. If VTPlus is selected as the calibration device, select low flow channel first, as Figure a shows. If PF300 is selected as the calibration device, connect the tube to the low flow channel of PF300 first. Push the button for low flow channel. The red indicator light is lit and "Flow Low" is displayed in the upper left corner of the screen. Connect the protection filter at the gas inlet, as shown in Figure b.

Figure a

Figure b: low flow connection, with protection filter

6. After the screen for switching range appears, create a circuit by connecting the anesthesia machine and VTPlus high flow channel if VTPlus is selected as the calibration device, as show below. Then select [**Continue**].

If PF300 is selected as the calibration device, connect the tube to the high flow channel of PF300 and push the button for high flow channel. The red indicator light for high flow is lit and “Flow High” is displayed in the upper left corner of the screen. Connect the protection filter at the gas inlet, as shown below. Then select [**Continue**].

7. After flow calibration success is prompted, refer to ***1.2.5Check the Flow Sensor Accuracy*** to test the effectiveness of flow calibration. In case of calibration failure, first fix the problem and then perform flow calibration again.

4.3.2.3 Commonly-encountered Problems and Recommended Actions

NOTE

- **In the following table, there may be more than one action to be taken. If taking one action resolves the problem, you do not need to take subsequent actions.**

SN	Calibration error code	Potential cause	Action to be taken
1	00 00 00 01	Calibration is cancelled.	/
2	00 00 00 02	Drive gas low.	Replace or connect gas supply to make gas pressure stay at 350-450kPa. If the gas supply is air compressor, check the air compressor to make its pressure stay at 350-450kPa or replace with pipeline gas supply.
3	00 00 00 04	The bag/vent switch is set to Bag.	Switch the bag/vent switch to Vent.
4	00 00 00 08	The zero point of the inspiratory flow sensor is abnormal.	1. Refer to 4.2.4Check the Sensor Zero Point . 2. Replace the monitor board assembly.
5	00 00 00 10	The zero point of the expiratory flow sensor is abnormal.	
6	00 00 00 20	The zero point of flow sensor inside the machine is abnormal.	
7	00 00 00 40	The inspiratory flow sensor abnormal.	1. Check that the sampling line and the pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Check the setting of the calibration device. 4. Refer to *5.4Troubleshoot* Sensor and Valve Related Failures by Using the Valves-test Tool**.** 5. Replace corresponding flow sensor in the circuit. 6. Replace the monitor board.
8	00 00 00 80	The expiratory flow sensor abnormal.	
9	00 00 01 00	Internal flow sensor abnormal.	
10	00 00 02 00	The inspiratory flow sensor unidirection error.	1. Check that the sampling line and the pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Refer to *5.4Troubleshoot* Sensor and Valve Related Failures by Using the Valves-test Tool**.** 4. Replace corresponding flow sensor in the circuit. 5. Replace the monitor board.
11	00 00 04 00	The expiratory flow sensor unidirection error.	
12	00 00 08 00	Internal flow sensor unidirection error.	

SN	Calibration error code	Potential cause	Action to be taken
13	00 00 10 00	The inspiratory flow sensor resolution error.	1. Check that the sampling line and the pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Check the setting of the calibration device. 4.Refer to *5.4Troubleshoot* Sensor and Valve Related Failures by Using the Valves-test Tool**.** 5. Replace corresponding flow sensor in the circuit. 6. Replace the monitor board.
14	00 00 20 00	The expiratory flow sensor resolution error.	
15	00 00 40 00	Internal flow sensor resolution error.	
16	00 00 80 00	The valve output flow rate is insufficient.	1. Check that the sampling line and the pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Check the setting of the calibration device. 4. Replace the inspiratory valve assembly.
17	00 01 00 00	The valve resolution is insufficient.	1. Check that the sampling line and the pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Check the setting of the calibration device. 4. Check that the sampling line is properly connected. 5. Refer to*5.4Troubleshoot* Sensor and Valve Related Failures by Using the Valves-test Tool**.** 6. Replace the inspiratory valve assembly.
18	00 02 00 00	The flow rate is not unidirectional.	1. Check that the sampling line and the pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Check the setting of the calibration device. 4. Check that the sampling line is properly connected. 5 .Refer to *5.4Troubleshoot* Sensor and Valve Related Failures by Using the Valves-test Tool**.** 6. Replace the inspiratory valve assembly.

SN	Calibration error code	Potential cause	Action to be taken
19	00 04 00 00	Communication with the calibration device breaks off.	1. Check the connection between the calibration device and make sure the communication line is ok. Otherwise replace the communication line. 2. Check the setting of the calibration device. Reset the calibration device if necessary.
20	00 08 00 00	Writing EEPROM failed	Replace the monitor board assembly.
21	00 10 00 00	ACGO is set to “On”.	Set ACGO to “Off”.
22	00 20 00 00	Valve maximum DA value cannot be found.	1. Check that the sampling line and the pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Check the setting of the calibration device. 4. Check that the sampling line is properly connected. 5 .Refer to ***5.4Troubleshoot Sensor and Valve Related Failures by Using the Valves-test Tool.*** 6. Replace the inspiratory valve assembly.
23	00 40 00 00	Valve minimum DA value cannot be found.	

4.3.3 Pressure Calibration (factory)

NOTE

- **Factory pressure calibration is necessary in case of replacing the monitor board, expiratory valve assembly or three-way valve assembly.**
- **When a great deviation is detected between the measured value of the built-in pressure sensor and that of the standard pressure measurement device, you need to perform factory pressure calibration.**

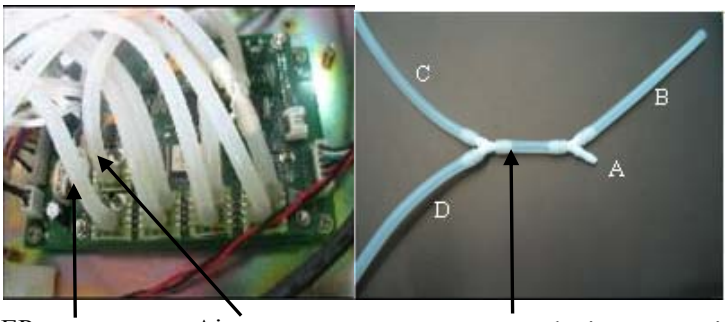
This calibration is intended for the airway pressure sensor in the breathing circuit, PEEP pressure sensor and PEEP proportional valve of the expiratory valve assembly. The standard pressure measurement device is used to calibrate the pressure sensors and PEEP proportional valve.

4.3.3.1 Preparations

NOTE

- **Before pressure calibration, make sure that the tubes are not leaky when connected.**
- **Do not move or press the tubes during calibration.**

1. Let the anesthesia machine calibration device be powered. Refer to the method described in ***4.3.2Flow Calibration (factory)*** to manually zero the calibration device first. Use the special communication cable to connect the calibration device to the anesthesia machine. Fluke VTPlus and PF300 can also be used for pressure calibration. Set up by following the method described in ***4.3.2.1Preparations.***
2. A four-way device is required to connect the sampling lines for pressure calibration. The following pictures show the four-way device, connectors on the anesthesia machine calibration device, Fluke VTPlus, PF300 and monitor board involved for pressure calibration.



PEEP pressure sampling line

Airway pressure sampling line

Four-way device connecting the pressure calibration sampling lines

Airway pressure sampling connector (high pressure)

PEEP pressure sampling connector (high pressure)

Fluke VTPlus pressure sampling connector (high pressure)

Set pressure unit to cmH2O for the convenience of checking if the calibration is normal.

Pressure calibration sampling port of PF300. When calibrating, push the button for the channel and the red indicator light is lit.

3. Unplug the PEEP pressure sampling line from the PEEP pressure sampling connector on the monitor board. Then connect it to one connector (Connector A) of the four-way device.
4. Connect the second connector (Connector B) of the four-way device to the PEEP pressure sampling connector (high pressure) on the monitor board.
5. Unplug the airway pressure sampling line from the airway pressure sampling connector (high pressure) on the monitor board.
6. Connect the third connector (Connector C) of the four-way device to the airway pressure sampling connector (high pressure).
7. Connect the fourth connector (Connector D) of the four-way device to pressure sampling connector (high pressure) of the calibration device.

NOTE

- **The sampling lines going through the four-way device must be connected to the high pressure ends of the pressure sampling connectors of the pressure sensors.**
- **It is recommended to connect the sampling lines for pressure calibration to the four-way device following the procedures to avoid errors.**

4.3.3.2 Calibration Procedures

1. Make sure that the anesthesia machine is in standby mode.
2. Select the [**Maintenance**] shortcut key → [**Factory Maintenance >>**] → enter the required password → [**Factory Cal. >>**] → [**Pressure Cal. >>**] → [**Start**].
3. After pressure calibration success is prompted, refer to ***4.2.6Check the Pressure Sensor Accuracy*** to test the effectiveness of pressure calibration. In case of calibration failure, first fix the problem and then perform pressure calibration again.

NOTE

- **After pressure calibration, test the accuracy of pressure sensors by referring to 4.2.6Check the Pressure Sensor Accuracy.**
- **In case of calibration failure, first fix the problem and then perform pressure calibration again.**

4.3.3.3 Commonly-encountered Problems and Recommended Actions

NOTE

- **In the following table, there may be more than one action to be taken. If taking one action resolves the problem, you do not need to take subsequent actions.**

SN	Calibration error code	Potential cause	Action to be taken
1	00 00 00 01	Calibration is cancelled.	/
2	00 00 00 02	Drive gas pressure low.	Replace or connect gas supply to make gas pressure stay at 350-450kPa. If the gas supply is air compressor, check the air compressor to make its pressure stay at 350-450kPa or replace with pipeline gas supply.
3	00 00 00 04	The bag/vent switch is set to Bag.	Switch the bag/vent switch to Vent.
4	00 00 00 08	The zero point of the airway pressure sensor is abnormal.	1. Refer to ***4.2.4Check the Sensor Zero Point*** 2. Replace the monitor board assembly.
5	00 00 00 10	The zero point of the Peep pressure sensor is abnormal.	
6	00 00 00 20	The airway pressure sensor abnormal.	1 .Check that the pipes and pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Check the setting of the calibration device. 4. Refer to ***5.4Troubleshoot Sensor and Valve Related Failures by Using the Valves-test Tool***. 5. Replace the monitor board.
7	00 00 00 40	Peep pressure sensor abnormal.	
8	00 00 00 80	The airway pressure sensor unidirection error.	1. Check that the pipes and pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Refer to ***5.4Troubleshoot Sensor and Valve Related Failures by Using the Valves-test Tool.*** 4. Replace the monitor board.
9	00 00 01 00	Peep pressure sensor unidirection error.	
10	00 00 02 00	The airway pressure sensor resolution error.	1. Check that the pipes and pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Check the setting of the calibration device. 4. Refer to *5.4Troubleshoot* Sensor and Valve Related Failures by Using the Valves-test Tool**.** 5. Replace the monitor board.
11	00 00 04 00	Peep pressure sensor resolution error.	
12	00 00 08 00	The valve output pressure is insufficient.	1. Check that the pipes and pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Check the setting of the calibration device. 4. Replace the Peep valve assembly.

SN	Calibration error code	Potential cause	Action to be taken
13	00 00 10 00	The pressure is not unidirectional.	1. Check that the pipes and pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Check the setting of the calibration device. 4. Refer to *5.4Troubleshoot* Sensor and Valve Related Failures by Using the Valves-test Tool**.** 5. Replace the Peep valve assembly.
14	00 00 20 00	Communication with the calibration device breaks off.	1. Check the connection between the calibration device and make sure the communication line is ok. Otherwise replace the communication line. 2. Check the setting of the calibration device. Reset the calibration device if necessary.
15	00 00 40 00	Writing EEPROM failed	Replace the monitor board assembly.
16	00 00 80 00	ACGO is set to “On”.	Set ACGO to “Off”.
17	00 01 00 00	Valve resolution is insufficient.	1. Check the gas supply pressure. 2. Check the setting of the calibration device. 3. Replace the Peep valve assembly.
18	00 02 00 00	Valve maximum DA value cannot be found.	1. Check that the pipelines and pneumatic circuit do not leak. 2. Check the gas supply pressure. 3. Check the setting of the calibration device. 4. Check the connection of the sampling line. 5. Refer to ***5.4Troubleshoot Sensor and Valve Related Failures by Using the Valves-test Tool.*** 6. Replace the PEEP valve assembly.
19	00 04 00 00	Valve minimum DA value cannot be found.	

4.3.4 Pressure and Flow Zeroing (factory)

During the operation of the anesthesia machine, pressure and flow are zeroed automatically at a specific interval. You can also zero pressure and flow manually in the factory maintenance menu. Manual zeroing can eliminate the measurement deviations caused by zero offset immediately. This system provides the function of pressure and flow automatic zeroing at a specific interval.

4.3.4.1 Zeroing Procedures

1. Select [**Maintenance**] → [**Factory Maintenance >>**] → enter the required password → [**Factory Cal. >>**] → [**Paw and Flow Zero Cal. >>**]. The message [**Zeroing**] is prompted.
2. If pressure and flow zeroing is passed, the message [**Zeroing Completed!**] is displayed. If pressure and flow zeroing is failed, the message [**Zeroing Failure! Please try again**.] is displayed.

NOTE

- **In case of zeroing failure, other faults may exist. You must isolate and eliminate the problem.**

4.3.4.2 Troubleshoot Pressure and Flow Zeroing Failure

In case of zeroing failure, troubleshoot as follows:

1. Set the anesthesia machine to manual ventilation or standby mode. Turn off fresh gas. Unplug the breathing tubes in the breathing system, causing the inspiration and expiration connectors to open to the air. Bleed the residual gas inside the bellows. Make sure that there is no flow or pressure entering the flow or pressure sensors inside the machine.
2. Check if the zero points of the sensors are normal by referring to ***4.2.4Check the Sensor Zero Point.***
3. If a zero point error is detected, unplug the sensor sampling line to eliminate the effects caused by sampling line occlusion or three-way valve. If zero point is still out of the range, the monitor board is faulty. Replace the monitor board.
4. If zero points of the sensors are correct but zeroing is still failed, the three-way valve assembly is faulty. Replace the three-way valve assembly.

4.3.5 O2 Sensor Calibration (optional)

NOTE

- **Calibrate the O2 sensor again when a great deviation of O2 concentration monitored value occurs or when the O2 sensor or monitor board is replaced.**
- **Before calibration, observe if the O2 sensor displays numerics on the measure screen. If not, confirm that the O2 measure switch is turned on, check the O2 sensor connection line, or replace the O2 sensor until measure numerics are displayed.**

4.3.5.1 Calibration Procedures

For details, refer to the section about O2 sensor calibration in the Operator's Manual.

4.3.5.2 Commonly-encountered Problems and Recommended Actions

Failure description	Possible cause	Recommended action
After [Start] is selected, calibration failure is prompted very soon.	If the alarm [O2 Sensor Unconnected] is displayed, it indicates that O2 sensor is not connected.	Connect the O2 sensor.
	Select [Maintenance] → [User Maintenance >>] → [Set O2 Sensor Monitoring >>]. The O2 sensor is set to OFF.	Set the O2 sensor to ON.
	O2 supply pressure is insufficient (lower than 200 kPa).	Change or connect the gas supply and make sure that O2 supply pressure is sufficient.
	21% O2 calibration is not completed before 100% O2 calibration.	Perform 21% O2 calibration followed by 100% O2 calibration.
Calibration failure is prompted about 3 minutes after calibration is started.	O2% count value is not within the normal range (450 to 2700). Select [Maintenance] → [Factory Maintenance >>] → [Diagnostic Test >>] → [Display A/D Channels] → [Ventilator >>] to access the [Display A/D Channels —Ventilator] menu.	Replace the O2 sensor.

4.3.6 CO2 Calibration (factory)

4.3.6.1 Preparations

Prepare the following before doing the calibration:

- Gas cylinder: one or more cylinders filled with 3% , 4%, 5%, 6% , or 7% CO_2
- T-shape connector
- Samping line

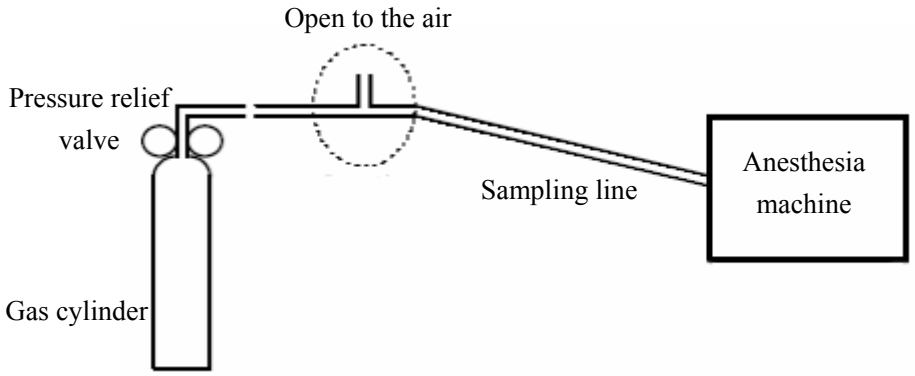
4.3.6.2 Calibration Procedures

NOTE

- **During the calibration, selecting [Calibrate] again does not take effect or exit the calibration menu. Other operations than menu options are disabled until the end of calibration.**

Calibrate as follows:

1. Make sure that the CO2 module is already warmed up.
2. Select [**Maintenance**] → [**Factory Maintenance >>**] → enter the required password → [**Module Cal. >>**] → [**Gas Module Cal. >>**] → [**CO2 Module Cal.**].
3. Check the airway and make sure that there are no occlusions or leaks.
   - ◆ Vent the sampling line to the air and check that the current rate is approximately 150 mL/min. If the deviation is great, it means that the airway is occluded. Check the airway for occlusions.
   - ◆ Block the gas inlet of the sampling line. The current rate should drop rapidly and the message of airway occlusion should be prompted. Otherwise, it means that the airway leaks. Check the airway for leakage.
4. Wait for the sensor temperature to reach and stay at 35ºC.
5. Select [**Zero**] to start zeroing.
6. Connect the gas cylinder to the sampling line using a T-shape connector, as shown below.



7. Vent the sampling line to CO2 opening the cylinder pressure relief valve.
8. In the [**CO2 Module Cal.**] menu, enter the vented CO2 concentration in the [**CO2**] field.
9. In the [**CO2 Module Cal.**] menu, the measured CO2 concentration, barometric pressure, sensor temperature and current pump rate are displayed. After the measured CO2 concentration becomes stable, select [**CO2 % Cal**.] to calibrate the CO2 module.

10. After a successful calibration, the screen shows [**Calibration Completed!**]. Otherwise, the message [**Calibration Failure! Please try again.**] is displayed. In this case, you need to do the calibration again.

4.3.6.3 Commonly-encountered Problems and Recommended Actions

Failure description	Possible cause	Recommended action
Calibration is not completed.	1. The module is damaged. 2. The difference between the set AG calibration concentration and the selected standard AG concentration is too great.	1. Return the module to factory for repair. 2. The difference between the standard gas concentration and the set calibration concentration can not exceed 40% of the standard gas concentration.

4.4 Software Upgrade and Software Configuration Activation

⚠CAUTION

- **Software upgrade and software configuration activation can be performed by professional service personnel only.**

You can perform program upgrade on the anesthesia machine by downloading the upgrade software through network. You can also perform online upgrade of the software supported configuration through the activation code.

4.4.1 Software Upgrade

You can upgrade the following programs on the anesthesia machine by downloading the upgrade software through network:

- Booting software
- System software
- Multi-lingual library
- Icon libray
- Startup screen
- General configuration (password)
- Main control board FPGA display drive software
- MO2B module software

- Monitor module software
- Auxiliary control module software
- Heating moduel software

⚠CAUTION

- **Before software upgrade, disconnect the anesthesia machine from the patient and back up the important data.**

NOTE

- **Make sure that the version of the upgrade package is the desired one. To obtain the latest upgrade package, please contact us.**
- **Before upgrading the system software, check the version information of the booting software. If it is not the latest, upgrade the booting software to the latest version first and make sure of software compatibility.**

You can select the following operations to upgrade the corresponding software based on your requirement. You must perform ***4.4.1.1Network Connection*** before upgrading any software.

4.4.1.1 Network Connection

NOTE

- **Before upgrading any software, make sure that the network cable, Hub, and notebook computer are connected correctly and reliably.**
- **The recommended length of the network cable is not greater than 1 m.**

Perform network connection as follows before software upgrade:

1. Connect the anesthesia machine, Hub and notebook computer by using the straight through cable. Connect the Hub to the power source and make sure that the network is connected.
2. Select [**Maintenance**] → [**User Maintenance >>**] → [**Set IP Address >>**] to check the current IP address of the anesthesia machine, which is “192.168.23.250” by default.
3. Set the IP address of the notebook computer. Make sure that the IP address of the anesthesia machine is in the same IP segment with the notebook computer. For example, if the current IP address of the anesthesia machine is the default “192.168.23.250”, the IP address of the notebook can be set to “192.168.23.23”.

4.4.1.2 Booting Software Upgrade

⚠CAUTION

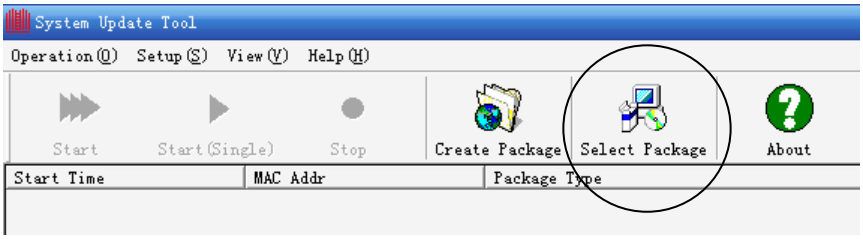
- **Switching off or powering off the equipment during booting software upgrade can cause system down.**

NOTE

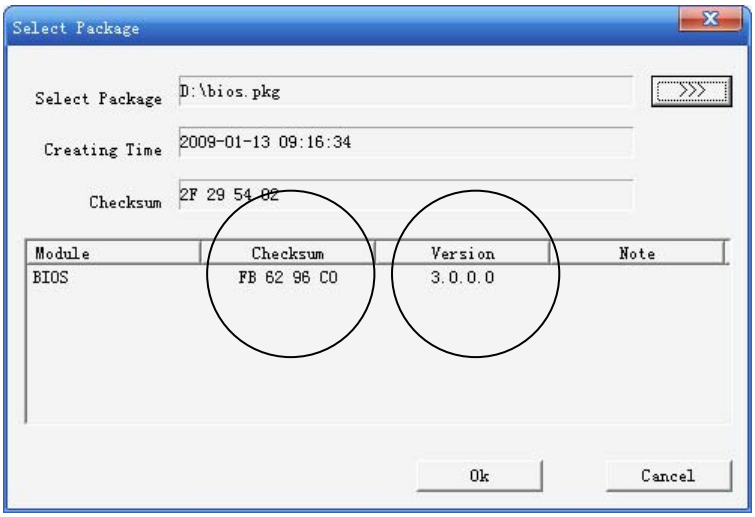
- **When selecting the upgrade package, make sure that the checksum and version are same to that provided by the factory.**

To upgrade the booting software of the anesthesia machine:

1. Run the network upgrade downloading software on the notebook computer, select [**Wato Series**] in [**Product Series Selection**] menu and select [**Ok**] to access the software upgrade screen.
2. Click [**Select Package**] to enter the [**Select Package**] menu.

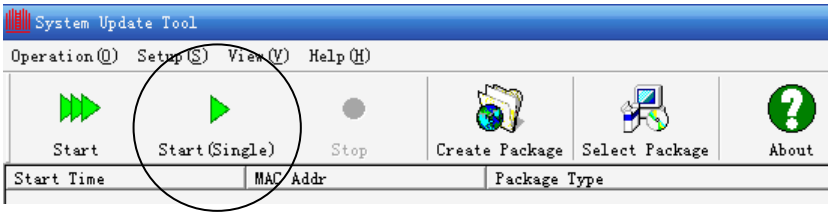


4. Click [>>>]. Select the booting software of the anesthesia machine (Code: BIOS) in the dialog box and then click [**Open**].
5. Check the checksum and version of the booting software as shown below.



6. If the checksum and version are correct, click [**Ok**].

7. Click [**Start (Single)**] on the main screen.



8. Re-start the anesthesia machine to start to upgrade the booting software.
9. Wait for the message prompting upgrade success. Select [**Maintenance**] → [**Factory Maintenance >>**] → [**System Information >>**] to check the version information of the booting software.

NOTE

- **After completing booting software upgrade, turn on the anesthesia machine to confirm the correctness of booting software version information.**

4.4.1.3 System Software Upgrade

NOTE

- **Before upgrading the system software, check the version information of the booting software. If it is not the latest, upgrade the booting software to the latest version first and make sure of software compatibility.**
- **Before upgrading the system software, record the current settings of the anesthesia machine so as to restore the pre-upgrade settings after software upgrade.**
- **When selecting the upgrade package, make sure that the checksum and version are same to that provided by the factory. You also need to check the machine code corresponding to the anesthesia machine to be upgraded.**

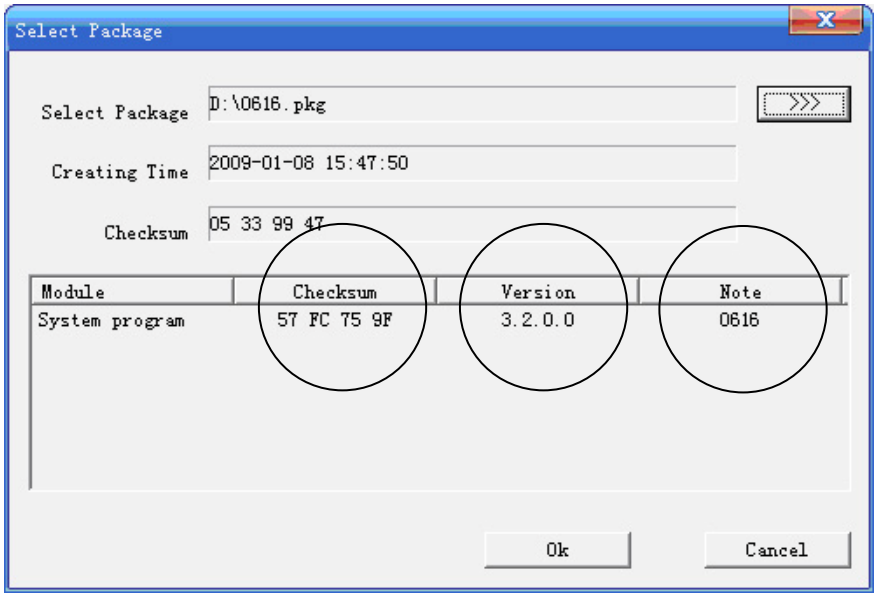
Before upgrading the system software, note the matching between machine name and machine code as listed below.

Machine name	Machine code	Notes
WATO EX-55/65	0621/0622/0623/0624	/
WATO EX-20	0615	Borrows the breathing circuit of WATO EX-55/65
WATO EX-25	0616	Borrows the breathing circuit of WATO EX-55/65
WATO EX-30	0617	Borrows the breathing circuit of WATO EX-55/65
WATO EX-35	0618	Borrows the breathing circuit of WATO EX-55/65
WATO EX-50/60 (improved breathing circuit)	0613/0614	Borrows the breathing circuit of WATO EX-55/65

Machine name	Machine code	Notes
WATO EX-50/60（0611）	0611/0612	External single-flow sensor circuit before EBU017 engineering change
WATO EX-50/60（0611C）	0611C/0612C	External single-flow sensor circuit before EBU017 engineering change

To upgrade the system software:

1. Check and confirm that the booting software of the anesthesia machine is of the latest version. If not, refer to ***4.4.1.2Booting Software Upgrade*** to upgrade to the latest version.
2. When selecting the system software upgrade package, confirm the correctness of checksum and version. You also need to check the machine code, as shown below.



3. Other operations are similar to those for booting software upgrade. Refer to ***4.4.1.2Booting Software Upgrade*** to finish the upgrade.

NOTE

- **After completing system software upgrade, turn on the anesthesia machine to confirm the correctness of upgrade software version information.**
- **After completing system software upgrade, restore the pre-upgrade settings of the system settings which are saved in case of power failure.**

4.4.1.4 Module Software Upgrade

NOTE

- **When selecting the upgrade package, make sure that the checksum and version are same to those provided by the factory. You also need to check the module code corresponding to the module to be upgraded.**

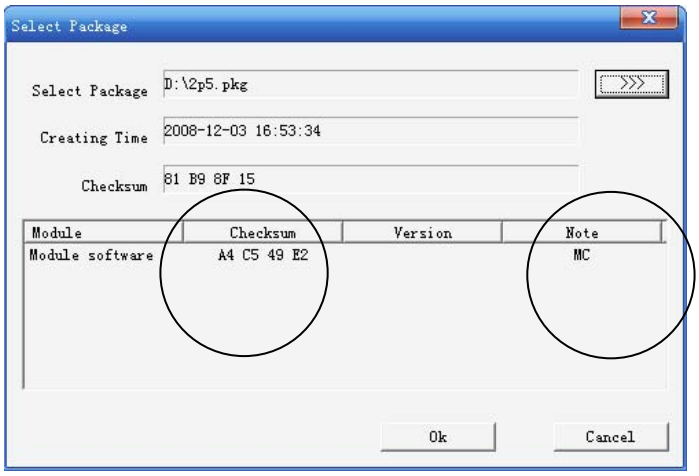
The module software mentioned here includes monitor module software, auxiliary control module software and power board software. Their upgrade procedures are similar to those for booting software upgrade except that when selecting the upgrade package, apart from making sure of the correctness of checksum and version, you also need to confirm the module code corresponding to the module to be upgraded.

Before upgrading the module software, note the matching between module name and module code as listed below.

Module name	**Module code**
Monitor module	VCM
Auxiliary control module	VPM
Power board	POWER
Electronic flowmeter	FLOW
Keyboard	KEYBOARD
Modular MO2B CO2 module	0621-CO2
Serial port cable connected MO2A	0611-CO2-M02A
Serial port cable connected MO2B	0611-CO2-M02B
Heating module of 0615, 0616, 0617 and 0618 types	HEATING MODULE
Flow and pressure analyzer	FPM

To upgrade the module software:

1. When selecting the module software upgrade package, confirm the correctness of checksum and version. You also need to check the module code, as shown below.



2. Other operations are similar to those for booting software upgrade. Refer to ***4.4.1.2Booting Software Upgrade*** to finish the upgrade.

NOTE

- **After completing module software upgrade, turn on the anesthesia machine to confirm the correctness of upgrade software version information.**

4.4.1.5 Commonly-encountered Problems and Recommended Actions

Failure description	Possible cause	Recommended action
During upgrade, the buzzer on the main control board buzzes long, resulting in upgrade failure.	The BIOS program of the main control board is damaged due to possible power failure during upgrade or upgrade failure.	Return the main control board to factory for repair.
In case of system software upgrade, the upgrade screen can be accessed but upgrade is always failed.	The version of BIOS program is incompatible with that of system software. The network is not stable.	1. Check the compatibility of software version. Select the appropriate version for upgrade. Refer to the system software-BIOS-upgrade tool compatibility table. 2. Check the network connection between the notebook computer, Hub and anesthesia machine to make sure that the network cable is not loose.

Failure description	Possible cause	Recommended action
After software upgrade success, only VCV mode is available.	The BIOS program does not match the system software. The main control board does not support system software version greater than V03.01.00.00.	1. Check the version compatibility between BIOS program and system software. 2. Return the main control board to factory for repair.
The upgrade booting screen is inaccessible.	The network is not in good condition.	1. Re-check the network connection between the notebook computer, Hub and anesthesia machine. Check that the network cable is connected correctly and reliably. 2. Make sure that Hub is powered on.
After the system software or XX module software is upgraded, XX module communication stop is alarmed.	The version of system software does not match that of XX module software. Or, the module is damaged.	Re-confirm the version information of XX module software and the module code. If they are correct, return the faulty module to factory for repair.
Black screen appears when starting the machine after system software upgrade.	The system software does not match the upgrade tool used.	Make upgrade packet of system software above V04.10.00 (included) using upgrade tool above V4.4 (included). Upgrade the system software above V04.10.00 (included) using upgrade tool above V4.4 (included).

4.4.2 Software Function Activation

For system software version greater than V03.01.00, online upgrade is supported. The factory can activate all the functions listed in the following table through activation codes. When the user wants to add any function listed in this table, the service engineer can apply to the factory for activation code so as to activate the corresponding function.

Function	**Description**
PCV	Pressure control ventilation mode
P-mode	Pressure control ventilation mode
PSV	Pressure support ventilation mode
SIMV	Synchronized intermittent mandatory ventilation mode
Spirometry loops	F-V and P-V loops
P-mode	Pressure mode
PCV-VG	Pressure control ventilation-volume guaranteed
SIMV-PRVC	/

Activation code generators of different versions differ in the corresponding payment configuration that can be activated and there is also corresponding relationship between activation code generator version and system software version, as listed below.

Version of activation code generator	**Configuration item that can be activated**	**Corresponding system software**	**Activation way**	**Digit of generated activation code**
V1.0	PCV, PSV, SIMV, Spirometry loops	V03.01.00~V03.02.00	Non-incremental activation	13
V1.1	P-mode, PCV, PSV, SIMV, Spirometry loops	V04.00.00~V04.05.01	Non-incremental activation	13
V2.0	P-mode, PCV, PSV, SIMV, Spirometry loops, PCV-VG	V04.06.00~V04.07.00	Non-incremental activation	13
V3.0	P-mode, PCV, PSV, SIMV, Spirometry loops, PCV-VG, SIMV-PRVC	Version greater than V04.08.00（included）	Incremental activation	18
V4.0	P-mode, PCV, PSV, SIMV, Spirometry loops, PCV-VG, SIMV-PRVC	Version greater than V04.08.00（included）	Incremental activation	18

Note: activation code generator of V3.0 and V4.0 cannot be used to activate machine whose system software version is below V04.07.00 (included). Similarly, activation code generator below V2.0 (included) cannot be used to activate machine whose system software version is above V04.08.00 (included).

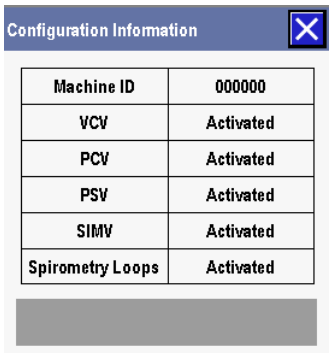
4.4.2.1 Apply for Software Function Activation Code

NOTE

- **To apply for activation code, you must provide the relevant information of the anesthesia machine whose configurations are to be activated, such as machine ID, existing configuration and configuration to be activated. (Note that you need to know the existing configuration and configuration to be activatedf for activation code generator version of non-incremental activation and know the configuration requiring incremental activation for activation code generator version of incremental activation.)**

When the user wants to add any paid configuration listed in the above table, the service engineer must apply to the Service Department for the software function activation code based on the user's need.

1. Record the serial number of the anesthesia machine (see the label on the left side of the machine) whose configurations are to be activated.
2. Record the machine ID and the current configuration of the anesthesia machine. Select [**Maintenance**] → [**User Maintenance >>**] → [**Configuration Information >>**] to open the configuration information menu as shown below.



3. Record the configuration the user wants to activate.
4. Return the above recorded information to the Service Department to apply for the corresponding activation code.

4.4.2.2 How to Activate Software Function

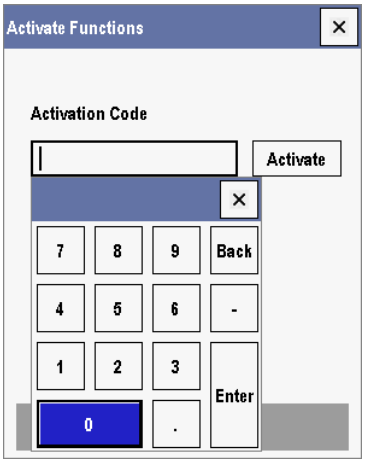
NOTE

- **Before activation, check and record the user's existing paid configurations and also the paid configurations to be added.**
- **After entering the activation code, make sure that the entered activation code is same to that provided by the factory.**

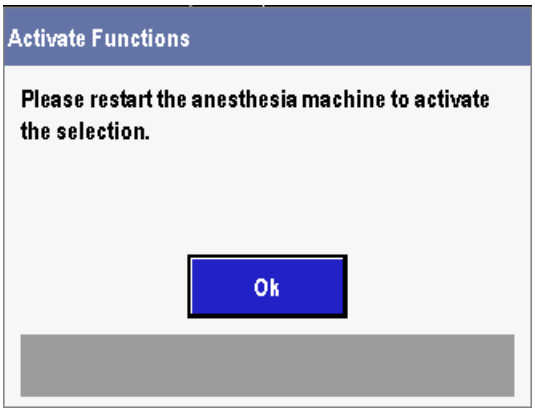
To activate software functions:

1 Select [**Maintenance**] → [**Factory Maintenance >>**] → enter the required password → [**Function Configuration >>**] → [**Activate Functions >>**] to open the [**Activate Functions**] menu as shown below.

2. Enter the required activation code.



3. Select [**Activate**]. If the entered activation code is correct, a prompt message is displayed as shown below.



4. Select [**Ok**] to restart the anesthesia machine so as to activate the new configuration.

NOTE

- **Powering off the anesthesia machine before the message [Function activation completed! Please restart the anesthesia machine to activate the function.] is prompted can damage the BIOS program on the main control board.**
- **After activation success is prompted, restart the anesthesia machine to activate both the existing and new paid configurations after software upgrade.**

4.4.2.3 Commonly-encountered Problems and Recommended Actions

Failure description	Possible cause	Recommended action
After activation, restart the anesthesia machine. The main control board buzzes long, resulting in restart failure.	During activation, the anesthesia machine is powered off or turned off before activation success is prompted, which damages the BIOS program on the main control board.	Return the main control board to factory for repair.
Invalid activation code is prompted.	The activation code is entered improperly or the activation code itself is wrong.	1. Check that the activation code entered is same to that provided by the factory. 2. If the activation code is entered correctly and invalid activation code is still prompted, send the machine ID, existing configurations and the configurations to be added to the factory for confirmation. 3. Wrong activation code generator version is used to generate activation code. Feed back the current system software version of the machine to the factory and ask the factory to re-generate activation code.
After system activation, the activated functions are not consistent with the user's configurations.	The factory activation code is wrong. Or, the existing configurations and the configurations to be added which are provided for the factory are not complete.	Check the existing configurations and the configurations to be added again. Request the factory to generate activation code again.

4.4.3 Load O2 Sensor Monitoring Function

The anesthesia machine provides online upgrade of O2 sensor monitoring function. When the user wants to add the functional configuration of O2 sensor, the service engineer provides the O2 sensor for the user as per the corporate procedures for adding parts configuration after sales. The engineer can go to the site or guide the user on the phone to load the monitoring function of O2 sensor.

1. (Guide the user to) mount the O2 sensor onto the circuit and connect the O2 sensor cable.
2. Select [**Maintenance**] → [**User Maintenance >>**] → [**Set O2 Sensor Monitoring >>**]. Select [**ON**] for [**O2 Sensor Monitoring**].
3. Select [**User Setup**] → [**O2 Monitoring Source >>**]. Select [**O2 Sensor**] in the [**O2 Monitoring Source**] menu to start the monitoring function of O2 sensor.
4. The FiO2 value is displayed on the normal screen.
5. Generally, you need to calibrate a new sensor to ensure its correct measurement. Refer to ***4.3.5O2 Sensor Calibration (optional)*** for calibration.

NOTE

- **After an O2 sensor is configured, if the FiO2 value is displayed as [---], make sure that O2 sensor software function is loaded already. Then check the electrical connection of the O2 sensor. If [O2 Sensor Unconnected] or [Replace O2 sensor] is alarmed, usually, the problem lies in the electrical connection of the O2 sensor. Refer to 5Troubleshooting to troubleshoot the problem.**
- **After adding or replacing an O2 sensor, calibrate the O2 sensor at 21% O2 and 100% O2. For details, refer to the section about O2 sensor calibration.**

4.5 Adjust the APL Valve Accuracy

To calibrate the APL valve:

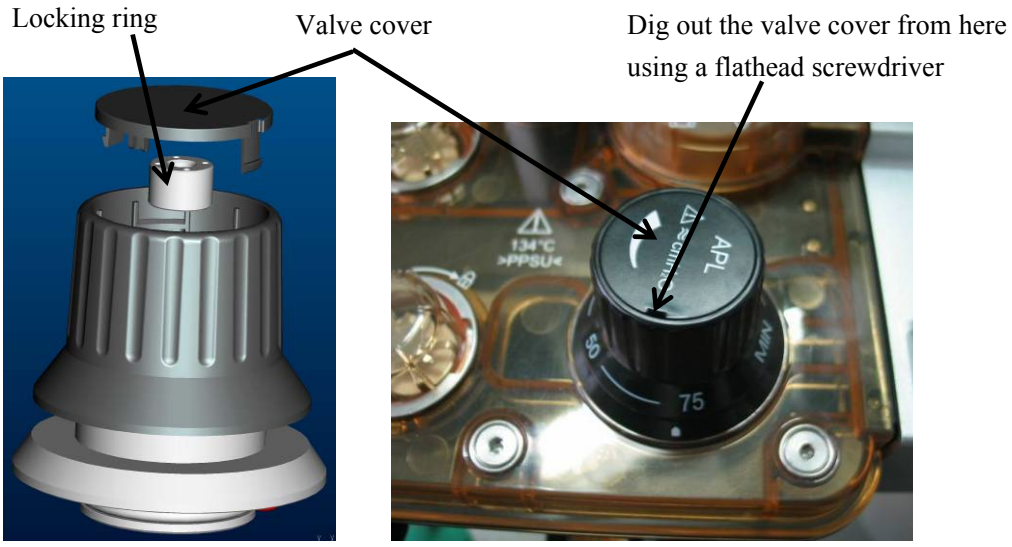
1. Connect the inspiration connector and bag arm port using a breathing tube, as shown below.

2. Set the Bag/vent switch to the bag position.
3. Set the APL valve reading to Min.
4. Push the O2 flush button.
5. The reading on the airway pressure gauge should fall within the range of 0 to 10 cmH2O.
6. Set the APL valve reading to 30 cmH2O.

7 Push the O2 flush button.

8. The reading on the airway pressure gauge should fall within the range of 25 to 35 cmH2O.
9. Set the APL valve reading to 50 cmH2O.
10. Push the O2 flush button.
11. The reading on the airway pressure gauge should fall within the range of 45 to 55 cmH2O.

12. If the reading on the airway pressure gauge fails to fall within the required range during steps 3 through 11, adjust the APL valve until the measurement requirements are met.



To adjust the APL valve:

(1)Remove the valve cover.

(2)Install the locking ring mounting fixture onto the locking ring.

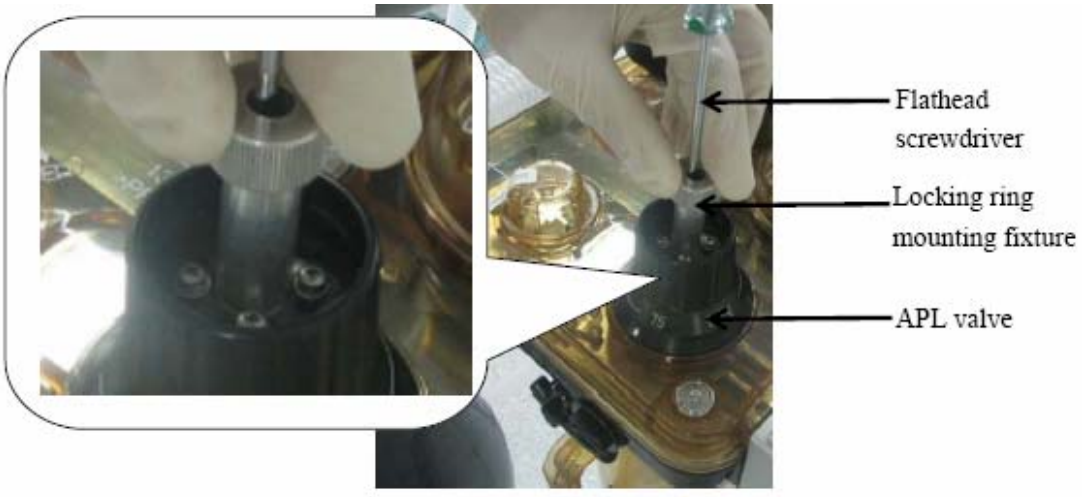
(3)Press the drive axis of the new APL valve using a flathead screwdriver and keep the screwdriver unmoved.

(4)Turn the locking ring mounting fixture counterclockwise to loosen the locking ring.

(5)Keep the locking ring mounting fixture unmoved. Turn the flathead screwdriver clockwise or counterclockwise to adjust the drive axis of the new APL valve, as shown below (turn the drive axis clockwise to increase APL and counterclockwise to decrease).

(6)After completing adjustment, keep the flathead screwdriver unmoved. Turn the locking ring mounting fixture clockwise to lock the locking ring.

(7)Re-install the valve cover.



FOR YOUR NOTES

5 Troubleshooting

5.1 Introduction

In this chapter, anesthesia machine problems are listed along with possible causes and recommended actions. Refer to the tables below to check the anesthesia machine, isolate and eliminate the problems.

Once isolating the part you suspect defective, refer to ***6Repair and Disassembly*** to disassemble the equipment and repair and replace the defective part.

5.2 Technical Alarm Check

Before troubleshooting the anesthesia machine, check for technical alarm message. If an alarm message is presented, eliminate the technical alarm first.

The following sections detail how to troubleshoot technical alarms related to the ventilator. For detailed information on possible causes and actions for technical alarm messages of other modules, refer to the Operator's Manual.

5.2.1 Main Unit Related Alarms

In the "Level" column of the following table, the default alarm level is indicated: H for high, M for medium, L for low and P for prompt message.

Alarm message	Level	Possible cause	Recommended action
RT Clock Need Reset	H	There was no button cell available in the system, or the battery had no capacity.	1. Replace with a new button cell. 2. If the problem persists, replace the main control board.
RT Clock Not Exist	H	RT chip malfunction.	1. Restart the machine. 2. If the problem persists, replace the board.
Keyboard Init Error	H	Keyboard malfunction. Stop using the keyboard.	1. Restart the machine. 2. If the problem persists, replace the keyboard.
Key Error	M	The key was pressed and held for more than five seconds.	1. Check the pop-up status of the key and the keyboard. 2. If the problem persists, replace the keyboard.
Ventilator Hardware Error 01 to 09	H	Monitor board selftest error	Replace the monitor board.

Alarm message	Level	Possible cause	Recommended action
Ventilator Hardware Error 11	H	Safety valve control failure by the auxiliary control board	1. Perform leak test again. 2. Check if the PEEP valve works normally. Restart the machine. (This fault occurs only when leak test is being carried out).
Auxi Ctrl Module Error	H	During leak test and zeroing, a failure occurred during the interaction between the auxiliary control board and the monitor board.	1. Restart the machine. 2. Perform leak test. 3. Perform manual zeroing. 4. Replace the monitor board.
Ventilator Comm Stop	H	The ventilator module failed to communicate with the main system.	1. Re-plug or replace the communication cable between the main control board and the monitor board. 2. If the problem persists, replace the monitor board. 3. If the problem persists, replace the main control board.
Drive Gas Pressure Low	H	The pressure of drive gas was low.	1. Check the status of actual gas supply to confirm if the alarm is in compliance with the actual status. 2. Short circuit the pressure switch and the alarm regarding outputted signals should disappear. Otherwise, it indicates that the pressure switch is faulty. Replace the pressure switch. Otherwise, check the connection between the pressure switch and the monitor board and check the socket. 3. If the above two items are normal, replace the monitor board.
O2 Supply Failure	H	The O2 pressure was low.	Use the same method to drive gas pressure low to check the O2 pressure switch.
Sustained Airway Pressure	H	The airway pressure in the breathing circuit was greater than sustained airway pressure alarm limit for 15 seconds.	1. Check if the airway pressure sensor is in correct measurement status. 2. Check if the sampling line of the airway pressure sensor is in normal status. 3. Sensor failure. Replace the monitor board.
Paw<-10cmH2O	H	Less than the barometric pressure for 10cmH2O.	

Alarm message	Level	Possible cause	Recommended action
ACGO On	P	ACGO was switched on	1. Switch off ACGO. 2. Check if the connection line of ACGO is broken or short circuited. 3. If the ACGO switch is in correct status, and its connection line and connector are normal but the problem persists, replace the monitor board.
PEEP Valve Failure	M	Valve voltage error or valve opening status error	Check if the sensor is normal. Replace the sensor or monitor board when necessary. Replace the expiratory valve assembly.
Insp Valve Failure	M		
PEEP Safety Valve Failure	M		
O2 Flush Failure	M	Oxygen flushing having lasted too long (more than 15 seconds)	1. Check if the O2 flush button fails to pop up. 2. Check if the O2 flush pressure switch is in normal status. 3. Check if the connection line of O2 flush button and its connector are normal. 4. Replace the monitor board.
Replace O2 sensor	M	O2 sensor failure	Replace the O2 sensor.
Pressure Monitoring Channel Failure	M	The measured value by the pressure sensor exceeded the range. Or, the zero point of the pressure sensor was outside of the range.	1. Disconnect the gas supply and disconnect connection to the patient airway. Check the counts value of pressure sensor. 2. If there is a great deviation of zero point, check if the pressure sampling line is blocked or pressed. 3. Perform manual zeroing. 4. Restart the machine. If the problem persists, replace the monitor board.
Calibrate Flow Sensor	L	Last calibration of the flow sensor and inspiratory valve failed. Or, great drift occurred to the flow sensor and inspiratory valve.	Perform factory calibration. Refer to 4Maintenance and Calibration.
Calibrate PEEP Valve	L	Last calibration of the Paw sensor and PEEP valve failed. Or, great drift occurred to the Paw sensor and PEEP valve.	Perform factory calibration. Refer to 4Maintenance and Calibration.

Alarm message	Level	Possible cause	Recommended action
Calibrate O2 Sensor	L	Last calibration of the O2 sensor failed. Or, O2 concentration was measured outside of the range.	1. Calibrate the O2 sensor again. 2. Replace the O2 sensor.
O2 Sensor Unconnected	L	The O2 sensor was not connected to the cable or was not connected properly.	1. Make sure that the O2 sensor is connected to the cable correctly. 2. Replace the O2 sensor.
Flow Sensor Failure	L	The measured value by the flow sensor exceeded the range. Or, the zero point of the pressure sensor was abnormal. Ventilator flow sensor failure or sampling line connection error.	1. Check if the zero point of the flow sensor is normal. 2. Check if the measurement performed by the flow sensor is normal. 3. Replace the flow sensor and perform calibration. 4. Replace the monitor board and perform calibration.
Pinsp Not Achieved	L	In the PCV mode, the inspiratory pressure was less than the set inspiratory pressure level for 6 consecutive breathing cycles to some extent.	1. Check for breathing circuit leakage. 2. Check the measurement accuracy of the pressure sensor. 3. Perform calibration in case of measurement failure. 4. Replace the monitor board and perform calibration.
TV Not Achieved	L	TVi was less than the set value for 6 consecutive breathing cycles to some extent.	1. Check for breathing circuit leak. 2. Check the measurement accuracy of the pressure sensor. 3. Perform calibration in case of measurement failure.
Three-way Valve Failure	L	Error of three-way valve electrical signal control status	1. Check the three-way valve connection line. 2. Replace the three-way valve assembly. 3. Replace the monitor board.
IP Address Conflict	M	IP address conflict	1. Set the IP address again. 2. If the problem persists, update the system software code or replace the main control board.
Check Flow Sensors	H	The flow sensor detected erroneous gas flow.	1. Check the check valve. 2. Check if the sampling lines of the sensor are connected in correct order. 3. Test the measurement status of the sensor in the valves test tool.

Alarm message	Level	Possible cause	Recommended action
ACGO 3-way Valve Failure	M	For machine with ACGO2 function, the status of CGO 3-way valve is not consistent with the expected status.	Check if the pipeline connection of CGO 3-way valve is correct.
Mechanical Ventilation Failure	H	When ventilator module reset error occurred, the high level alarm of [Mechanical Ventilation Failure] was triggered. This alarm disappeared when the ventilator module restored to normal	1. Check the hardware of main control board and monitor board. 2. Restart the machine. If the failure problem persists, replace the board.
Ventilator Init Error	H	Ventilator hardware failure occurred during initialization.	1. Check the flow and pressure sensors. 2. Check the inspiratory valve, expiratory valve, and PEEP valve. 3. Check the monitor board hardware. 4. Replace the corresponding hardware when a failure is detected.
Ventilator Selftest Error	H	Ventilator hardware failure occurred during selftest.	1. Check the flow and pressure sensors. 2. Check the inspiratory valve, expiratory valve, and PEEP valve. 3. Check the monitor board hardware. 4. Replace the corresponding hardware when a failure is detected.
CO2 Canister Not Mounted	M	The CO2 canister was not correctly installed.	1. Check if the CO2 canister is correctly installed. 2. Re-install the CO2 canister.
Patient Disconnected?	H	The patient was disconnected.	1. Check the tube connection with the patient. 2. Re-connect the patient.
Fresh Gas Flow Too High	M	The fresh gas flow delivered exceeded the limit	Decrease the fresh gas flow.

Alarm message	Level	Possible cause	Recommended action
Breathing Circuit Not Mounted	H	The breathing circuit was not mounted or the connection line of breathing circuit seat was incorrectly connected.	1. Check if the circuit is installed in place. 2. Test the connection between the connection line and connector. 3. Replace the power board (for WATO anesthesia machine, the power board monitors if the circuit is in place).
Low Battery Voltage!	H	The battery voltage was low.	1. Connect the AC supply to charge the battery. Check if the battery is normal. 2. If battery charging fails, check if the charging circuit is normal. 3. If the problem persists, replace the battery.
Battery in Use	L	The battery was being used.	1. Check the AC power connection. 2. If AC supply is normally connected and the voltage is normal, check the connection and socket between AC power and power board. 3. If the problem persists, replace the power board.
System DOWN for battery depletion!	H	1. The battery was faulty and could not be charged. 2. The system software version did not match the machine type.	1. The system shuts off automatically. Connect the AC supply. Check if the machine can start up normally and if battery charging is normal. 2. If battery charging fails, check if the charging circuit is normal. 3. If the problem persists, replace the battery. 4. Check if the system software version matches the current machine type. If not, upgrade the system software. 5. If the problem persists, replace the power board.

5.2.2 Auxiliary Control Module Related Alarms

Alarm message	Level	Possible cause	Recommended action
Auxi Ctrl Module Hardware Error 01 to 05	H	Auxiliary control module hardware error occurred.	Replace the monitor board and auxiliary control board assembly.
Pressure Monitoring Channel Failure	M	The auxiliary control board detected pressure monitoring error.	1. In the AD channel of auxiliary control board, check the statuses of Paw sensor and PEEP sensor. 2. If pressure monitoring failure occurs to the auxiliary control board, replace the auxiliary control board.
Auxi Ctrl Module Comm Stop	H	The auxiliary control modules failed to communicate with the main system normally.	1. Check the communication connection between the auxiliary control board and main control board. 2. If the LED light of the auxiliary control board flashes at 1Hz, it indicates that the auxiliary control board is working normally. If not, this board is faulty. 3. Restart the machine or upgrade the software of auxiliary control board. If the problem persists, replace the board.

5.2.3 CO2 Module Related Alarms

Alarm message	Level	Possible cause	Recommended action
CO2 Comm Stop	H	The CO2 module failed to communicate with the system normally.	1. Replace the communication cable for CO2 module. 2. Replace the CO2 module.
CO2 Sensor High Temp	M	The temperature of sensor assembly is too high (greater than 63^{o} C).	Replace the CO2 module.
CO2 Sensor Low Temp	M	The temperature of sensor assembly is too low (less than 5^{o} C).	Replace the CO2 module.
CO2 High Airway Press.	M	The airway pressure is too high (exceeding 790mmHg).	Replace the CO2 module.

Alarm message	Level	Possible cause	Recommended action
CO2 Low Airway Press.	M	The airway pressure is too low (less than 428mmHg).	Replace the CO2 module.
CO2 High Barometric	M	The barometric pressure exceeds 790mmHg.	Replace the CO2 module.
CO2 Low Barometric	M	The barometric pressure is less than 428mmHg.	Replace the CO2 module.
CO2 Hardware Error	H	Errors occurred to: 1. External A/D sampling 2.5 V 2. 12V power supply voltage 3. Internal A/D sampling 2.5 V 4. Pump. 5. Three-way valve.	Replace the CO2 module.
CO2 Sampleline Occluded	M	An error or occlusion occurred to the sampling line.	Replace the CO2 module.
CO2 System Error	H	Multiple system errors occurred.	Replace the CO2 module.
CO2 No Watertrap	M	The CO2 watertrap was disconnected or was not properly connected.	1. Check the CO2 watertrap. 2. Re-install the CO2 watertrap. 3. If the problem is not eliminated, replace the CO2 watertrap. 4. If the problem persists, replace the CO2 module.
EtCO2 Overrange	H	The parameter measured value is outside the measurement range (error range should be calculated).	1. Re-calibrate the CO2 module. 2. Replace the CO2 module.
FiCO2 Overrange	H	The parameter measured value is outside the measurement range (error range should be calculated).	1. Re-calibrate the CO2 module. 2. Replace the CO2 module.

Alarm message	Level	Possible cause	Recommended action
CO2 Zero Failed	M	Mindray CO2 module failure.	Replace the CO2 module.
CO2 Cal. Failed	M	Mindray CO2 module failure.	Replace the CO2 module.
CO2 Factory Cal. Invalid	M	Mindray CO2 module failure.	Replace the CO2 module.
CO2 Init Error	H	An error occurred to the CO2 module during initialization.	Replace the CO2 module.
CO2 Selftest Error	H	An error occurred to the CO2 module during selftest.	Replace the CO2 module.

5.2.4 Heating Module Related Alarms

Alarm message	Level	Possible cause	Recommended action
Heating Module Failure	L	The voltage of heating module exceeded 16V.	1. Determine if the heating module heating voltage exceeded the limit through measuring or in AD channel. 2. If yes, replace the power board.
		Heating failed (the temperature of two thermistors was less than 35 degrees continuously).	1. Determine the test temperature in display AD channel. 2. Check the status of thermistor. 3. Check the function of heating wire. 4. Replace the power board.
		Overtemperature.	
Heating Module Selftest Error	L	The heating module selftest had an error.	Restart the machine. If the problem persists, replace the heating module.
Heating Module Comm Stop	L	The heating module failed to communicate with the main control board.	Check if the communication cable of heating module is normally connected. If the problem persists, replace the main control board. If the problem persists, replace the heating module.

5.3 Pneumatic Circuit System Problems

The pneumatic circuit system is mainly composed of gas supplies, anesthetic gas delivery system, anesthetic gas delivery device (vaporizer), anesthetic ventilator, breathing system and anesthetic gas scavenging system. This chapter details possible failures regarding the pneumatic circuit system and how to troubleshoot them.

5.3.1 Tools for on-site Maintenance

The tools required for troubleshooting are listed below.

Name	Negative pressure ball	Injector (100 ml)	Circuit adapter test fixture	Flow sensor pressure sampling pipeline test fixture	Vaporizer manifold test fixture	1 MPa (10 bar) Test pressure gauge	Anesthesia machine calibration device
Quantity	1	1	1	1	1	1	1

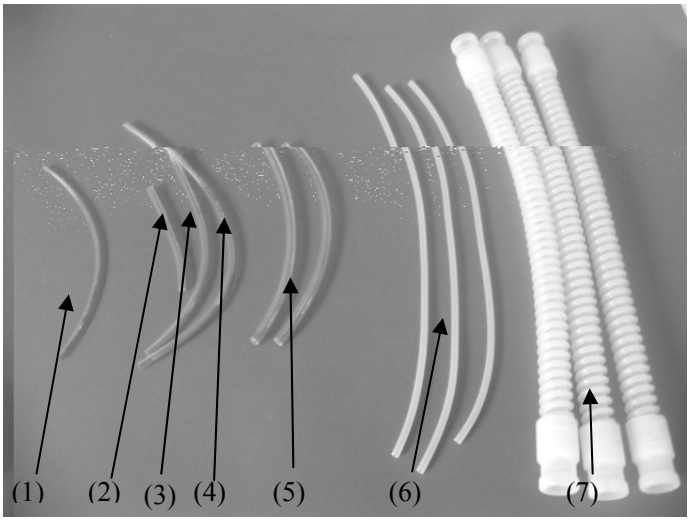
Name	T-shaped Allen wrench
Quantity	1

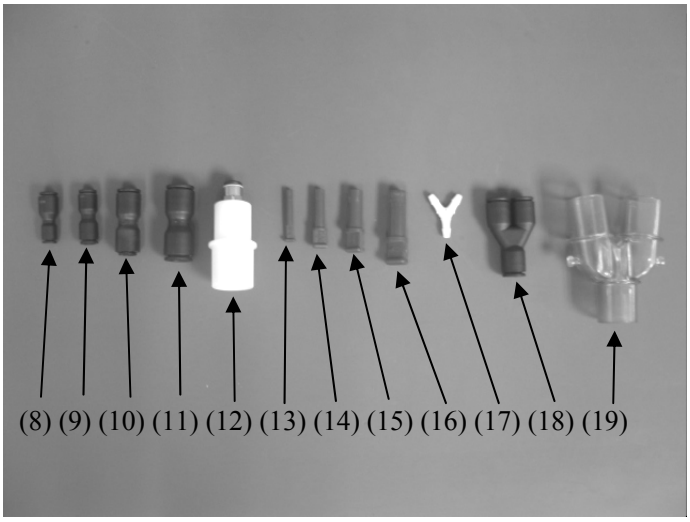
Name	3106-04-06 adapter connector	3106-06-08 adapter connector	3106-10-00 adapter connector	3106-06-00 adapter connector	Breathing tube adapter connector	3126-04-00 tube plug	3126-06-00 tube plug
Quantity	1	1	2	1	1	1	2

Name	3126-08-00 tube plug	3126-10-00 tube plug	Y piece	Breathing tube Y piece	3140-08-00 Y piece
Quantity	3	2	2	1	1

Name	PU tube (4X200)	PU tube (6X100)	PU tube (6X200)	PU tube (6X300)	PU tube (8X200)	Breathing tube	Φ6 silicone tube
Quantity	1	1	1	1	2	3	3

The following pictures show the tools listed above.

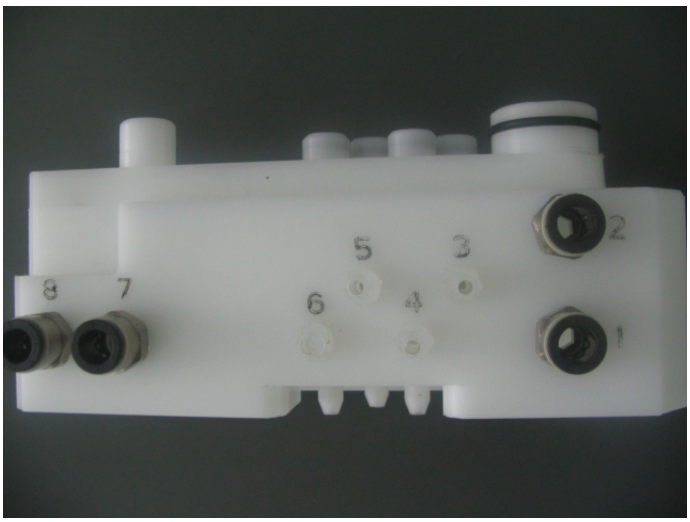




(1)PU tube (4X200)； (2)PU tube (6X100)； (3)PU tube (6X200)； (4)PU tube (6X300)； (5)PU tube (8X200)； (6)Φ6 silicone tube； (7)Breathing tube； (8)3106-04-06 adapter connector； (9)3106-06-00 adapter connector； (10)3106-06-08 adapter connector； (11)3106-10-00 adapter connector； (12)Breathing tube adapter connector； (13)3126-04-00 tube plug； (14)3126-06-00 tube plug； (15)3126-08-00 tube plug； (16)3126-10-00 tube plug； (17)Y piece； (18)3140-08-00 Y piece； (19)Breathing tube Y piece；

Negative pressure ball:

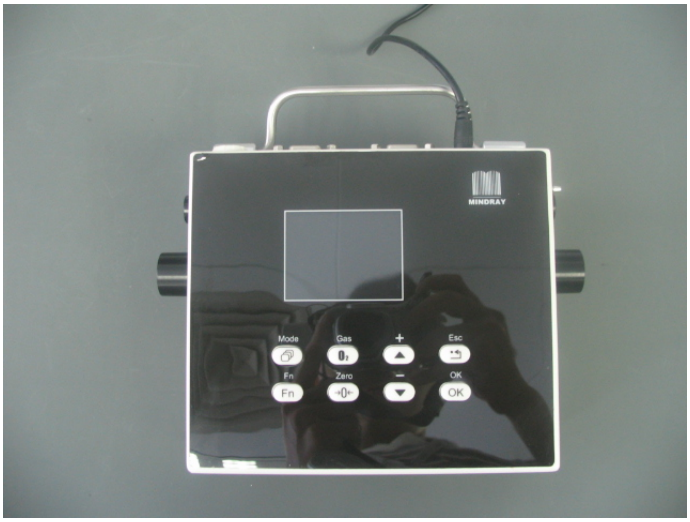
Circuit adapter test fixture:



Flow sensor pressure sampling pipeline test fixture:

Vaporizer manifold test fixture:

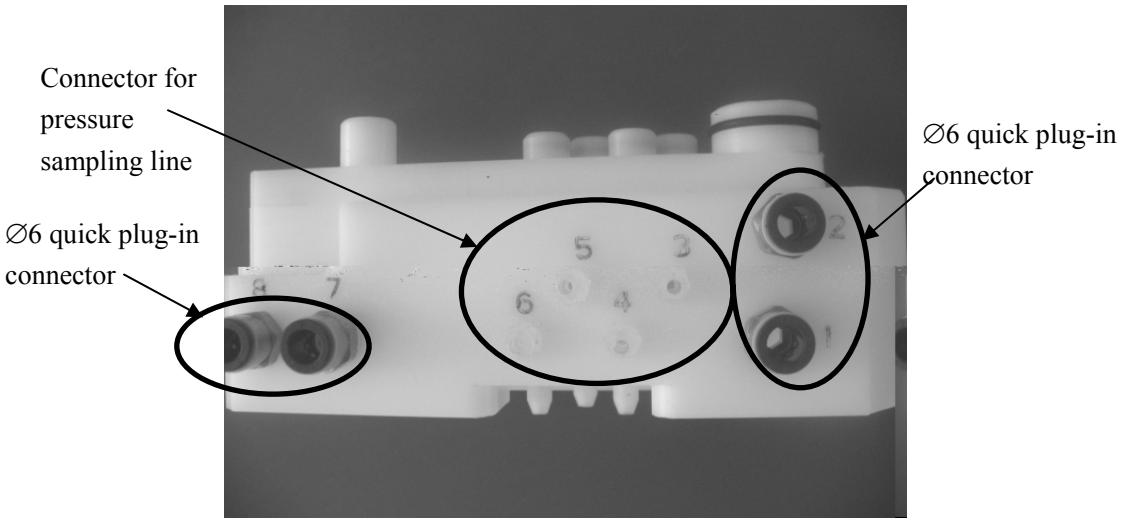
Anesthesia machine calibration device:



1 MPa (10 bar) test pressure gauge:

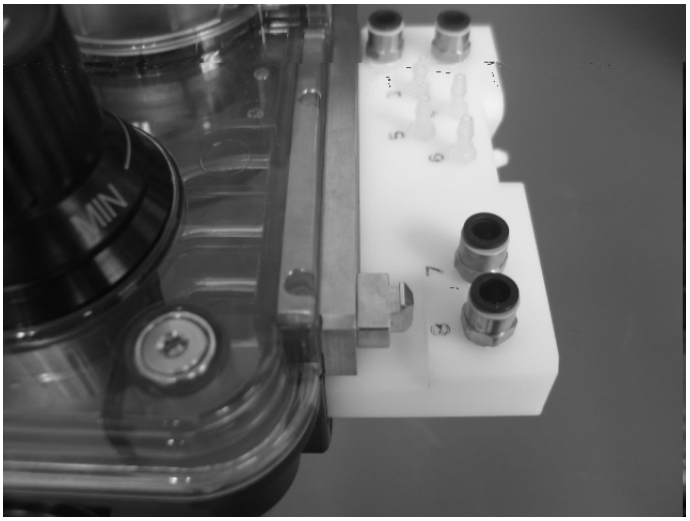
5.3.1.1 Precautions for Use of Circuit Adapter Test Fixture

There are four connectors for pressure sampling lines and four ∅6 quick plug-in connectors with number marked on the circuit adapter test fixture, as shown below.

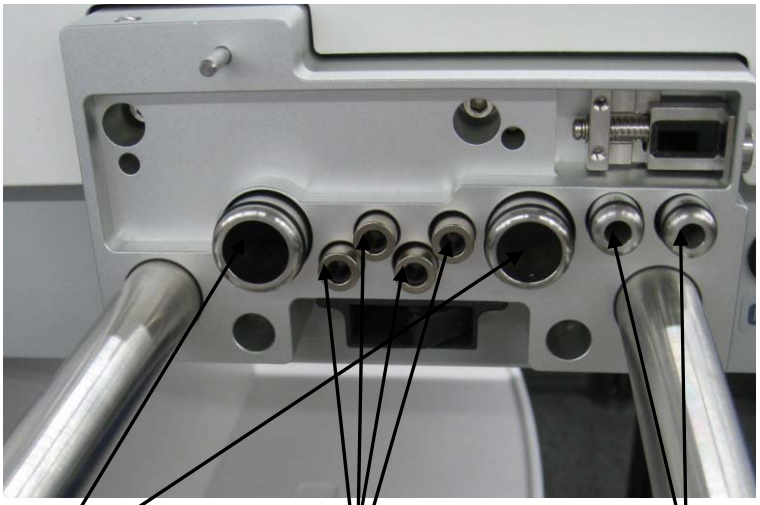


The connectors for pressure sampling lines can be connected with Φ6 silicone tubes and the ∅6 quick plug-in connectors with PU tube (6X100), PU tube (6X200) and PU tube (6X300), as shown below.

The circuit adapter test fixture can be mounted either onto the circuit adapter or onto the removed patient circuit. The following pictures show the test fixture mounted in position.



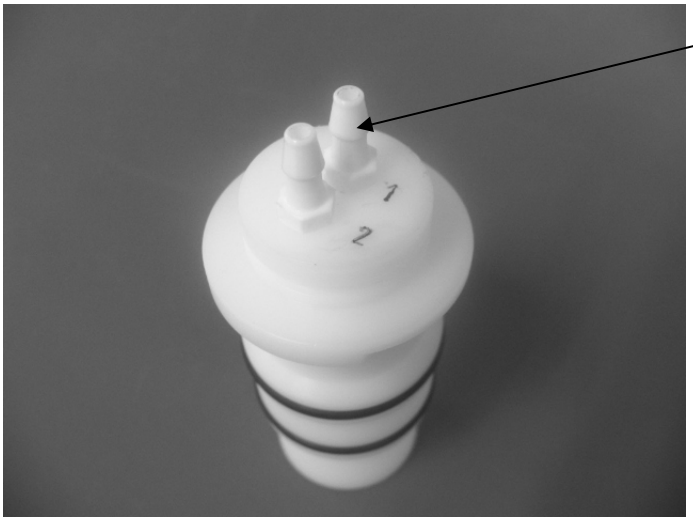
If it is hard to plug in and out the test fixture, apply a layer of KRYTOX lubricant (BOM number: M6F-020003---) to the seals (as shown below).



Seal (M6M-010058---）　Seal (M6M-010063---）　Seal (M6M-010006---）

5.3.1.2 Precautions for Use of Flow Sensor Pressure Sampling Pipeline Test Fixture

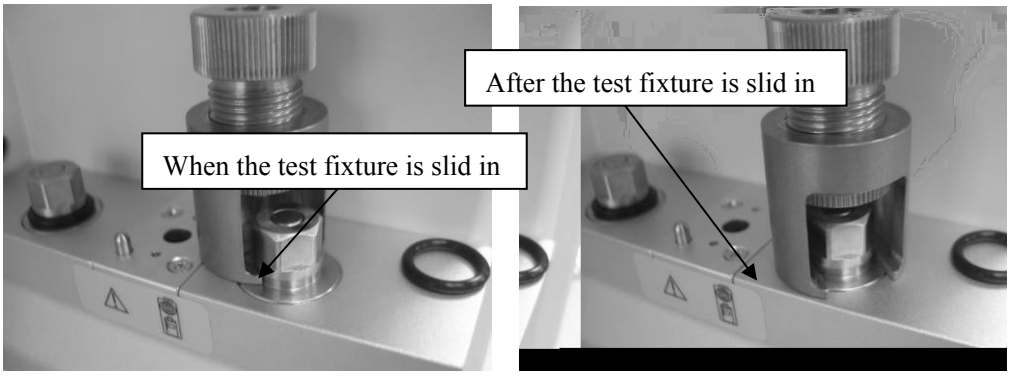
There are two connectors for pressure sampling lines on the flow sensor pressure sampling pipeline test fixture, as shown below.



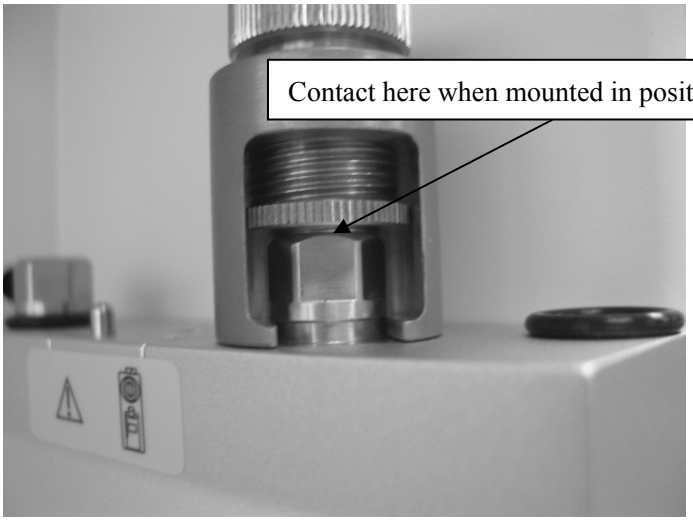
The connector for pressure sampling line can be connected with Φ6 silicone tubes.
When using the flow sensor pressure sampling pipeline test fixture, remove the expiratory or inspiratory flow sensor from the patient circuit first. Then mount the flow sensor pressure sampling pipeline test fixture onto the position where the expiratory or inspiratory flow sensor was originally mounted and tighten the inspiratory/expiratory connector rotary caps, as shown below. Perform test after connecting the Φ6 silicone tube to the connector for pressure sampling line.

5.3.1.3 Precautions for Use of Vaporizer Manifold Test Fixture

When using the vaporizer manifold test fixture, remove the seal between the connector of vaporizer manifold assembly and the vaporizer first. Then slide the test fixture into the connector, as shown below.

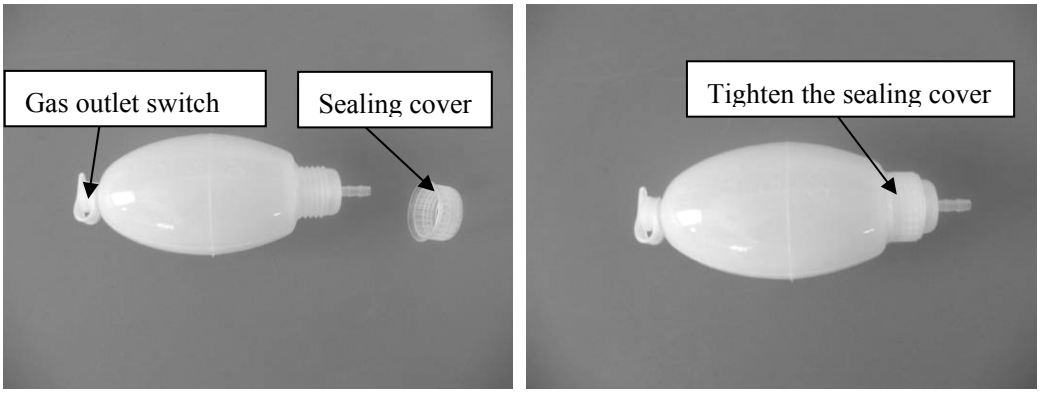


Turn the pressure head of vaporizer manifold test fixture clockwise until the bottom surface of the pressure head is in contact with the top surface of the connector of the vaporizer manifold assembly, as shown below.

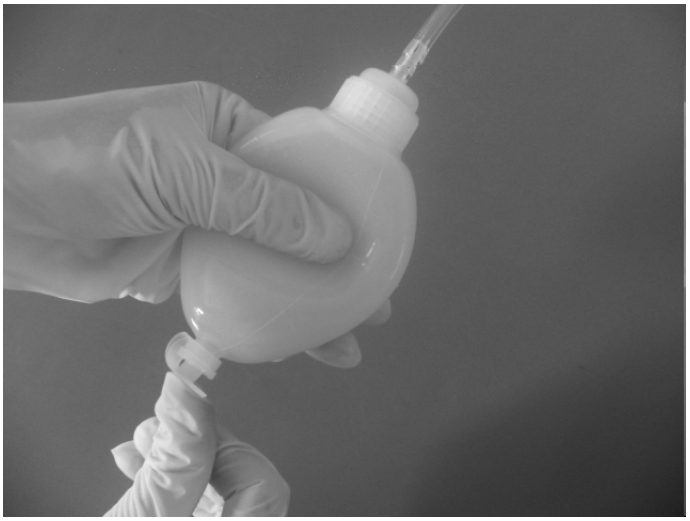


5.3.1.4 Precautions for Use of Negative Pressure Ball

The negative pressure ball has a sealing cover and a built-in one-way valve at its front end and a gas outlet switch at its back end, as shown below. If the front sealing cover is removed or loosened, the sealing performance of the negative pressure ball will compromise. In this case, you need to tighten the sealing cover.



Remove the gas outlet switch to flatten the negative pressure ball. Re-install the gas outlet switch properly when performing the test, as shown below.



Before using the negative pressure ball, make sure that it is not leaky. Check if the front sealing cover is tightened. Then flatten the negative pressure ball to remove the gas inside. Install the gas outlet switch properly. Block the front gas inlet with your hand to release the negative pressure ball main unit. Visible expansion of the ball cannot be seen within 30 seconds. Otherwise, replace the ball.

5.3.2 Gas Supplies and Drive Gas

The following table lists gas supplies and drive gas related failures.

Failure description	Possible cause	Recommended action
Leak	The gas supply tube is damaged or the seal at the connection is damaged.	Replace the gas supply tube or the seal at the connection.
	The quick plug-in connector leaks.	Replace the quick plug-in connector or PU tube (when the PU tube is not damaged, if the tube is long enough, cut off a small segment of the tube where the quick plug-in connector is met, and then insert the tube into position).
	The pipeline gas supply inlet assembly leaks.	Check if the one-way valve of the quick plug-in connector of the pipeline gas supplies inlet assembly leaks in the reverse direction. Replace it if necessary. Check and replace the damaged seal of the pipeline gas supplies inlet assembly. If the problem persists, replace the pipeline gas supplies inlet assembly.
	The drive gas pipeline leaks.	Check and repair the expiratory valve assembly as per the procedures described in ***5.3.4.2Leak Test of Low-pressure Pneumatic Circuit System***.
Pipeline pressure gauge shows inaccurate readings or no readings.	The pipeline pressure gauge is damaged.	Replace the pipeline pressure gauge.
The readings on the pipeline pressure gauge fluctuate greatly.	The filter of pipeline gas supply inlet assembly or the PU tube of the pipeline pressure gauge is occluded or the pressure gauge is damaged.	1. After confirming that the pipeline gas pressure is stable, check the PU tube of the pipeline pressure gauge and filter of the pipeline gas supply inlet assembly. If the tube or the filer is occluded, replace it (replaced at least once per year). 2. If the problem persists, replace the pipeline pressure gauge.

Failure description	Possible cause	Recommended action
No “O2 Supply Failure” alarm occurs when the O2 pressure is low or this alarm occurs when the O2 supply pressure is normal.	The gas pressure switch of the O2 supply inlet assembly is ineffective.	Adjust the pressure switch of the O2 supply inlet assembly to cause O2 supply pressure to approach 0.2 MPa as much as possible within the range of 0.15 to 0.25 MPa when this alarm occurs. If the adjustment fails, replace the pressure switch (refer to ***5.3.2.3Adjust the Pressure Switch***).
No “Drive Gas Pressure Low” alarm occurs when the drive gas pressure is low or this alarm occurs when the drive gas pressure is normal.	The pressure switch on the integrated pneumatic circuit of the expiratory valve assembly or the PEEP safety valve is ineffective. Or, the filter on the integrated pneumatic circuit of the expiratory valve assembly is occluded.	Adjust the pressure switch on the integrated pneumatic circuit of the expiratory valve assembly to cause drive gas pressure to approach 0.14 MPa as much as possible within the range of 0.05 to 0.2 MPa when this alarm occurs. If the adjustment fails, replace the pressure switch. If the problem persists after the pressure switch is replaced, replace the integrated pneumatic circuit of the expiratory valve assembly (refer to ***5.3.2.3Adjust the Pressure Switch***).

5.3.2.1 Test the Pipeline Pressure Gauge and Correct the Regulator

Use the following tools to test the pipeline pressure gauge and regulator of the pipeline gas supply inlet assembly:

- 1 MPa (10 bar) test pressure gauge (before the test, make sure that the 1 MPa (10 bar) test pressure gauge is in good condition) (quantity: 1)
- 3106-04-06 adapter connector (quantity: 1)
- PU tube (4X200) (quantity: 1)

Test procedures:
I O2 supply inlet assembly:

1. Turn off the pipeline gas supply and bleed the residual pressure through O2 flushing.
2. Pull out No.42 PU tube which connects the O2 supply inlet assembly to other assembly (Note 1). The end of the tube which connects the O2 supply inlet assembly is not pulled out but the other end is.
3. Connect the pulled-out tube end to the 1 MPa (10 bar) test pressure gauge through 3106-04-06 adapter connector, as shown below.

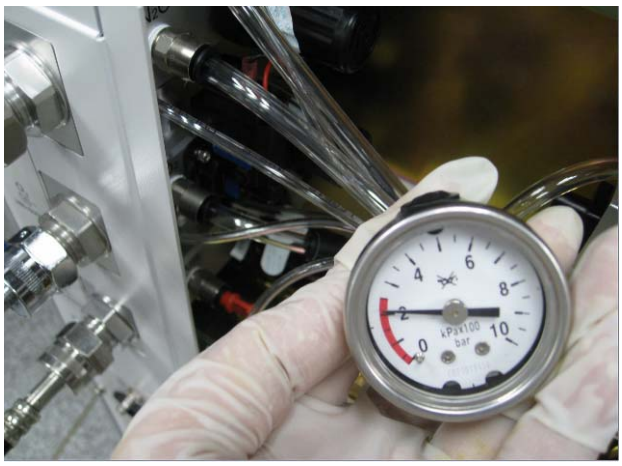
4. Turn on O2 pipeline supply and record the reading on the O2 pipeline pressure gauge. Observe the test pressure gauge. If the reading on the test pressure gauge is not within the range of 0.15 to 0.25 MPa (namely 1.5 to 2.5 bar), adjust the regulator of the O2 supply inlet assembly to cause the reading on the test pressure gauge to reach 0.2 MPa (namely, 2 bar). For operations of the regulator, refer to section ***5.3.2.4Adjust the Regulator of the Pipeline Gas Supply Inlet Assembly.***
5. Turn off the pipeline gas supply and bleed the residual pressure through O2 flushing.
6. Insert the pulled-out tube properly.
7. Pull out No.39 PU tube which connects the O2 supply inlet assembly to the O2 pipeline pressure gauge. The end of the tube which connects the O2 supply inlet assembly is not pulled out but the other end is.
8. Connect the pulled-out tube end to the test pressure gauge, as shown below.

9. Turn on the pipeline gas supply and record the reading on the test pressure gauge. If the difference between this reading and the reading on the O2 pipeline pressure gauge is more than 0.1 MPa (1 bar), it indicates that the O2 pipeline pressure gauge is damaged. Handle this problem as described in the troubleshooting table.
10. Insert the pulled-out tube properly.

Note 1: The Nos. of the PU tubes described here correspond to the gas tube Nos. when O2, N2O and AIR are all configured. In case of other gas supply configurations, if the PU tube is numbered differently, notes will be given in brackets. For Nos. of all PU tubes, refer to ***6.4.2Pneumatic Connections.***

II N2O supply inlet assembly:

1. Turn off the pipeline gas supply. Pull out No.48 PU tube which connects the N2O supply inlet assembly to other assembly. The end of the tube which connects the N2O supply inlet assembly is not pulled out but the other end is.
2. Connect the pulled-out tube end to the test pressure gauge through 3106-04-06 adapter connector, as shown below.



3. Turn on N2O and O2 pipeline supplies. Adjust the regulator of the N2O supply inlet

8. Turn on the N2O pipeline supply and record the reading on the test pressure gauge. If the difference between this reading and the reading on the N2O pipeline pressure gauge is more than 0.1 MPa (1 bar), it indicates that the N2O pipeline pressure gauge is damaged. Handle this problem as described in the troubleshooting table.
9. Insert the pulled-out tube properly.

III AIR supply inlet assembly:

1. Turn off the pipeline gas supply. Pull out No.50 PU tube which connects the AIR supply inlet assembly to other assembly. The end of the tube which connects the AIR supply inlet assembly is not pulled out but the other end is.
2. Connect the pulled-out tube end to the test pressure gauge through 3106-04-06 adapter connector, as shown below.

3. Turn on AIR pipeline supply. If the reading on the test pressure gauge is not within the range of 0.2±0.05 MPa (namely 2±0. 5 bar), adjust the regulator to cause the reading on the test pressure gauge to reach 0.2 MPa (namely, 2 bar). For operations of the regulator, refer to section ***5.3.2.4Adjust the Regulator of the Pipeline Gas Supply Inlet Assembly***. Record the reading on the AIR pipeline pressure gauge.
4. Turn off AIR pipeline supply and bleed the residual pressure by turning on the AIR flow regulator.
5. Insert the pulled-out tube properly.

6. Pull out No.41 PU tube which connects the AIR supply inlet assembly to the AIR pipeline pressure gauge. The end of the tube which connects the AIR supply inlet assembly is not pulled out but the other end is.
7. Connect the pulled-out tube end to the test pressure gauge, as shown below.

8. Turn on the AIR pipeline supply and record the reading on the test pressure gauge. If the difference between this reading and the reading on the AIR pipeline pressure gauge is more than 0.1 MPa (1 bar), it indicates that the AIR pipeline pressure gauge is damaged. Handle this problem as described in the troubleshooting table.
9. Insert the pulled-out tube properly.

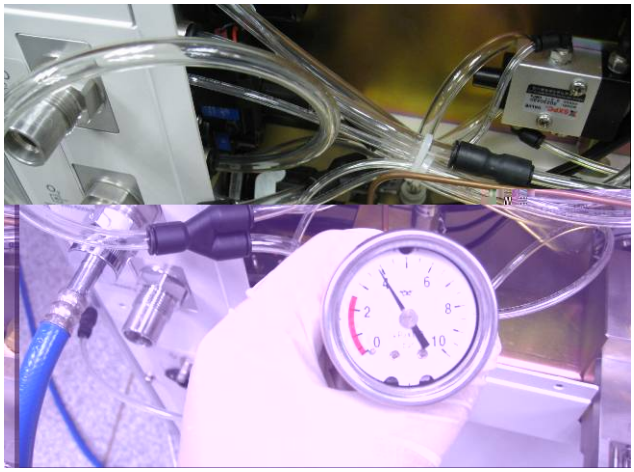
5.3.2.2 Test the Pressure Switch

Use the following tools to test if the pressure switch of the O2 supply inlet assembly and that on the integrated pneumatic circuit of the expiratory valve assembly are normal:

- 1 MPa (1 bar) test pressure gauge (before the test, make sure that the 1 MPa (1 bar) test pressure gauge is in good condition) (quantity:1)
- 3106-04-06 adapter connector (quantity:1)
- 3106-06-08 adapter connector (quantity:1)
- 3140-08-00 Y piece (quantity:1)
- PU tube (8X200) (quantity:2)
- PU tube (6X200) (quantity:1)
- PU tube (4X200) (quantity:1)

Test procedures:

1. Turn off the pipeline gas supply and bleed the residual pressure through O2 flushing.
2. Pull out No.54 PU tube which connects the O2 supply inlet assembly to the expiratory valve assembly. The end of the tube which connects the O2 supply inlet assembly is not pulled out but the other end is.
3. Connect one PU tube (8X200) to the pulled-out tube end of the O2 supply inlet assembly. Then connect this PU tube and the pulled-out end of No.54 PU tube to the two connectors of 3140-08-00 Y piece respectively.
4. Connect the test pressure gauge to another connector of 3140-08-00 Y piece through 3106-04-06 and 3106-06-08 adapter connectors, as shown below.

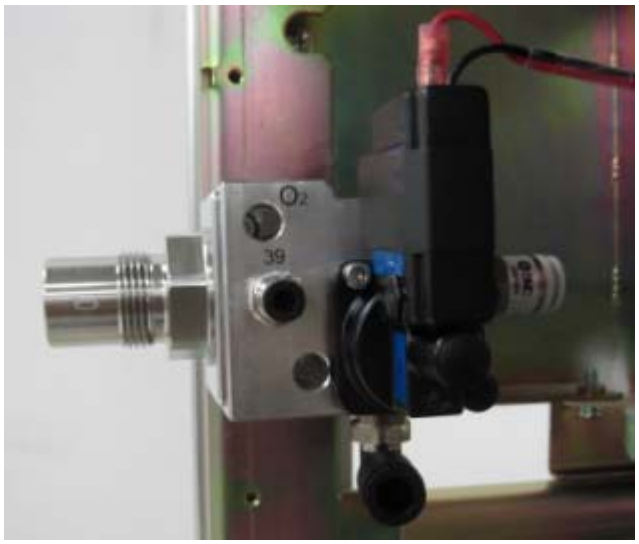


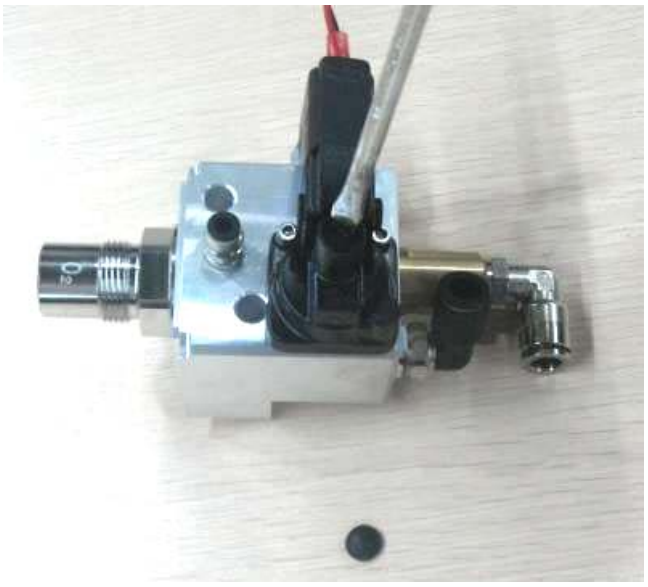
5. Turn on the O2 pipeline supply.
6. Turn on the machine to enter Standby.
7. Turn off all flowmeters.
8. Turn off the pipeline gas supply (if the reading on the test pressure gauge begins to fall dramatically and continuously after the gas supply is turned off, it indicates that one or several leaks occur to the O2 supply inlet assembly, expiratory valve assembly, O2 flush button assembly, system switch assembly, and flowmeter. Perform the subsequent operations after the leaks are serviced. Failures can be located by using the methods described in section ***5.3.3Anesthetic Gas Delivery System*** and ***5.3.4Patient Circuit*** except O2 supply inlet assembly related failures).
9. Manually adjust the O2 flow control until O2 flow is approximately 1 L/min, causing the reading on the test pressure gauge to fall gradually to 0.25 MPa (2.5 bar).
10. Turn off O2 flow to cause the reading on the test pressure gauge not to fall. If the “O2 Supply Failure” alarm occurs 10 s later, it indicates that the pressure switch of the O2 supply inlet assembly is faulty. Troubleshoot this problem as described in the relevant failure table.

11. Adjust the O2 flow control until O2 flow is approximately 0.5 L/min, causing the reading on the test pressure gauge to fall gradually to 0.2 MPa (2 bar).
12. Turn off O2 flow to cause the reading on the test pressure gauge not to fall. If the “Drive Gas Pressure Low” alarm occurs 10 s later, it indicates that the pressure switch on the integrated pneumatic circuit of the expiratory valve assembly is faulty. Troubleshoot this problem as described in the relevant failure table.
13. Adjust the O2 flow control until O2 flow is approximately 0.3 L/min, causing the reading on the test pressure gauge to fall gradually to 0.15 MPa (1.5 bar).
14. Turn off O2 flow to cause the reading on the test pressure gauge not to fall. If the “O2 Supply Failure” alarm does not occur 10 s later, it indicates that the pressure switch of the O2 supply inlet assembly is faulty. Troubleshoot this problem as described in the relevant failure table.
15. Adjust the O2 flow control until O2 flow is approximately 0.3 L/min, causing the reading on the test pressure gauge to fall gradually to 0.05 MPa (0.5 bar).
16. Turn off O2 flow to cause the reading on the test pressure gauge not to fall. If the “Drive Gas Pressure Low” alarm does not occur 10 s later, it indicates that the pressure switch on the integrated pneumatic circuit of the expiratory valve assembly is faulty. Troubleshoot this problem as described in the relevant failure table.

5.3.2.3 Adjust the Pressure Switch

Adjust the O2 supply pressure switch and drive gas pressure switch as described below. For the convenience of operations, disassemble the corresponding assembly. Take the O2 supply pressure switch as an example. Use a flathead screwdriver to adjust the O2 supply pressure switch as shown below. Turn for small degrees each time such as 30 degrees. Note that turning the pressure switch clockwise will decrease its alarm limits and counterclockwise increase its alarm limits. Assemble the assembly after each pressure adjustment is made and perform a test. Repeat the operations until the pressure at the time moment when the alarm occurs meets the requirement.





5.3.2.4 Adjust the Regulator of the Pipeline Gas Supply Inlet Assembly

Pull up the knob cover of the regulator. Turn the cover clockwise to increase pressure or counterclockwise to decrease pressure, as shown below. Bleed the inside pressure of the pipeline gas supply inlet assembly after each pressure adjustment is made. Then, turn on the pipeline gas supply again. Observe the adjusted pressure through the test pressure gauge. Refer to ***5.3.2.1Test the Pipeline Pressure Gauge and Correct the Regulator*** on how to observe the pressure of the regulator.

5.3.3 Anesthetic Gas Delivery System

The following table lists anesthetic gas delivery system related failures.

Failure description	Possible cause	Recommended action
	The O2 flush button assembly leaks.	Replace the seal on the O2 flush button assembly or replace the O2 flush button assembly.
	The system switch assembly leaks.	Replace the seal on the system switch assembly or replace the systems switch assembly.
	The vaporizer is installed improperly, which results in leak.	Re-install the vaporizer.
	The seal between the vaporizer manifold assembly and the vaporizer is damaged.	Clean or replace the seal. The seal should be replaced at least once per year as required.
	The seal between the vaporizer manifold inside and the connection or the rubber plain washer between the vaporizer manifold inside and the spring is damaged or dirty.	Clean the sealing part or replace the faulty seal and rubber plain washer.
	The vaporizer manifold assembly is damaged.	Replace the vaporiaanifold

		Low-pressure Pneumatic Circuit System. Replace the faulty parts and re-install the parts.
The gas supplies cannot be turned off after the machine is turned off.	The seal inside the system switch assembly is damaged.	Replace the seal inside the system switch assembly or replace the system switch assembly.
The machine cannot be powered on after turned on.	The contact switch is ineffective.	Replace the contact switch of the system switch assembly.
O2-N2O cut-off is ineffective.	The O2-N2O cut-off valve assembly is damaged.	Replace the O2-N2O cut-off valve assembly.
The flowmeter float indicates inaccurate value or remains unmoved.	The flowmeter is damaged.	Replace the flowmeter.
The flow control gets loose.	The flowmeter is damaged.	Replace the flowmeter.
The O2-NO link system is ineffective.	The flowmeter is damaged.	Replace the flowmeter.
N2O supply cannot be cut off in case of O2 supply failure.	The O2-N2O cut-off valve is damaged.	Replace the O2-N2O cut-off valve assembly.

5.3.3.1 Leak Test of the O2 Flush Button Assembly

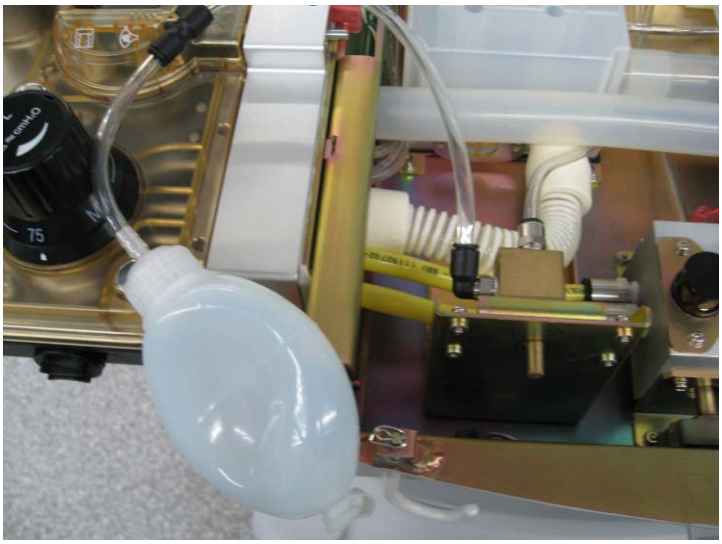
Perform a leak test of the O2 flush button assembly by using the following tools:

- Negative pressure ball (quantity:1)
- 3106-06-00 adapter connector (quantity:1)
- PU tube (6X100) (quantity:1)

Test procedures:

1. Turn off the pipeline gas supplies and bleed the residual pressure through O2 flushing.
2. Pull out No.52 PU tube which connects the O2 flush button assembly to the ACGO assembly. The end of the tube which connects the O2 flush button assembly is not pulled out but the other end is.
3. Flatten the negative pressure ball to remove the gas inside. Then re-install the gas outlet switch of the negative pressure ball properly. Connect the other end of the negative pressure ball to the pulled-out tube through 3106-06-00 adapter connector.

4. Release the negative pressure ball as shown below. If the negative pressure ball is fully expanded within 30 s, it indicates that the O2 flush button assembly is damaged. Handle this problem as described in the troubleshooting table.



5.3.3.2 Leak Test of the Flowmeter Related Assembly

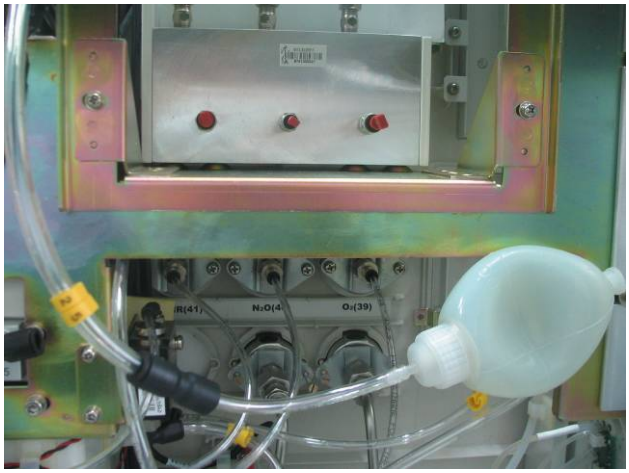
Perform a leak test of the flowmeter related assembly (from flow regulator to float flowmeter) by using the following tools:

- Negative pressure ball (quantity:1)
- 3106-06-08 adapter connector (quantity:1)
- 3126-04-00 tube plug (quantity:1)
- 3126-06-00 tube plug (quantity:2)
- PU tube (6X100) (quantity:1)

Test procedures:

1. Turn off the pipeline gas supplies and turn on the system switch. Bleed the residual pressure by turning on the flowmeters.
2. Turn off the system switch. Turn on the flowmeters and turn the flow controls counterclockwise for more than half a circle.
3. Pull out No.25 PU tube which connects the flowmeter to the vaporizer manifold assembly. The end of the tube which connects the flowmeter is not pulled out but the other end is.
4. Pull out No.46, 49 and 51 PU tubes (No.46 and 49 tubes in case of O2+N2O configuration, No.45 and 51 tubes in case of O2+AIR configuration, and No.45 tube in case of single O2 configuration) which connect the system switch assembly and O2-N2O cut-off valve assembly to the flow regulator. The ends of the tubes which connect the flow regulator are pulled out but the other ends are not.

5. Occlude the pulled-out tube end on the flowmeter by using 3126-04-00 or 3126-06-00 tube plug.
6. Flatten the negative pressure ball to remove the gas inside. Then re-install the gas outlet switch of the negative pressure ball properly. Connect the other end of the negative pressure ball to the pulled-out end of No.25 PU tube through 3106-06-00 adapter connector, as shown below.



7. Release the negative pressure ball. If the negative pressure ball is fully expanded within 30s, it indicates that the flowmeter is damaged. Handle this problem as described in the troubleshooting table.

5.3.3.3 Leak Test of the System Switch Assembly

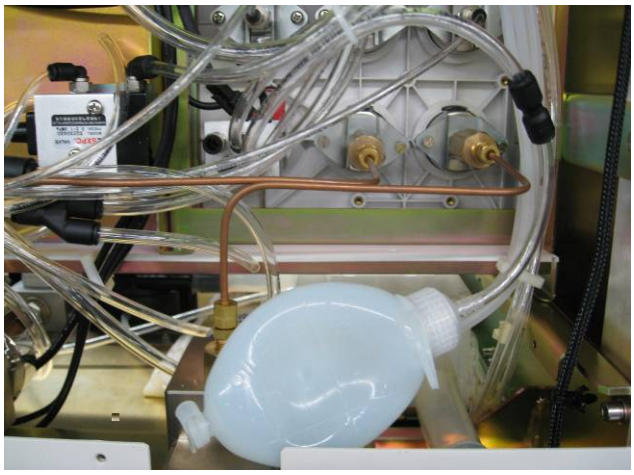
Perform a leak test of the system switch assembly by using the following tools:

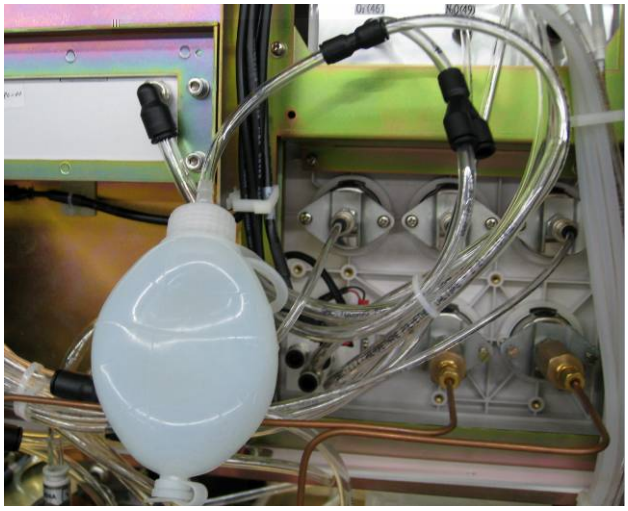
- Negative pressure ball (quantity:1)
- 3106-06-00 adapter connector (quantity:1)
- 3126-06-00 tube plug (quantity:2)
- PU tube (6X100) (quantity:1)

Test procedures:

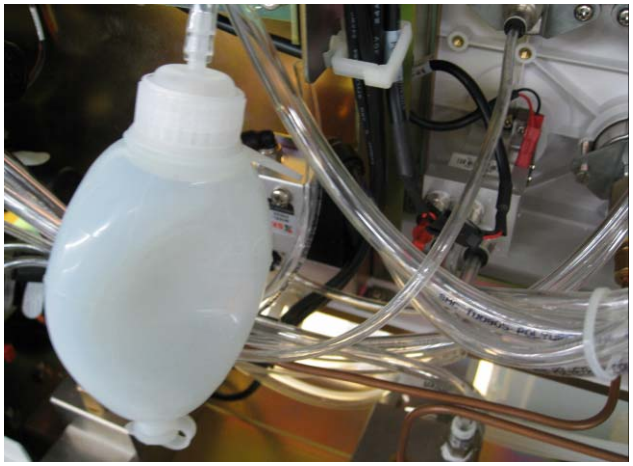
1. Turn off the pipeline gas supplies and turn on the system switch. Bleed the residual pressure by turning on the flow regulators.
2. Turn off the system switch.
3. Pull out No.45 or 51 PU tube (No.45 tube in case of O2+N2O configuration) which connects the system switch assembly to the flow regulator. The end of the tube which connects the system switch assembly is not pulled out but the other end is.
4. Pull out No.43 or 50 PU tube (No.43 tube in case of O2+N2O configuration) which connects the pipeline gas supply inlet assembly to the system switch assembly. The end of the tube which connects the system switch assembly is pulled out but the other end is not.

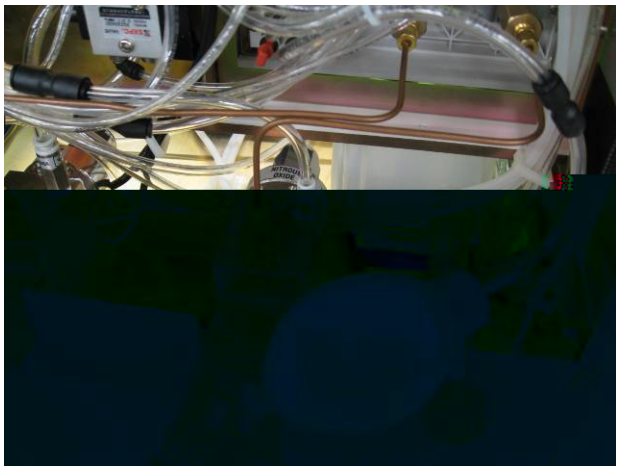
5. Flatten the negative pressure ball to remove the gas inside. Then re-install the gas outlet switch of the negative pressure ball properly. Connect the other end of the negative pressure ball to the pulled-out end of No.45 or 51 PU tube in turn through 3106-06-00 adapter connector, as shown below.





6. Release the negative pressure ball. If the negative pressure ball is fully expanded within 30s during one of the two tests, it indicates that the system switch assembly is damaged. Handle this problem as described in the troubleshooting table.
7. Turn on the system switch.
8. Occlude the pulled-out tube end on the system switch assembly by using 3126-06-00 tube plug.
9. Flatten the negative pressure ball to remove the gas inside. Then re-install the gas outlet switch of the negative pressure ball properly. Connect the other end of the negative pressure ball to the pulled-out end of No.45 or 51 PU tube in turn through 3106-06-00 adapter connector, as shown below.





10. Release the negative pressure ball. If the negative pressure ball is fully expanded within 30 s during one of the two tests, it indicates that the system switch assembly is damaged. Handle this problem as described in the troubleshooting table.

5.3.3.4 Leak Test of the O2-N2O Cut-off Valve Assembly

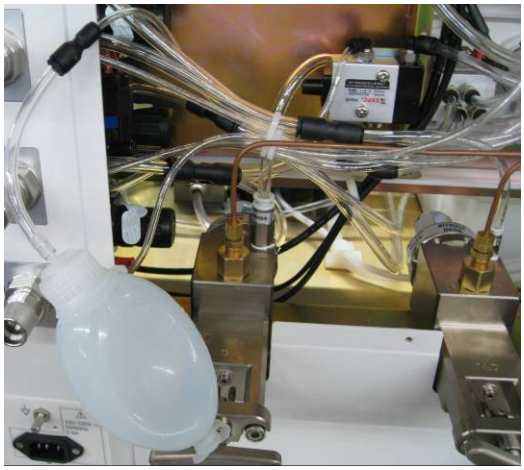
Perform a leak test of the O-N2O cut-off valve assembly by using the following tools:

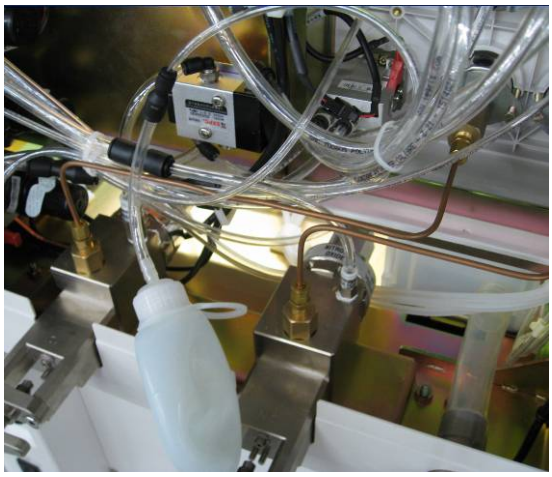
- Negative pressure ball (quantity:1)
- 3106-06-00 adapter connector (quantity:1)
- 3106-04-06 adapter connector (quantity:1)
- PU tube (6X100) (quantity:1)

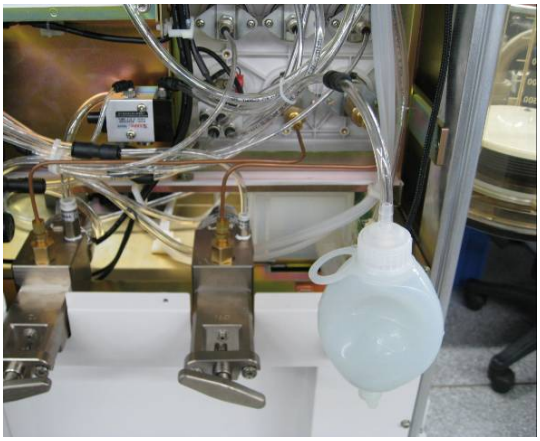
Test procedures:

1. Turn off the pipeline gas supplies and turn on the system switch. Bleed the residual pressure by turning on the flow regulators. Then turn off the system switch.
2. Pull out No.49 PU tube which connects the O2-N2O cut-off valve assembly to the N2O connector on the flowmeter (this test is not required in case of O2+AIR configuration or single O2 configuration). The end of the tube which connects the O2-N2O cut-off valve assembly is not pulled out but the other end is.

3. Pull out No.47 PU tube which connects the system switch assembly to the O2-N2O cut-off valve assembly. The end of the tube which connects the O2-N2O cut-off valve assembly is not pulled out but the other end is.
4. Pull out No.48 PU tube which connects the N2O supply inlet assembly to the O2-N2O cut-off valve assembly. The end of the tube which connects the O2-N2O cut-off valve assembly is not pulled out but the other end is.
5. Flatten the negative pressure ball to remove the gas inside. Then re-install the gas outlet switch of the negative pressure ball properly. Connect the other end of the negative pressure ball to the pulled-out tube through 3106-06-00 or 3106-04-06 adapter connector in turn, as shown below.







6. Release the negative pressure ball. If the negative pressure ball is fully expanded within 30s during one of the three tests, it indicates that the O2-N2O cut-off valve assembly is damaged. Handle this problem as described in the troubleshooting table.

5.3.3.5 Leak Test of the Vaporizer Manifold Assembly

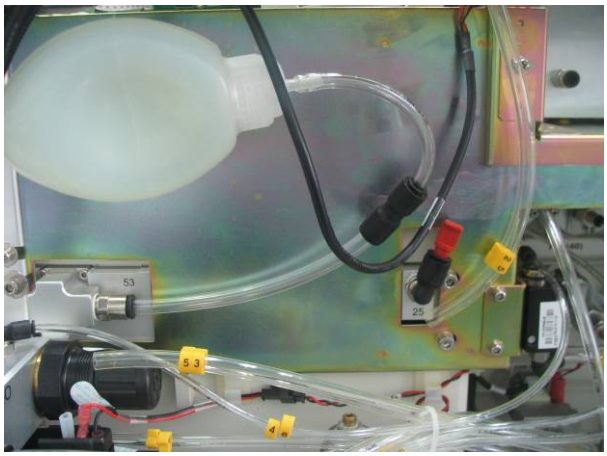
Perform a leak test of the vaporizer manifold assembly by using the following tools:

- Negative pressure ball (quantity:1)
- 3106-06-08 adapter connector (quantity:1)
- 3126-08-00 tube plug (quantity:1)
- PU tube (6X100) (quantity:1)
- PU tube (8X200) (quantity:1)
- Vaporizer manifold test fixture (quantity:1)

Test procedures:
I

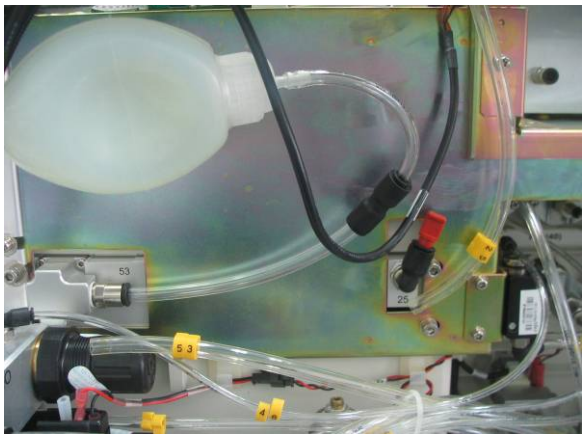
1. Turn off the system switch.
2. Mount the vaporizer but do not turn it on, as shown below.

3. Pull out No.25 PU tube which connects the flowmeter to the vaporizer manifold assembly. The end of the tube which connects the vaporizer manifold assembly is pulled out but the other end is not.
4. Occlude the pulled-out tube end on the vaporizer manifold assembly by using 3126-08-00 tube plug.
5. Pull out No.53 PU tube which connects the vaporizer manifold assembly to the ACGO assembly. The end of the tube which connects the vaporizer manifold assembly is pulled out but the other end is not.
6. Flatten the negative pressure ball to remove the gas inside. Then re-install the gas outlet switch of the negative pressure ball properly. Connect the other end of the negative pressure ball to the pulled-out No.53 tube through 3106-06-08 adapter connector and PU tube (8X200), as shown below.



7. Release the negative pressure ball. If the negative pressure ball is not fully expanded within 30s, it indicates that the vaporizer manifold assembly is not leaky. Otherwise, check the seal between the vaporizer manifold assembly and the vaporizer (replace the seal if it is damaged), or re-install the vaporizer. Do the test again until it is passed.
8. Remove the vaporizer as shown below.

9. Repeat steps 3 through 5 as shown below. If the vaporizer manifold assembly is leaky, one or several rubber plain washers and seal of the vaporizer manifold assembly or its contacted mechanical surface are damaged. Handle this problem as described in the troubleshooting table.

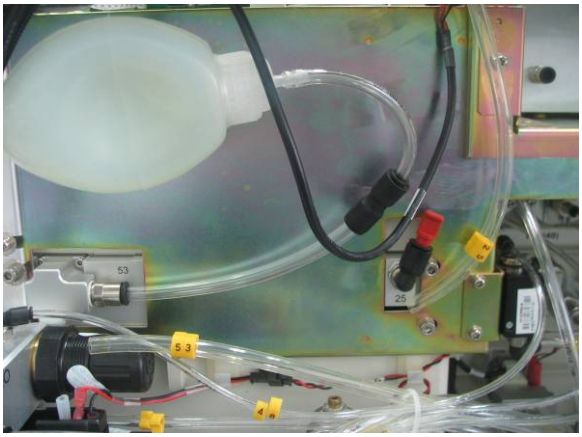


II Ensure that the vaporizer manifold assembly with vaporizer mounted (mentioned in "I") is not leaky and perform the following operations.

1. Remove the vaporizer and mount the vaporizer manifold test fixture onto the connector of the vaporizer manifold assembly (remove the seal between the connector and the vaporizer when mounting the test fixture), as shown below.

2. Pull out No.25 PU tube which connects the flowmeter to the vaporizer manifold assembly. The end of the tube which connects the vaporizer manifold assembly is pulled out but the other end is not.
3. Occlude the pulled-out tube end on the vaporizer manifold assembly by using 3126-08-00 tube plug.
4. Pull out No.53 PU tube which connects the vaporizer manifold assembly to the ACGO assembly. The end of the tube which connects the vaporizer manifold assembly is pulled out but the other end is not.

5. Flatten the negative pressure ball to remove the gas inside. Then re-install the gas outlet switch of the negative pressure ball properly. Connect the other end of the negative pressure ball to the pulled-out No.53 tube through 3106-06-08 adapter connector and PU tube (8X200). Occlude the pulled-out tube end on the flowmeter as shown below.



6. Release the negative pressure ball. If the negative pressure ball is fully expanded within 30s, it indicates that the rubber plain washers and seal of the tested pipeline or its contacted mechanical surface are damaged. Handle this problem as described in the troubleshooting table.
7. Test each connector on the vaporizer manifold assembly by following the above steps 1 through 6.

5.3.4 Patient Circuit

The following table lists patient circuit related failures.

Failure description	Possible cause	Recommended action
Leak	The CO2 absorbent canister is not installed properly.	Re-install the CO2 absorbent canister. Remove the absorbent at the sealing connection. Ensure the correct installation of CO2 absorbent canister.
	For WATO EX-25/30/35 anesthesia machine, the sealing components of the CO2 absorbent canister assembly are damaged, which refer to the seal cushion at the mouth of the CO2 absorbent canister (0601-20-78843) and the sealing component of the CO2 absorbent canister (0601-20-78842). For WATO EX-20 anesthesia machine, the sealing components of the CO2 absorbent canister assembly are damaged, which refer to the seal cushion at the outlet (049-000415-00) and the sealing component of the absorbent canister (049-000416-00).	Replace the sealing component of the CO2 absorbent canister assembly. It is required to replace the seal once a year.
	The seal for the bag arm is damaged.	Replace the seal for the bag arm. It is required to replace the seal once a year.
	The water collection cup gets loose.	Check and tighten the water collection cup.
	The seal for the water collection cup assembly is damaged.	Replace the seal for the water collection cup assembly. It is required to replace the seal once a year.
	The patient circuit is separated from the circuit adapter.	Reinstall the patient circuit. Make sure that the circuit is safely locked.
	The seal for the circuit adapter assembly is damaged.	Replace the seal, which is required to be replaced once a year.

	The bellows housing or bellows is not installed properly.	Re-install the bellows housing or bellows. Ensure their correct installation.
	The bellows sealing cushion falls off or is damaged.	Replace the bellows sealing cushion, which is required to be replaced once a year.
	The valve cover of the breathing valve assembly is not installed properly.	Re-install the valve cover and ensure its correct installation.
	The seal for the valve cover of the breathing valve assembly is damaged.	Replace the seal.
	The O2 sensor is not installed properly.	Re-install the O2 sensor and ensure its correct installation.
	The seal for the O2 sensor or the seal for the O2 sensor plug is damaged.	Replace the seal.
	The seal underneath the CO2 absorbent canister support is damaged.	Replace the seal underneath the CO2 absorbent canister support. It is required to replace the seal once a year.
	The breathing tube connecting the patient is damaged.	Replace the breathing tube.
	The bellows is damaged.	Replace the bellows, which is required to be replaced once a year.
	The sealing connection of other parts of the patient circuit is damaged.	Repair or replace the sealing connection as per the procedures described in section ***5.3.4.2Leak Test of Low-pressure Pneumatic Circuit System***

O2 concentration measurement fails or has great deviations.	There is water built up on the measurement surface of O2 sensor.	Remove the built-up water and allow the O2 sensor to air dry.
	The O2 sensor is not calibrated.	Calibrate the O2 sensor as per section ***4.3.5O2 Sensor Calibration (optional)*** .
	The O2 sensor is damaged.	Replace the O2 sensor.
The airway pressure gauge shows inaccurate reading or its pointer cannot move.	The airway pressure gauge is damaged.	Replace the airway pressure gauge.
The flow wave is displayed abnormal.	The flow sensor assembly is not installed properly.	Re-install the flow sensor assembly.
	There is water built up inside the flow sensor assembly.	Remove the flow sensor assembly and clear its inside water build-up.
	The membrane of the flow sensor assembly is distorted, dirty or its inside resistance changes.	Enter the user maintenance mode and calibrate the flow sensor as per section ***4.3.1Flow Calibration (user)***.
	The flow sensor is damaged.	Replace the flow sensor assembly.
	The flow sensor pressure sampling pipeline leaks.	Repair the flow sensor pressure sampling pipeline after checking as per the procedures described in section ***5.3.4.1Leak Test of Flow Sensor Pressure Sampling Pipeline***.

5.3.4.1 Leak Test of Flow Sensor Pressure Sampling Pipeline

If the flow waveform is displayed abnormal, the flow sensor pressure sampling pipeline may be leaky. Perform the leak test by using the following tools:

- Anesthesia machine calibration device (quantity:1)
- Flow sensor pressure sampling pipeline test fixture (quantity:1)
- Circuit adapter test fixture (quantity:1)
- Injector (quantity:1)
- Φ6 silicone tube (quantity:3)
- Y piece (quantity:1)

Test procedures:

I Leak test of the flow sensor pressure sampling pipeline (the four sampling pipelines of the expiratory and inspiratory flow sensors are all tested)

1. Turn off the system switch.
2. Install the patient circuit properly.
3. Remove the flow sensor assembly.
4. Mount the flow sensor pressure sampling pipeline test fixture onto the position where the flow sensor assembly was originally mounted. Tighten the breathing connector rotary cap.
5. Connect the Φ6 silicone tubes to the pressure sensor connector (positive pressure end) on the anesthesia machine calibration device), injector (before mounting, pull out the push rod of the injector) connector and the connector for the flow sensor pressure sampling pipeline test fixture by using a Y piece, as shown below.

6. Push in the push rod of the injector to let the pressure reading on the anesthesia machine calibration device rise to 70 to 90 cmH_2O and then stop pushing. Keep the relative position between the push rod and the injector unchanged. If the pressure reading on the anesthesia machine calibration device does not fall more than $5cmH_2O$ within 15 s, this test is passed.

II Leak test of the flow sensor pressure sampling pipeline inside the main unit (perform this test if test “I” fails)

1. Mount the circuit adapter test fixture onto the circuit adapter assembly.
2. Connect the Φ6 silicone tubes to the pressure sensor connector (positive pressure end) on the anesthesia machine calibration device), injector (before mounting, pull out the push rod of the injector) connector and the connector (one connector out of No.3 through 6 connectors on the test fixture) for the circuit adapter test fixture by using a Y piece, as shown below.

3. Push in the push rod of the injector to let the pressure reading on the anesthesia machine calibration device rise to 70 to 90 cmH_2O and then stop pushing. Keep the relative position between the push rod and the injector unchanged. If the pressure reading on the anesthesia machine calibration device does not fall more than 5 cmH_2O within 15s, this test is passed.

If test “I” is failed and “II” passed, it indicates that the flow sensor pressure sampling pipeline on the patient circuit is damaged. In this case, replace the patient circuit. If both tests “I” and “II” are failed, check the sampling lines and connectors inside the main unit, seals and three-way valves of the circuit adapter assembly until test “II” is passed. Then perform test “I”. If test “I” is still failed, it indicates the flow sensor pressure sampling pipeline on the patient circuit is damaged. In this case, replace the patient circuit.

5.3.4.2 Leak Test of Low-pressure Pneumatic Circuit System

After making sure that the flow sensor pressure sampling pipeline is not leaky, perform leak tests of the low-pressure pneumatic circuit system as shown in the following figures (figures a through d).

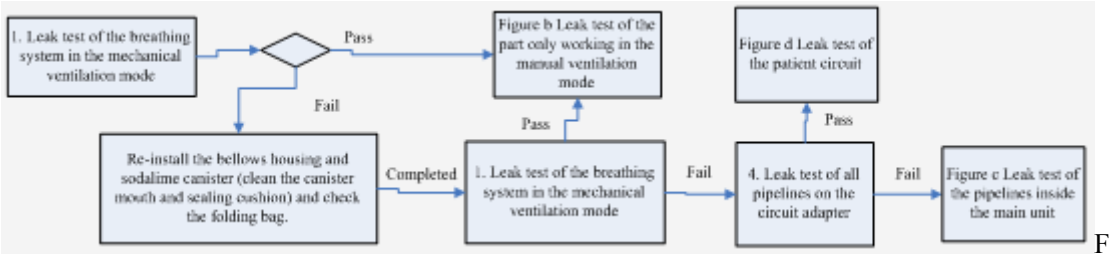


Figure a System leak test

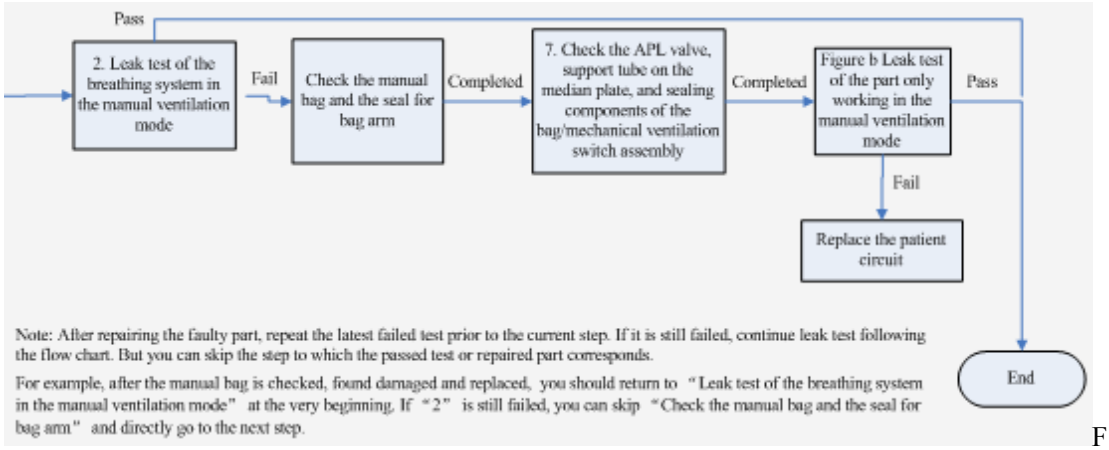


Figure b Leak test of the part only working in the manual ventilation mode

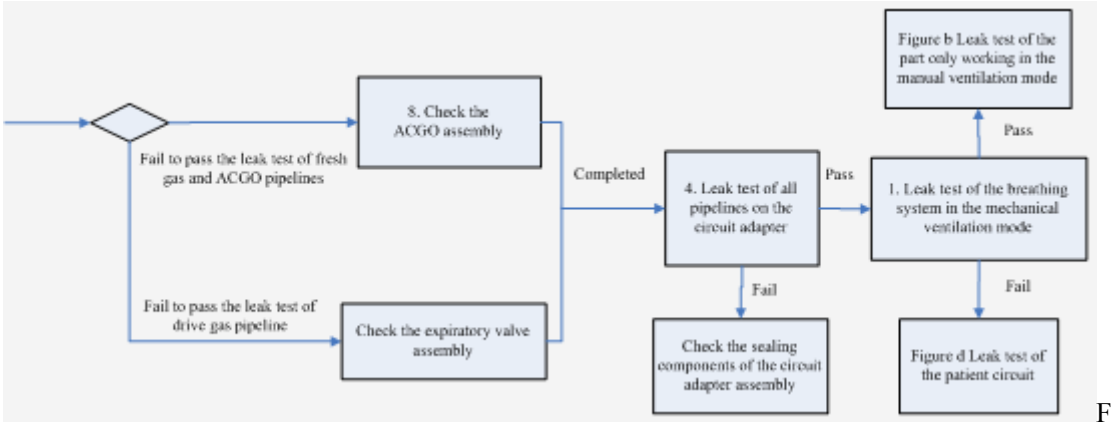


Figure c Leak test of the pipelines inside the main unit

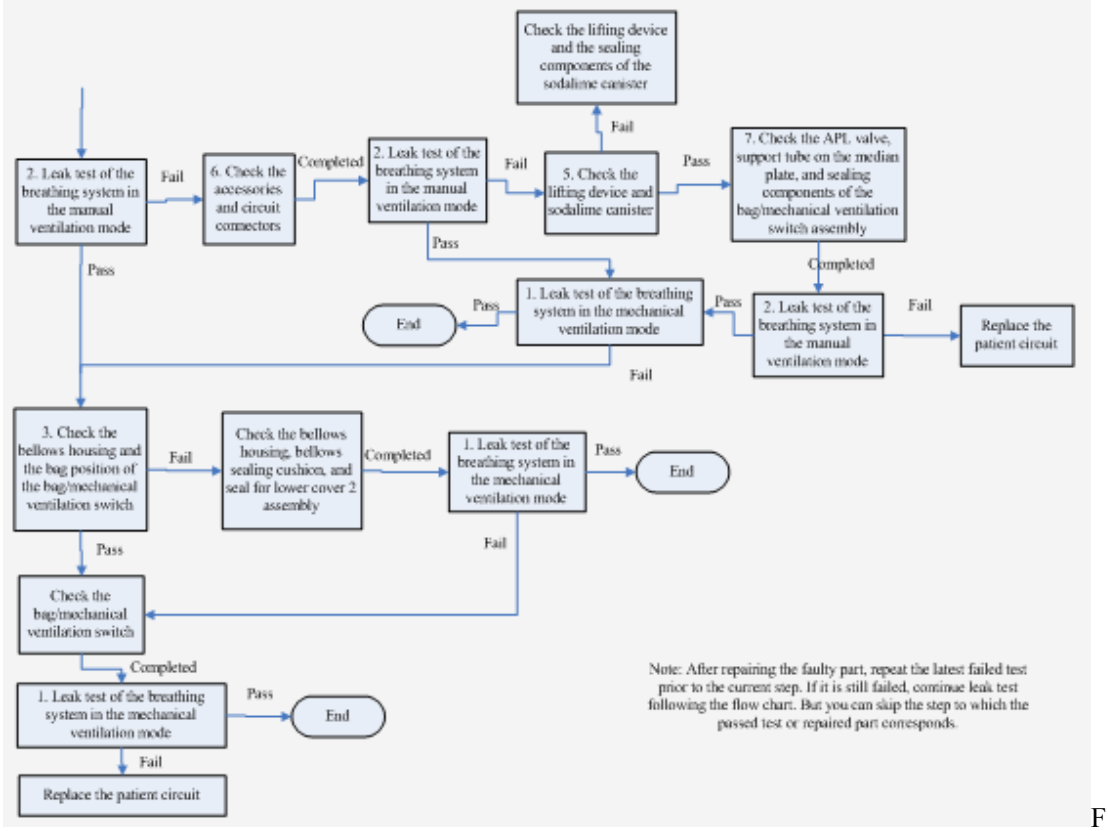


Figure d Leak test of the patient circuit

1. Leak test of the breathing system in the mechanical ventilation mode

   Perform the test as descried in section ***4.2.2Breathing System Leak Test in Mechanical Ventilation Mode***.

2. Leak test of the breathing system in the manual ventilation mode

Tools required:

- Breathing tube (quantity: 3)
- Breathing tube Y piece (quantity: 1)

Test procedures:

(1) Let the system enter Standby.

(2) Mount the patient circuit properly.

(3) Set the Bag/vent switch to the bag position.

(4) Set the pressure of the APL valve to maximum.

(5) Occlude the inspiratory&expiratory ports and bag arm port by using three breathing tubes and one breathing tube Y piece as shown below.

(6) Adjust the O2 flow control until O2 flow is approximately 0.2 L/min.,

(7) Push the O2 flush button to cause the reading on the airway pressure gauge to rise to 3 kPa.

(8) Stop O2 flushing. If the reading on the airway pressure gauge falls under 3 kPa, this test is failed.

(9) If the reading on the airway pressure gauge rises rapidly, to prevent defective APL valve from damaging the airway pressure gauge, note to turn off the O2 flow timely to prevent the overrange of the airway pressure gauge (the test which involves turning off O2 flow due to this reason is considered to be passed).

3. Check the bellows housing and the bag position of the Bag/vent switch

Tools required:

- Anesthesia machine calibration device (quantity: 1)
- Circuit adapter test fixture (quantity: 1)
- Injector (quantity: 1)
- Φ6 silicone tube (quantity: 2)
- PU tube (6X300) (quantity: 1)
- Y piece (quantity: 1)

Test procedures:

(1) Remove the bellows.

(2) Mount the bellows housing properly.

(3) Set the Bag/vent switch to the bag position

(4) Remove the patient circuit.

(5) Mount the circuit adapter test fixture onto the patient circuit.

(6) Connect the Φ6 silicone tubes and PU tube (6X300) to the injector connector, pressure sensor (of the anesthesia machine calibration device) connector (positive pressure end), and No.2 connector to which drive gas corresponds on the circuit adapter test fixture by using a Y piece, as shown below.

(7) Push in the push rod of the injector to let the pressure reading on the anesthesia machine calibration device rise to 30 to 35 cmH_2O and then stop pushing. Keep the relative position between the push rod and the injector unchanged. If the pressure reading on the anesthesia machine calibration device falls more than 10 cmH_2O within 30s, this test is failed. It indicates that the bellows housing or the bag position of the bag//mechanical ventilation switch is leaky.

4. Leak test of all pipelines on the circuit adapter

Tools required:

- Negative pressure ball (quantity: 1)
- Injector (quantity: 1)
- Y piece (quantity: 1)
- Anesthesia machine calibration device (quantity: 1)
- Φ6 silicone tube (quantity: 1)
- Circuit adapter test fixture (quantity: 1)
- PU tube (6X100) (quantity: 2)

Test procedures:

(1) Turn off the system switch.

(2) Turn off all the flows.

(3) Turn off ACGO.

(4) Remove the patient circuit.

(5) Mount the circuit adapter test fixture onto the circuit adapter.

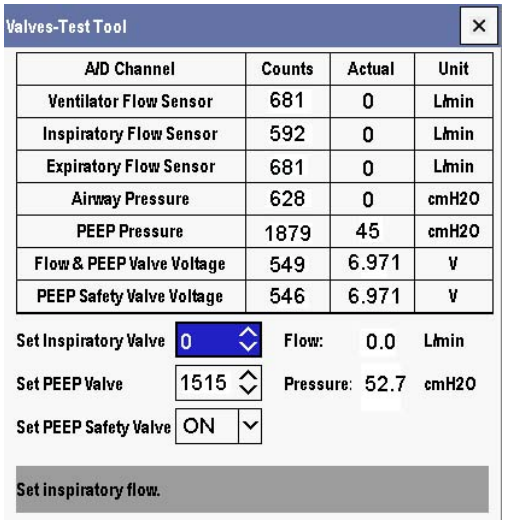
(6) Flatten the negative pressure ball to remove the gas inside. Then re-install the gas outlet switch of the negative pressure ball properly. Connect the other end of the negative pressure ball to No.7 (number is marked on the circuit adapter test fixture) connector to which fresh gas pipeline of the circuit adapter test fixture corresponds, as shown below.

(7) Release the negative pressure ball. If the negative pressure ball is fully expanded within 30 s, it indicates that the test of fresh gas pipeline is failed. Locate the leaking point inside the main unit as per the method described in section ***5.3.3Anesthetic Gas Delivery System***.

(8) Turn on ACGO. Test the ACGO pipeline in the similar way (the connector to which the circuit adapter test fixture corresponds is No.8 connector), as shown below.

(9) Turn on the system switch and let the systems enter Standby.

(10) Select [**Maintenance**] → [**Factory Maintenance**] → [**Diagnostic Test >>**] → [**Valves-Test Tool >>**] to set the A/D value of the PEEP valve to make PEEP exceed 50 cmH2O. Set the A/D value of the inspiratory valve to "0" to produce 0 L/min of flow. Set PEEP safety valve to ON, as shown below.



（11） Connect one Φ6 silicone tubes and two PU tube to the injector outlet, pressure sensor (of the anesthesia machine calibration device) connector (positive pressure end), and No.1 connector to which drive gas corresponds on the circuit adapter test fixture by using a Y piece, as shown below.

（12） Push in the push rod of the injector to let the pressure reading on the anesthesia machine calibration device rise to 30 to 35 cmH_2O and then stop pushing. Keep the relative position between the push rod and the injector unchanged. If the pressure reading on the anesthesia machine calibration device falls more than 10cmH_2O within 30s, the fresh gas pipeline is failed. Check the expiratory valve assembly and related pipelines of drive gas circuit. Check the expiratory valve assembly and the drive gas related pipeline inside the main unit.

5. Check the lifting device and CO2 absorbent canister

Tools required:

- Anesthesia machine calibration device (quantity: 1)
- Injector (quantity: 1)
- Φ6 silicone tube (quantity: 2)
- PU tube (6X300) (quantity: 1)
- Breathing tube (quantity: 3)
- Y piece (quantity: 1)
- Breathing tube Y piece (quantity: 1)
- Breathing tube adapter connector (quantity: 1)
- T-shaped Allen wrench (quantity: 1)

Test procedures:

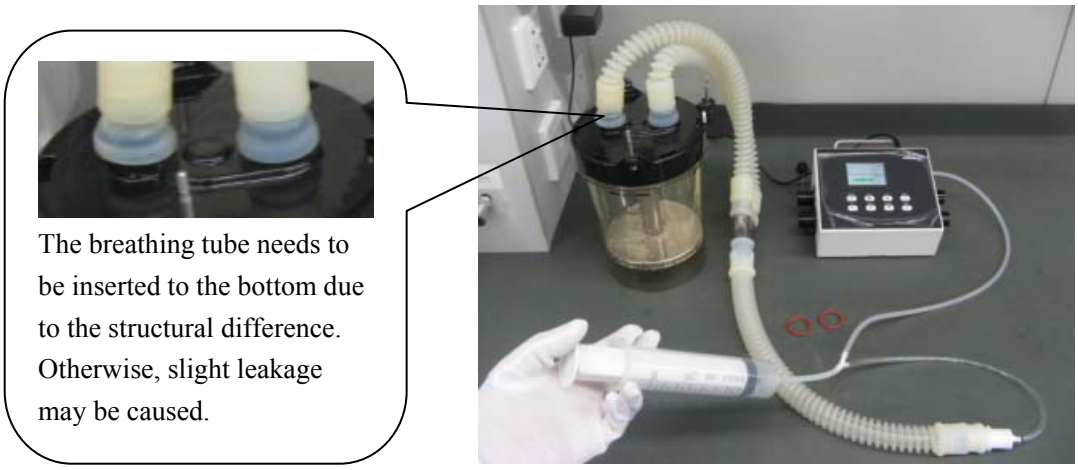
(1) Turn off the system switch.

(2) Mount the CO2 absorbent canister onto the lifting device properly.

(3) Remove the lifting device from the patient circuit.

(4) Connect the two connectors of the lifting device by using two breathing tubes and one breathing tube Y piece. The other end of the breathing tube Y piece is connected to the breathing tube adapter connector through another breathing tube. Connect the injector connector, pressure sensor (of the anesthesia machine calibration device) connector (positive pressure end), and the breathing tube adapter connector to a Y piece, as shown below.

WATO EX-25/30/35 anesthesia machine



WATO EX-20 anesthesia machine

(5) Push in the push rod of the injector to let the pressure reading on the anesthesia machine calibration device rise to 30 to 35 cmH_2O and then stop pushing. Keep the relative position between the push rod and the injector unchanged. If the pressure reading on the anesthesia machine calibration device falls more than 10 cmH_2O within 30s, it indicates that the lifting device and the CO2 absorbent canister are leaky. The test is failed.

(6) Check the seals on the two connections of the lifting device. It they are damaged, the test is failed. Replace the seal and then re-mount the lifting device onto the patient circuit.

6. Check the accessories and circuit in & out parts

Test procedures:

(1) Turn off the system switch.

(2) Check the manual bag and replace it if it is found damaged.

(3) Check the breathing tube and replace it if it is found damaged.

(4) Remove the water collection cup. Check the seal and replace it if it is found damaged.

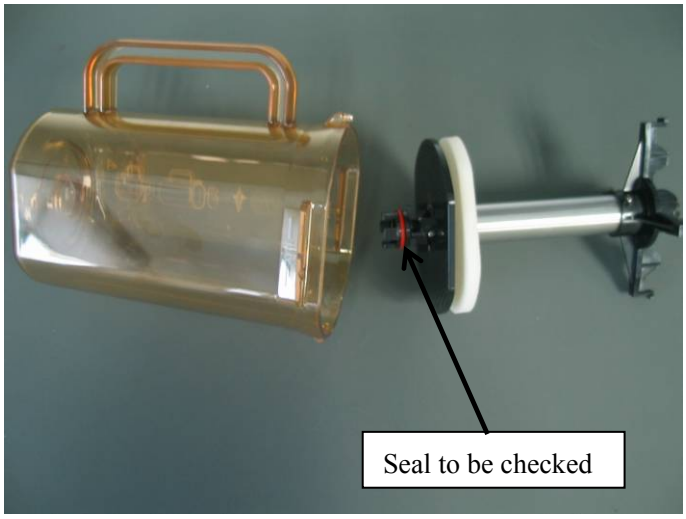
(5) Remove the O2 sensor (if there is no O2 sensor, remove the plug where the O2 sensor should be installed). Check the seal and replace it if it is found damaged.

(6) Remove the valve covers of the inspiratory check valve and expiratory check valve. Check the seal and replace it if it is found damaged.

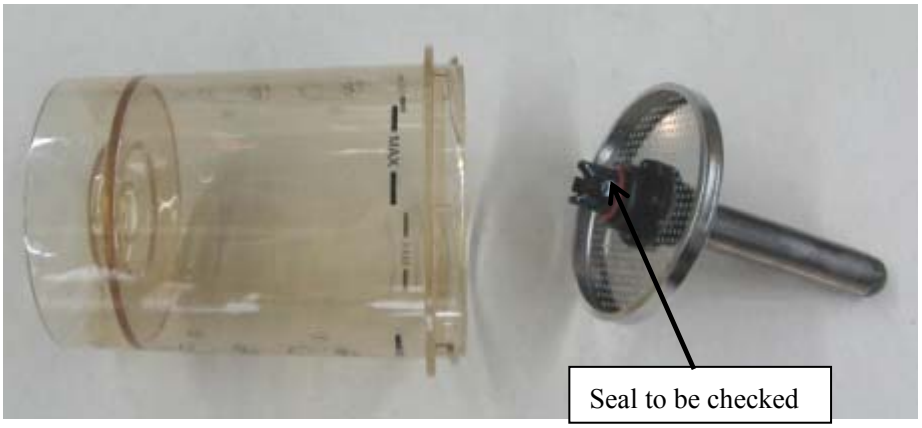
(7) Remove the bag arm. Check the seal and replace it if it is found damaged.

(8) Remove the CO2 absorbent canister support as shown below. Check the seal and replace it if it is found damaged.

WATO EX-25/30/35 anesthesia machine:



WATO EX-20 anesthesia machine:



7. Check the APL valve, support tube on the median plate, and sealing components of the Bag/vent switch assembly

The test requires a T-shaped Allen wrench.
Test procedures:

(1) Turn off the system switch.

(2) Remove the APL valve. Check all seals and replace the defective ones.

(3) Remove the support tube on the median plate. Check the seals and replace the defective one.

(4) Remove the Bag/vent switch. Check the seals and replace the defective one.

8. Check the ACGO assembly

Tools required:

- Negative pressure ball (quantity: 1)
- Circuit adapter test fixture (quantity: 1)
- PU tube (6X100) (quantity: 1)
- 3106-08-10 adapter connector (quantity: 1)
- 3140-08-00 Y piece (quantity: 1)
- 3126-06-00 tube plug (quantity: 1)
- 3126-08-00 tube plug (quantity: 2)

Test procedures:

(1) Turn off the system switch.

(2) Pull out No.21 and 22 PU tubes which connect the ACGO assembly to the circuit adapter assembly. The ends of the tubes which connect the ACGO assembly are pulled out but the other ends are not, as shown below.

(3) Occlude the pulled-out ends of No. 21 and 22 tubes by using two 3126-10-00 tube plugs.

(4) Repeat steps 3 through 7 in “4 Leak test of all pipelines on the circuit adapter”. If the test is failed, it indicates that the connectors of the circuit adapter or seals are damaged. If there is no leak, insert the pulled-out tubes into the ACGO assembly. Note that the relative position of the black wires on the No.21 and 22 yellow PU tubes should be same to that before pulled out.

(5) Pull out No.52 and 53 PU tubes which connect the O2 flush button assembly and the vaporizer manifold assembly to the ACGO assembly. The ends of the tubes which connect the ACGO assembly are pulled out but the other ends are not.

(6) Occlude the pulled-out tube ends by using 3126-06-00 and 3126-08-00 tube plugs, as shown below.

(7) Repeat steps 3 through 7 in “4 Leak test of all pipelines on the circuit adapter”. If the test is failed, it indicates the ACGO assembly is damaged. Check the seals in the ACGO assembly and replace the damaged seals.

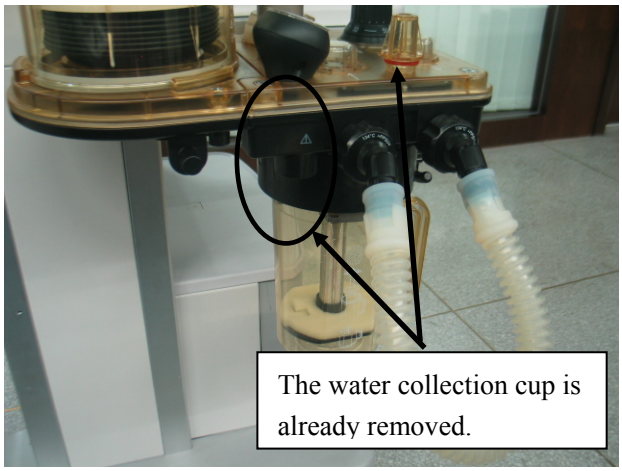
5.3.5 Tidal Volume Inaccuracy

The following table lists tidal volume inaccuracy related failures.

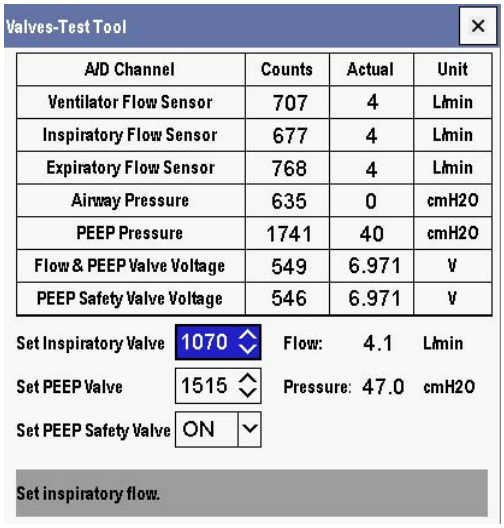
Failure description	Possible cause	Recommended action
Inaccurate tidal volume	The flow sensor is not installed properly.	Re-install the flow sensor.
	The setting of fresh gas flow is inappropriate.	Adjust the fresh gas flow.
	There are significant leaks in the breathing system and the fresh gas flow is too low.	Repair the leaking points after checking as per the procedures described in sections ***5.3.3Anesthetic Gas Delivery System*** and ***5.3.4Patient Circuit***.
	* There is water build-up inside the flow sensor.	Remove the flow sensor and clear its inside water build-up.
	*The membrane of the flow sensor assembly is distorted, dirty or its inside resistance changes. Zero drift occurs to the pressure sensor on the monitor board.	Enter the user maintenance mode and calibrate the flow sensor as per section ***4.3.2Flow Calibration (factory)***.
	*The flow sensor pressure sampling pipeline is leaky.	Repair the leaking points after checking as per the procedures described in section ***5.3.4.1Leak Test of Flow Sensor Pressure Sampling Pipeline***.
	*The flow sensor is damaged.	Replace the flow sensor.
	*The pressure sensor on the monitor board is faulty.	Replace the monitor board.
	The inlet gas flow regulator on the integrated pneumatic circuit of the expiratory valve assembly is faulty.	Replace the integrated pneumatic circuit block of the expiratory valve assembly or replace the expiratory valve assembly.
	The current Plimit is set too low, which causes expiration to start in advance.	Set Plimit to a higher value to cause Paw not to exceed the limit.
	The displayed TVe and TVi are not the same.	Enter factory maintenance and switch on TVi review. Observe the value of TVi. In the valves test tool, compare the measurement error made by three sensors and judge whether to perform calibration as per ***4.2.5Check the Flow Sensor Accuracy***.

In the above table, possible causes marked "*" are related to inaccurate measured values by flow sensors. Do the following to detect if tidal volume inaccuracy results from "*" marked causes.

1. Turn off the flow regulators.
2. Make sure that the patient is disconnected from the system and that the Bag/vent switch is set to the mechanical ventilation position.
3. Remove the bellows and install the bellows housing properly.
4. Remove the water collection cup.
5. Connect the inspiration and expiration connectors by using a breathing tube, as shown below.



6. Turn on gas supplies and enter Standby.
7. Select [**Maintenance**] → [**Factory Maintenance**] → [**Diagnostic Test >>**] → [**Valves-Test Tool >>**] to set the A/D value of the PEEP valve to make PEEP exceed 40 cmH2O. Set PEEP safety valve to ON, as shown below.



Set the A/D value of the inspiratory valve to cause the flow of inspiratory valve to reach a certain value. In this case, the flows measured by the ventilator flow sensor, inspiratory flow sensor, and expiratory flow sensor should be the same. Test multiple points by setting the A/D value of the inspiratory valve. For each point, the flows measured by the three sensors should be the same. If not, the measured value by the flow sensor is inaccurate. Troubleshoot the possible causes marked "*" in the above table.

5.4 Troubleshoot Sensor and Valve Related Failures by Using the Valves-test Tool

5.4.1 Preparations before Using the Valves-test Tool

Make the following preparations before using the valves-test tool to locate the valves or sensors related failures:

1 Connect the pneumatic circuit according to the type of sensor or valve to be checked.

- Constant-flow connection method: Connect the tubes of the anesthesia machine following the constant-flow connection method to check the flow sensors and inspiratory valve. For details, refer to ***4.3.2Flow Calibration (factory)***.
- Constant-pressure connection method: Connect the tubes of the anesthesia machine following the constant-pressure connection method to check the pressure sensors and PEEP proportional valve. For details, refer to ***4.3.3Pressure Calibration (factory)***.

2. Make sure that the supply gas pressure is normal.

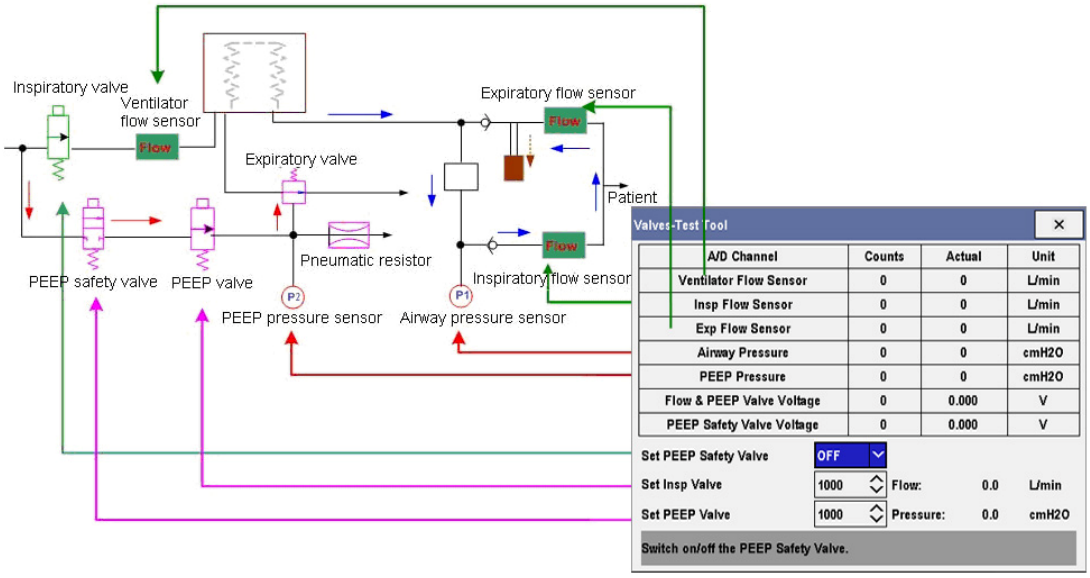
3. When the system is Standby, select [**Maintenance**] → [**Factory Maintenance >>**] → [**Diagnostic Test >>**] → [**Valves-Test Tool >>**] to access the [**Valves-Test Tool**] menu.

5.4.2 One-to-one Correspondence between the Sensors & Valves on the Valves-test Tool Screen and the Components

To use the valves-test tool to troubleshoot the sensors or valves related failures, you must be familiar with the one-to-one correspondence between the menu options on the valves-test tool screen and the actual pneumatic circuit and hardware components.

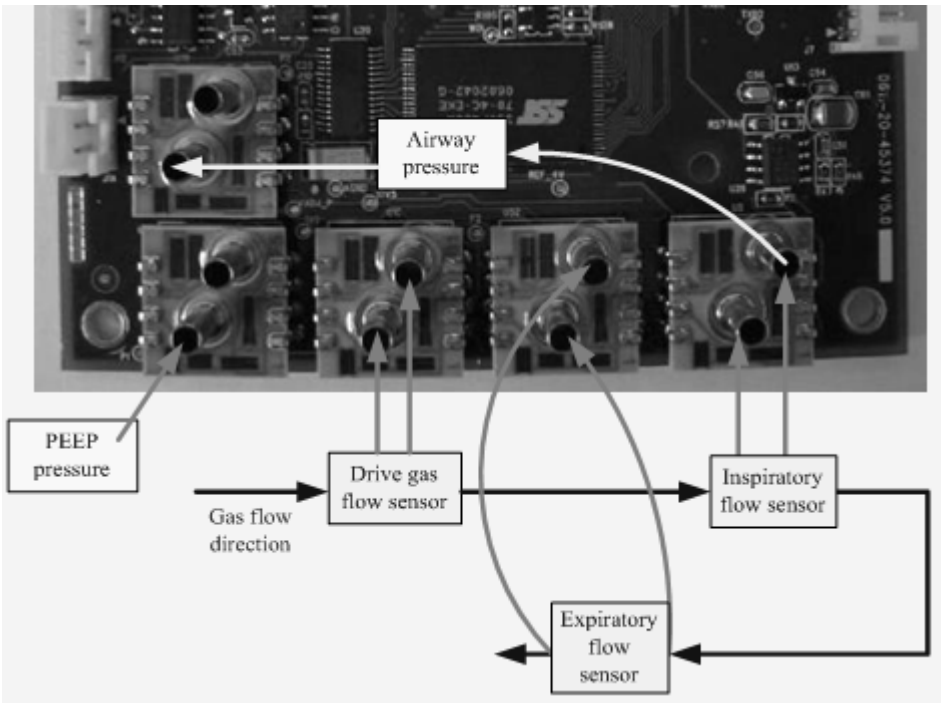
5.4.2.1 Correspondence with Pneumatic Circuit Components

The following figure shows the one-to-one correspondence between the sensors & valves on the valves-test tool screen and the actual components in the pneumatic circuit diagram.



5.4.2.2 Correspondence with Hardware Components

The following figure shows how the sampling lines of the sensors are actually connected on the monitor board.



5.4.3 Description

By using the valves-test tool, you can troubleshoot the problems related to:

- Zero points of the sensors
- Sampling line connection of the sensors
- Calibration data of the sensors
- Opening state of the inspiratory valve
- Opening states of the PEEP safety valve and PEEP proportional valve

5.4.3.1 Problems Related to Zero Points of the Sensors

By using the valves-test tool, you can easily detect if the zero points of all the pressure and flow sensors are normal.

To diagnose the zero points of the sensors:

1. Disconnect all gas supplies and make sure that the actual values of the sensors are “0”.
2. Check the A/D counts of the sensors in the valve-test tool menu, which are the zero points of the sensors.
3. If the zero point of one sensor is outside of the normal range, it indicates that the monitor board is faulty. You need to replace the board.

You can also test the zero points of the sensors by referring to ***4.2.4Check the Sensor Zero Point.***

NOTE

- **For the normal range of sensors' zero points, refer to 4.2.4Check the Sensor Zero Point.**

5.4.3.2 Problems Related to Sampling Line Connections of the Sensors

The flow sensor has two sampling lines. Connection errors include:

- The two sampling lines are connected reversely.
- One sampling line is not connected.
- Two sampling lines are not connected.

The pressure sensor has one sampling line. Connection errors include:

- The sampling line is not connected.
- The sampling line is connected incorrectly.

By using the valves-test tool, you can detect if the sampling lines are connected normally.

- To diagnose the sampling line connection of the flow sensor:

1. Connect the tubes of the anesthesia machine following the constant-flow connection method. Refer to ***5.4.1Preparations before Using the Valves-test Tool.***
2. Make sure that gas supplies are normal. In the [**Valves-Test Tool**] menu, set the PEEP safety valve to ON and the D/A value of the PEEP valve to more than "1500", making sure that the PEEP valve closes at 30 cmH2O above.
3. Increase the D/A value of the inspiratory valve gradually and the A/D value of the flow sensor should also increase. With the gradual increase of gas supplied,
   - If the A/D value of one sensor decreases gradually, it is possible that the two sampling lines of the sensor are connected reversely.
   - If the A/D value of one sensor keeps unchanged, it is possible that the two sampling lines of the sensor are broken or not connected.
   - If the A/D value of one sensor nears saturation (above "4000") quickly, it is possible that the sampling line at the low pressure end (gas outlet end) of the sensor is not connected.
4. If sampling line connection errors are detected, re-connect the sampling lines and check their connection correctness.

- To diagnose the sampling line connection of the pressure sensor:

  During normal ventilation, if a sampling line connection error occurs, it is easily detected through the Paw waveform and technical alarms.

  - If with the increase of actual pressure, pressure waveform data decreases and the alarm of "Paw Too Low" or "Patient Circuit Leak" occurs simultaneously, it is possible that the sampling line of the airway pressure sensor is connected incorrectly.
  - If from system standby to mechanical ventilation, continuous clicks are heard and the alarm of "Pressure Monitoring Channel Failure" occurs, it is possible that the sampling line of the PEEP pressure sensor is connected incorrectly. You can enter the [**Valves-Test Tool**] menu to set the PEEP safety valve to ON. Gradually increase the D/A value of the PEEP valve and observe if the A/D value of the PEEP pressure sensor also increases gradually. If not, it further indicates that the PEEP pressure sensor may be connected incorrectly.

To diagnose the sampling line connection of the pressure sensor in case of pressure calibration failure:

1. Connect the tubes of the anesthesia machine following the constant-pressure connection method. Refer to ***5.4.1Preparations before Using the Valves-test Tool.***
2. Make sure that gas supplies are normal. In the [**Valves-Test Tool**] menu, set the PEEP safety valve to ON.
3. Increase the D/A value of the PEEP valve gradually and the A/D value of the pressure sensor should also increase. With the gradual increase of actual pressure,
   - If the A/D value of one sensor decreases gradually, it is possible that the sampling line of the sensor is connected incorrectly.
   - If the A/D value of one sensor keeps unchanged, it is possible that the sampling line of the sensor is not connected.
4. If sampling line connection errors are detected, re-connect the sampling lines and check their connection correctness.

5.4.3.3 Problems Related to Calibration Data of the Sensors

After confirming that both the zero points of the sensors and the sampling line connections of the sensors are normal, you can detect if the calibration data of the sensors are accurate by using the valves-test tool.

- To diagnose the calibration data of the flow sensors:
  - With the gradual increase of actual flow, the measured value of the flow sensor should also increase. Otherwise, the calibration data have errors. You need to calibrate the flow sensor again.
  - Compared with the measured value of the standard flow measurement device (anesthesia machine calibration device), the measured value of the flow sensor should be accurate. Otherwise, the calibration data have great deviations. You need to calibrate the flow sensor again.

  For details, refer to ***4.2.5Check the Flow Sensor Accuracy.***
- To diagnose the calibration data of the pressure sensors:
  - With the gradual increase of actual pressure, the measured value of the pressure sensor should also increase. Otherwise, the calibration data have errors. You need to calibrate the pressure sensor again.
  - Compared with the measured value of the standard pressure measurement device (anesthesia machine calibration device), the measured value of the pressure sensor should be accurate. Otherwise, the calibration data have great deviations. You need to calibrate the pressure sensor again.

  For details, refer to ***4.2.6Check the Pressure Sensor Accuracy.***

5.4.3.4 Problems Related to Opening State of the Inspiratory Valve

By using the valves-test tool, you can detect if the opening state of the inspiratory valve is normal.

1. The methods for tube connections and settings of the anesthesia machine are same to those of sampling line connections of the flow sensors. For details, refer to ***5.4.3.2Problems Related to Sampling Line Connections of the Sensors.***
2. In the [**Valves-Test Tool**] menu, gradually increase the D/A value of the inspiratory valve. If the measured values of the ventilator flow sensor, inspiratory flow sensor, and expiratory flow sensor change very little and low gas flow is felt at the connector of water collection cup, it indicates that the inspiratory valve or the D/A on the monitor board is faulty.
3. Normally, when the D/A value of the inspiratory valve is set to “2500”, the flow measured by the standard flow measurement device can reach 90 L/min.

4. If when the D/A value of the inspiratory valve is set to more than “4000”, the flow measured by the standard flow measurement device fails to reach 90 L/min, flow calibration will be failed. In this case, you need to replace the expiratory valve assembly or the monitor board.
5. To locate if the DA on the monitor board is faulty, you can use a multimeter to measure the output of DA on the monitor board corresponding to the inspiratory valve. If voltage also increases with the increase of D/A value, and voltage nears 6V when D/A value is set to more than “4000”, it indicates that the DA on the monitor board corresponding to the inspiratory valve may be normal.
6. After the expiratory valve assembly or monitor board is replaced, you can use the similar method to check if the problem is fixed.

5.4.3.5 Problems Related to Opening States of the PEEP Safety Valve and PEEP Valve

When the PEEP safety valve is permanently OFF and the gas supplies are normal, the [**Drive Gas Pressure Low**] is alarmed. When the PEEP valve is faulty, pressure related alarms occur in mechanical ventilation state.

By using the valves-test tool, you can detect if the opening states of the PEEP safety valve and PEEP valve are normal.

- To diagnose the opening state of the PEEP safety valve:

1. Make sure that gas supplies are normal.
2. In the [**Valves-Test Tool**] menu, when the PEEP safety valve is switched on, a subtle click is heard.
3. Adjust the D/A value of the PEEP valve to cause the pressure measured by the PEEP pressure sensor to exceed 0 cmH2O.
4. Switch off the PEEP safety valve. The pressure measured by the PEEP pressure sensor should drop to 0 cmH2O immediately. Switch on the PEEP safety valve again. The measured value of the PEEP pressure sensor rapidly restores almost the same value to that before PEEP safety valve is switched off. During this period, gas flow and also change of gas flow when the PEEP safety valve is switched on or off can be felt at the PEEP outlet, which helps to judge if the PEEP safety valve can be switched on or off normally.
5. If an error is detected, it is possible that the PEEP safety valve or the safety valve drive voltage on the monitor board is faulty. You can use a multimeter to measure the drive signals on the monitor board corresponding to the PEEP safety valve (measurement can be performed at the corresponding socket). When the PEEP safety valve is turned on, the drive voltage should near 6V. When the PEEP safety valve is turned off, the drive voltage should near 0V. If these two conditions are met simultaneously, the monitor board is normal.

6. If the PEEP safety valve is faulty, replace the expiratory valve assembly. After replacement, you can use the similar method to check if the problem is fixed.

■ To diagnose the opening state of the PEEP valve:

1. Make sure that gas supplies are normal. In the [**Valves-Test Tool**] menu, set the PEEP safety valve to ON.
2. With the increase of D/A value of the PEEP valve, the measured value of the PEEP pressure sensor (or the anesthesia machine calibration device) should also rise. Note that there is a non-response area for the PEEP valve when the D/A value is relatively small. When the D/A value is less than this area, the PEEP valve cannot be opened and the output is "0" continuously. When the D/A value is greater than this area, the pressure output will increase with the increase of D/A value. This phenomenon also exists for the inspiratory valve.
3. For subsequent diagnosis rules, refer to ***5.4.3.4Problems Related to Opening State of the Inspiratory Valve.***

5.5 Hardware and Electrical Problems

Failure description	Possible cause	Recommended action
During the operation of the anesthesia machine, the display and AC indicator lamp are extinguished all of a sudden and the ventilator cannot be started.	The AC power supply is not connected properly and the capacity of the built-in battery is insufficient.	Check and make sure that the AC power supply is connected properly.
	The fuse of the mains inlet is damaged.	Replace the fuse. If the fuse is burned repeatedly, it indicates that the machine internal power is short-circuited.
The auxiliary electrical outlet has no output voltage.	The fuse of the auxiliary electrical outlet is damaged.	Replace the fuse.
	The isolation transformer is damaged.	Replace the isolation transformer.
During the operation of the anesthesia machine, the display is extinguished all of a sudden and ventilation remains normal.	The connection line of the internal inverter gets loose.	Properly insert the connection line of the inverter.

Failure description	Possible cause	Recommended action
When started up, the screen is immediately lit and dazzling. The screen becomes normal scores of seconds later. The alarm of power board communication failure occurs.	The power board software is damaged.	1. Disconnect the AC power supply and battery. Wait for 5 minutes to cause the power board to fully discharge and reset. Then update the power board software again. 2. If the problem persists, replace the power board.
During the operation of the anesthesia machine, ventilation stops all of a sudden but the display and buttons work normally.	The monitor board or valve is damaged.	Enter [**Maintenance**] → [**Factory Maintenance >>**]. Enter the required password to access the [**Factory Maintenance**] menu. Enter [**Diagnostic Test >>**] → [**Valves-Test Tool>>**] Test the status of each valve and reference power supply in the valves-test tool window. If valve malfunction or reference power supply error is detected, return the valve or monitor board to factory for repair.
The anesthesia machine cannot be started up.	The system switch cable falls off or other cable gets loose.	Properly insert the system switch cable or the loose cable.
	The fuse of the mains inlet is damaged.	Replace the fuse.
	The power board software is damaged.	Disconnect the AC power supply and battery. Wait for 5 minutes to cause the power board to fully discharge and reset. Restart the machine. If the machine works normally, it indicates that the software failure is fixed. If not, the problem is caused by hardware failure.
	The power board hardware is faulty.	Return the power board to factory for repair.
	The system switch is ineffective or the screws on the system switch get loose.	Repair the system switch or tighten the screws on the system switch.

Failure description	Possible cause	Recommended action
Exiting Standby fails.	The cable between the monitor board and the main control board gets loose.	Properly insert the cable between the monitor board and the main control board.
	The monitor board hardware selftest is failed.	Return the monitor board to factory for repair.
The buttons malfunction.	The buttons are ineffective.	Replace the keyboard.
	The cable gets loose.	Properly insert the cable between the keyboard and button board.
The isolation transformer buzzes.	The anesthesia machine is powered by 220V AC.	Resort to 110 V power supply
Alarm messages are displayed on the screen but without alarm sound.	The button board or speaker is damaged.	Return the button board to factory for repair or replace the speaker.
Operating the control knob is not responded.	The control knob is ineffective.	Replace the control knob.
	The button board is damaged.	Return the button board to factory for repair.
Network connection is failed.	The cables connected to the network connection board get loose.	Properly insert the cables.
	The network cable is too long.	Shorten the network cable. Recommended cable length is approximately 1.5 m.
	The network cable is used incorrectly.	The network cable has two linear orderings which should be differentiated.
No gas is outputted through the valve in mechanical ventilation mode.	The Bag/vent switch is faulty or the ACGO switch is turned on.	Check the screen to see if the anesthesia machine is in mechanical ventilation mode and if there is an alarm triggered.
	The valve cannot be opened.	1. Set tidal volume to maximum. 2. Switch between standby and mechanical statuses or between manual and mechanical statuses repeatedly. 3. Replace the pneumatic circuit block.

Failure description	Possible cause	Recommended action
The heater malfunctions.	The AC-DC power board is damaged.	Replace the AC-DC power board.
	The heater is burned out.	Replace the heater.
	The thermistor inside the heater is damaged.	Replace the heater.
	The 0616 heating control board is damaged.	Replace 0616 heating control board.
	The cable connection is loose.	Tighten the heater related cable.

6 Repair and Disassembly

⚠WARNING

- **To help prevent fires, only use lubricants approved for anesthesia or O_2 equipment.**
- **Do not use lubricants that contain oil or grease. They burn or explode in high O_2 concentrations.**
- **Obey infection control and safety procedures. Used equipment may contain blood and body fluids.**
- **Movable part and removable components may present a pinch or a crush hazard. Use care when moving or replacing system parts and components.**
- **Use care when disassembling the parts with sharp edges to avoid cuts.**
- **Pay attention to the screws during the disassembly to prevent screws from falling into the inside of the equipment. Failure to do so may cause short circuit.**
- **Make sure to bleed gas pressure before disassembling pneumatic fittings to avoid personal injury caused by high pressure gas.**

NOTE

- **When re-assembling, inspect all parts for deterioration. Replace them if necessary. Use appropriate screws and parts.**
- **After repairs are completed or parts replaced, perform the checkout procedure. Refer to 3Checkout and Test**

6.1 Prepare for Disassembly

6.1.1 Tools

During parts disassembling and replacing, the following tools may be required:

- Metric Allen wrench (2.5#, 3#, 4#, 5#, 8#)
- Phillips screwdriver
- Diagonal pliers
- Flathead screwdriver
- Metric M3 and M4 socket screwdriver
- Adjustable wrench
- Tweezers

6.1.2 Preparations

Before disassembly,

- Make sure that the anesthesia machine is not used on patients.
- Bleed the gas pressure inside the anesthesia machine as described below.
- Disconnect the AC power source.
- Disconnect all the pipeline and cylinder supplies.
- Prepare the tools required for disassembly.
- Maneuver the anesthesia machine to an appropriate location and then step down the four caster brakes to fix the machine.

⚠CAUTION

- **The internal parts may be contaminated during long-term use of the equipment. Wear special gloves during disassembling and inspecting.**

6.1.3 Bleed Gas Pressure

Make sure to bleed the gas pressure inside the anesthesia machine before disassembling pneumatic fittings to avoid personal injury or equipment damage. To bleed gas pressure:

1. Close other cylinder valves and disconnect pipeline supplies. Do not disconnect the O2 pipeline supply. If O2 pipeline supply is not available, connect O2 cylinder and open the O2 cylinder valve.
2. Set the system switch to ON.
3. Turn on all of the flow controls (except O2).
4. Make sure that N2O and AIR pipeline pressures read zero.
5. Disconnect the O2 pipeline supply (or close the O2 cylinder valve).Push the O2 flush button to bleed O2 from the system.
6. Set the system switch to OFF.

6.2 Disassemble the Assemblies

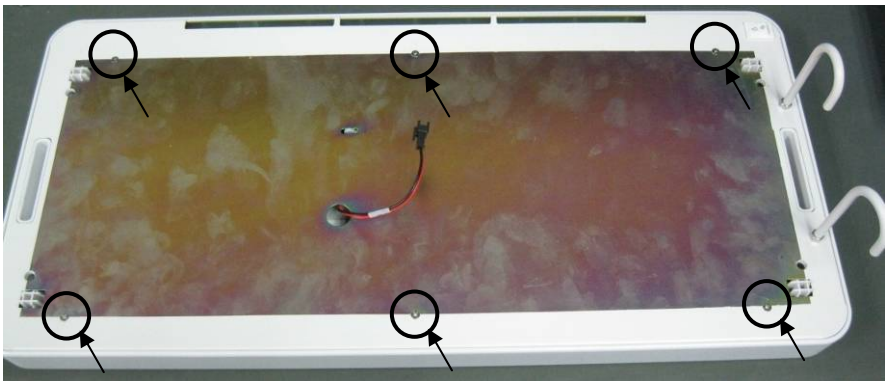
6.2.1 Remove the Top Plate Assembly

Pry up the screw plugs and unscrew the four screws as shown below.

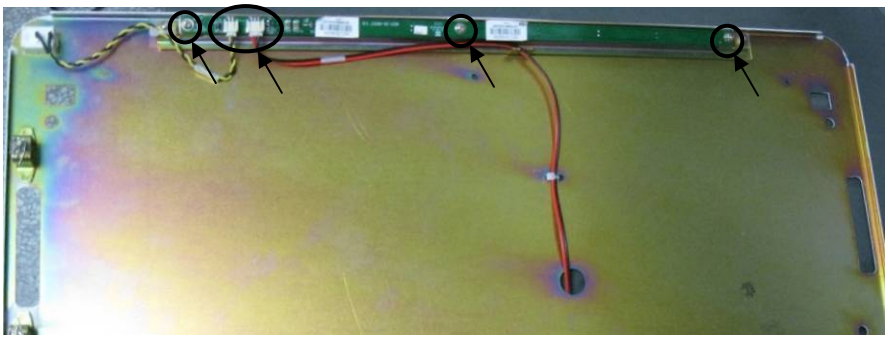
2. Lift off the top plate and disconnect the air connectors between the table toplight power cord and the power signal transfer cable to remove the top plate.

6.2.2 Remove the Table Toplight Board

1. Remove the top plate assembly.
2. Unscrew the six screws as shown below to remove the metal sheet of the top plate.



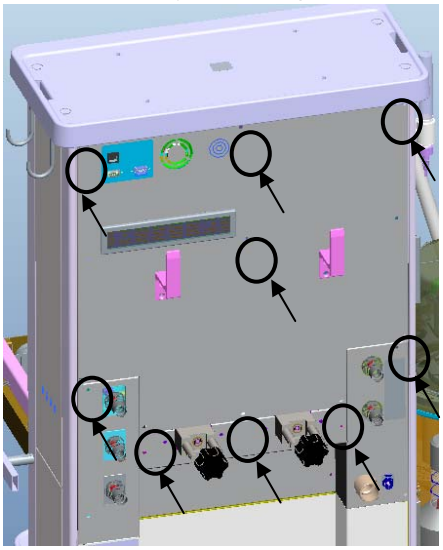
3. Disconnect the cables from the table toplight board and unscrew the three screws to remove the board.



6.2.3 Remove the Upper Rear Plate

Unscrew the nine screws as shown below to remove the upper rear plate.

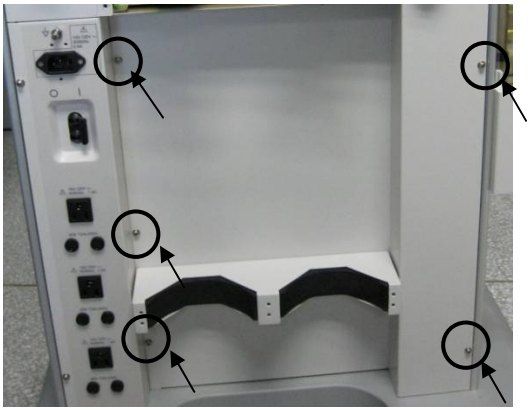
Without 4-yoke configuration



With 4-yoke configuration

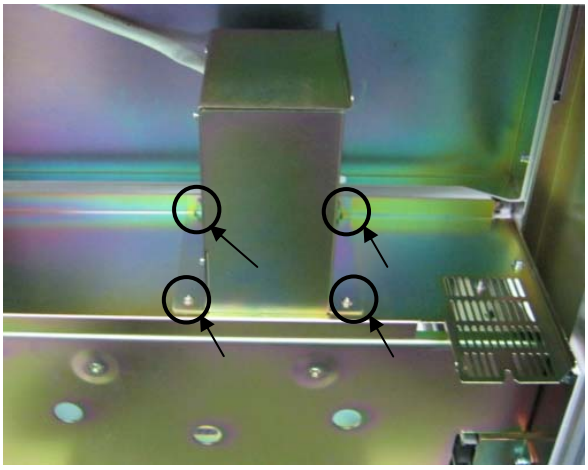
6.2.4 Remove the Lower Rear Plate

Unscrew the five screws as shown below to remove the lower rear plate.



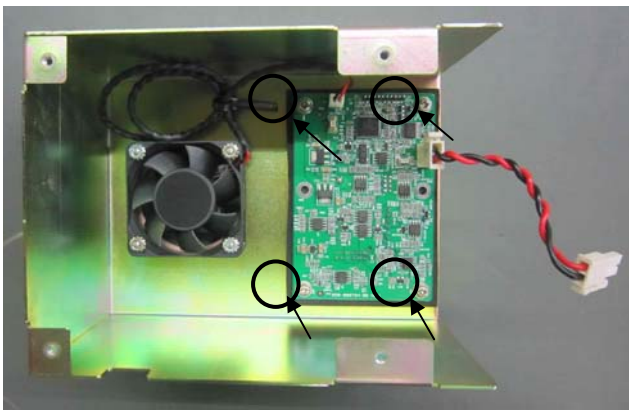
6.2.5 Disassemble the Heating Control Box Assembly

1. Disassemble the Heating Control Box Assembly.

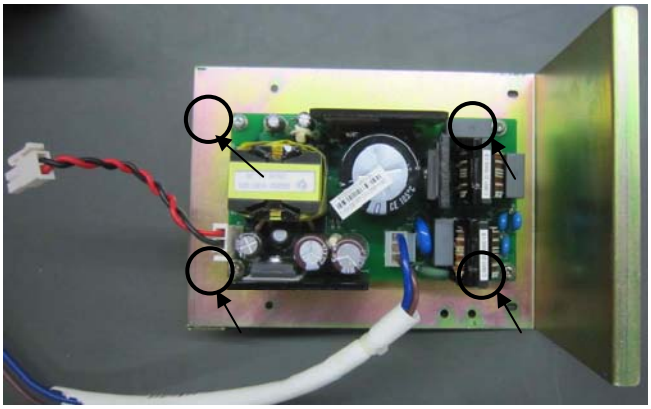


2. Unscrew the four M3x8 pan head screws to open the heating control box assembly.

3. Unscrew the four M3x8 pan head screws to remove the heating control board.

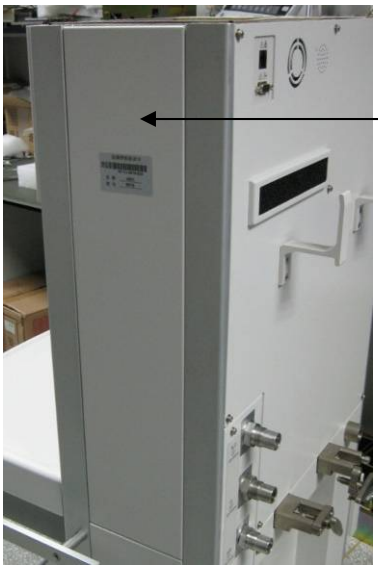


4. Unscrew the four M3x8 pan head screws to remove the power board.

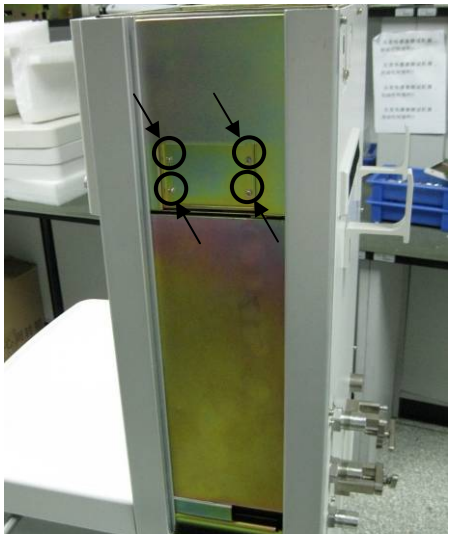


6.2.6 Replace the Batteries

1. Remove the top plate assembly.
2. Pull out the upper cover plate on the right side of the machine.

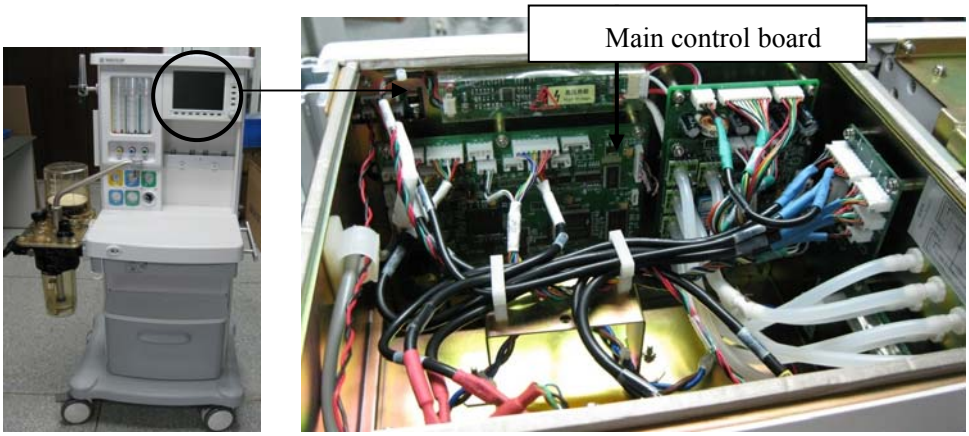


3. Unscrew the four screws fixing the battery box cover plate and push up the battery box cover to replace the batteries.

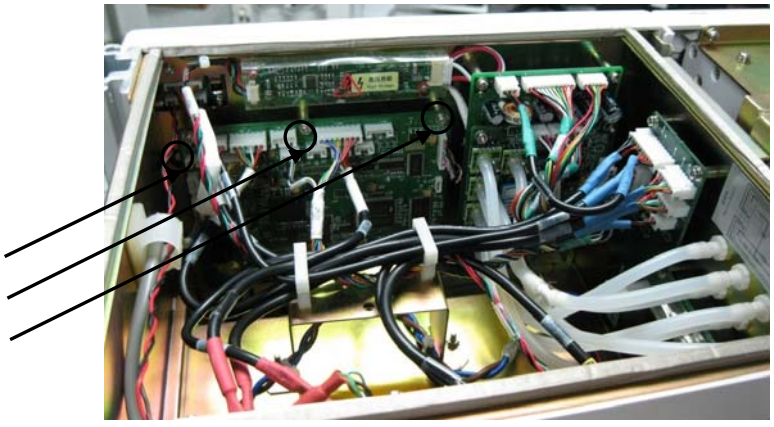


6.2.7 Remove the Main Control Board

1. Remove the top plate assembly.
2. Disconnect the cables from the main control board.

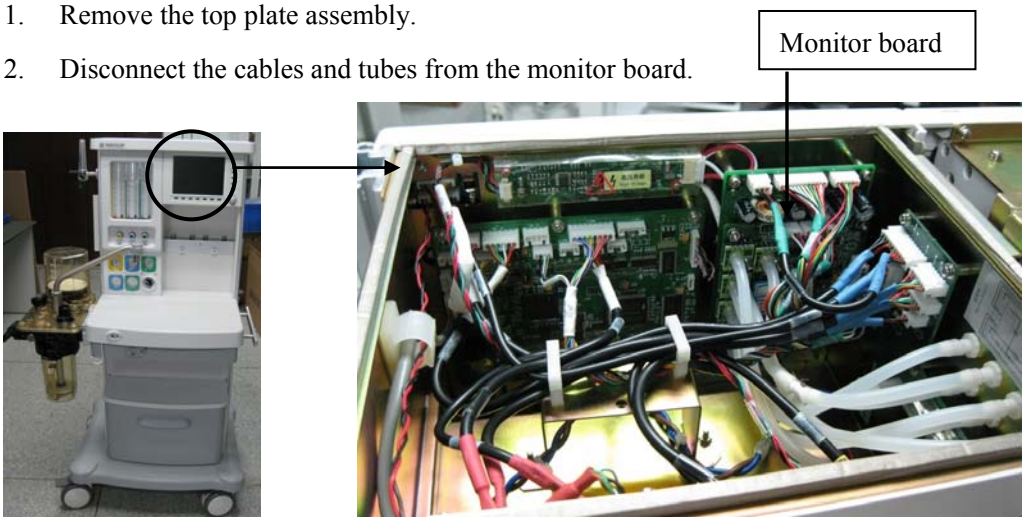


3. Unscrew the three screws as shown below to remove the main control board.

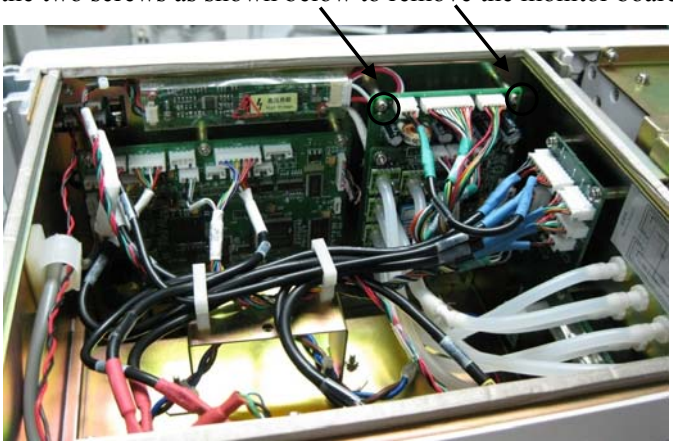


6.2.8 Remove the Monitor Board

1. Remove the top plate assembly.
2. Disconnect the cables and tubes from the monitor board.

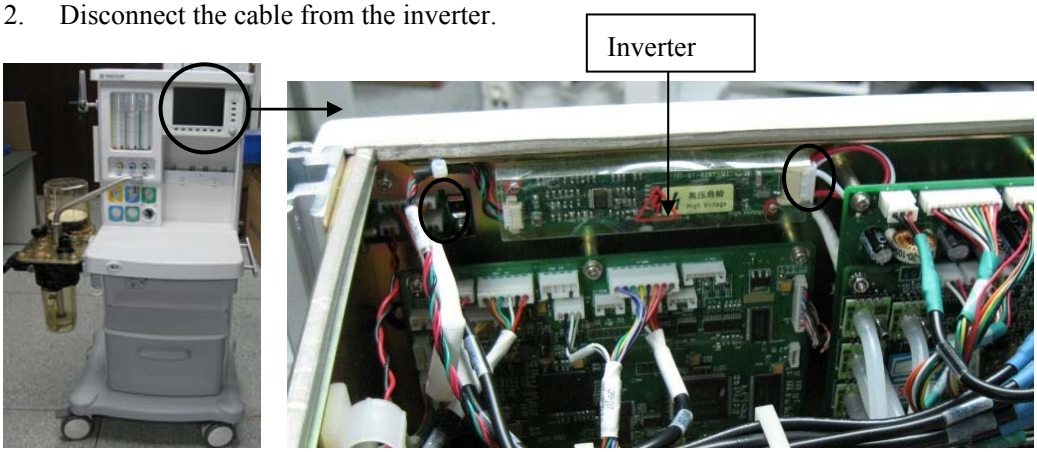


3. Unscrew the two screws as shown below to remove the monitor board.

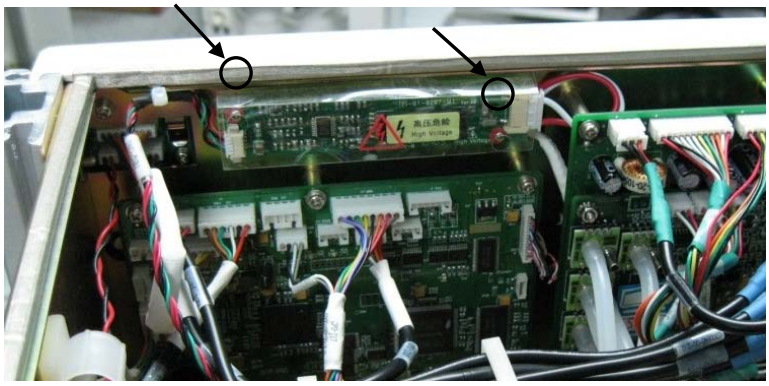


6.2.9 Remove the Inverter (8" display)

1. Remove the top plate assembly.
2. Disconnect the cable from the inverter.

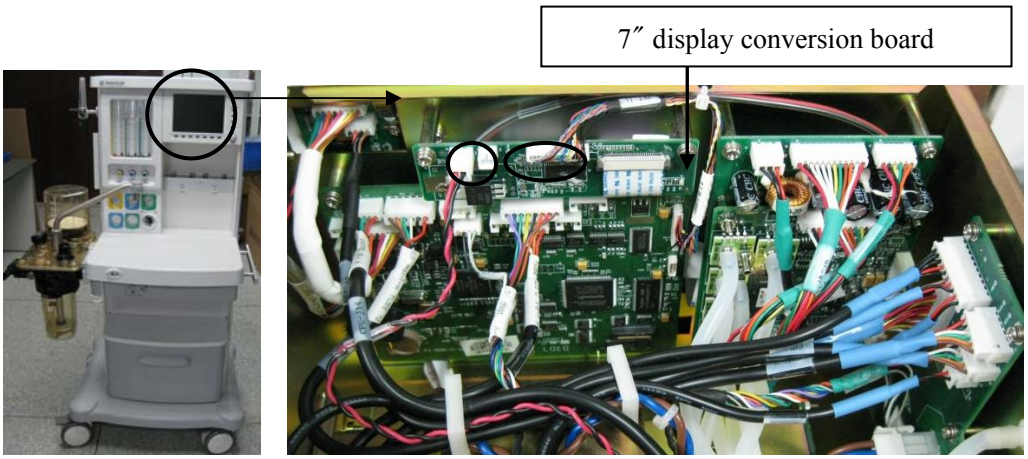


3. Unscrew the two screws as shown below to remove the inverter.

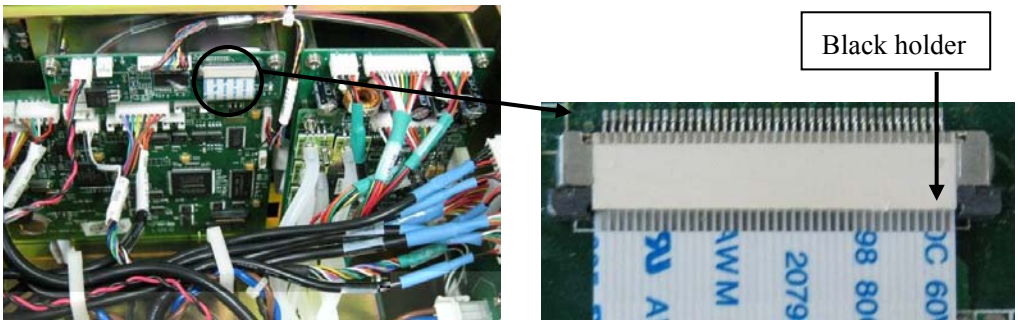


6.2.10 Remove the 7" Display Conversion Board (7" display)

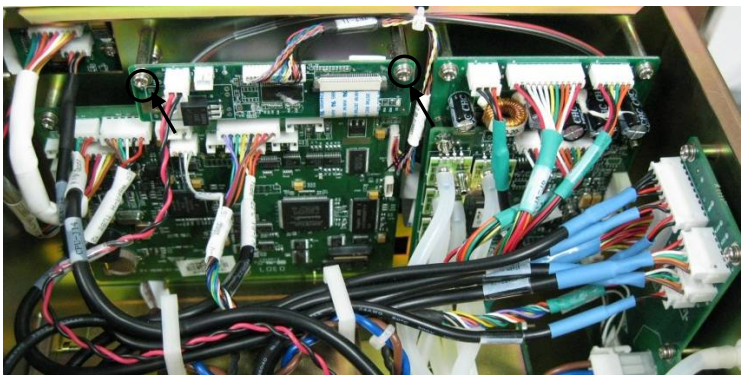
1. Remove the top plate assembly.
2. Disconnect the two cables from the 7″ display conversion board.



3. Disconnect the data line from the conversion board. Note: when disconnecting the data line, you must push out the black holder parallel to the conversion board.

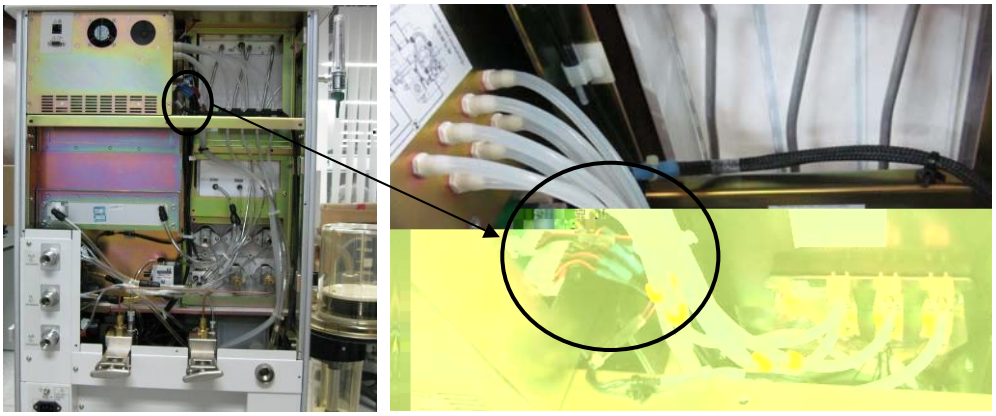


4. Unscrew the two screws as shown below to remove the conversion board.

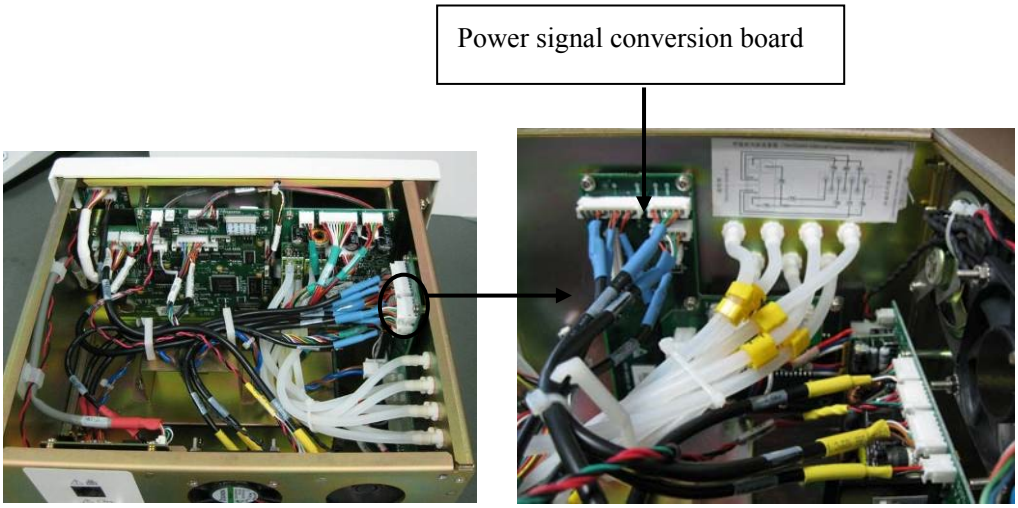


6.2.11 Remove the Power Signal Conversion Board

1. Remove the top plate assembly.
2. Remove the upper rear plate.
3. Disconnect the externally connected cables from the ventilator assembly.



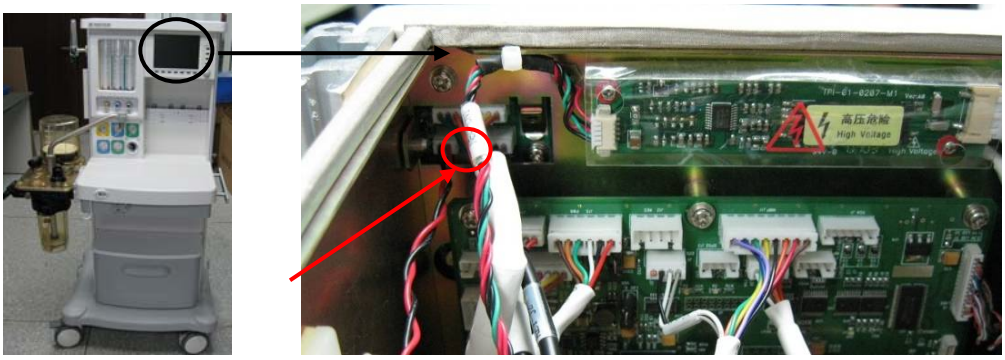
4. Disconnect the cables inside the ventilator connected to the power signal conversion board.



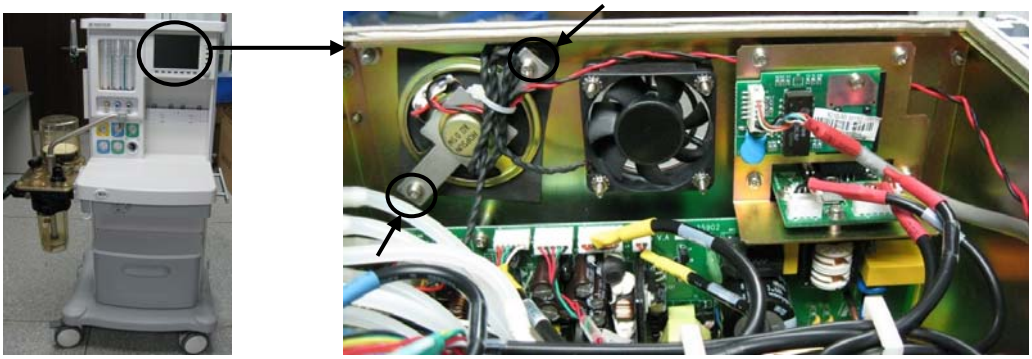
5. Unscrew the six screws as shown below to remove the power signal conversion board.

6.2.12 Remove the Speaker

1. Remove the top plate assembly.
2. Disconnect the speaker cable from the keypad board.

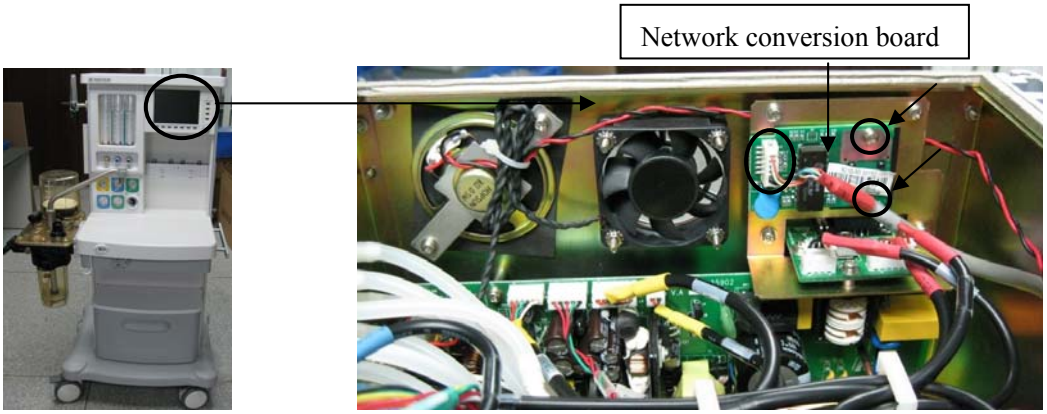


3. Unscrew the two screws as shown below to remove the speaker.



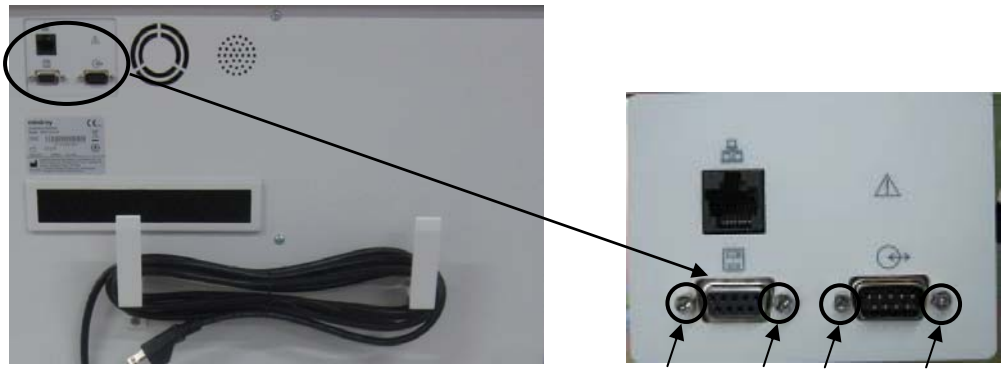
6.2.13 Remove the Network Conversion Board

1. Remove the top plate assembly.
2. Disconnect the cables from the network conversion board and unscrew the two screws as shown below to remove the conversion board.

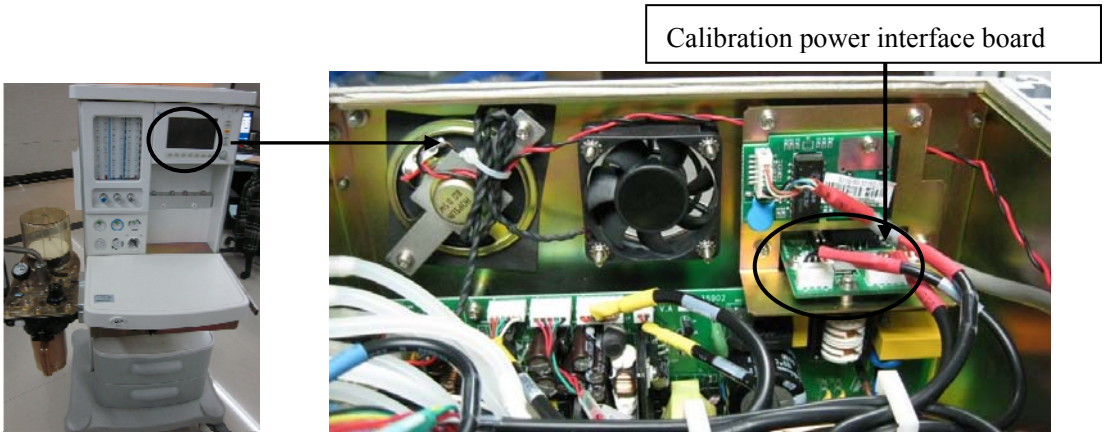


6.2.14 Remove the Calibration Power Interface Board

1. Remove the top plate assembly.
2. Unscrew the four screws as shown below.

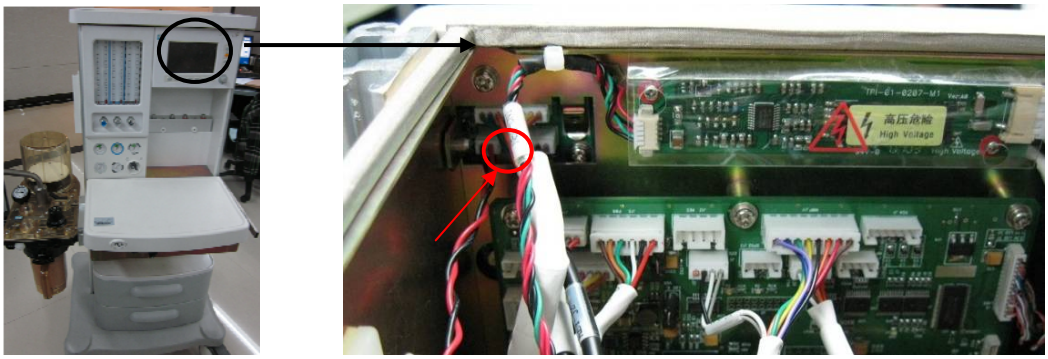


3. Disconnect the cables from the calibration power interface board and unscrew the three screws as shown below to remove the interface board.

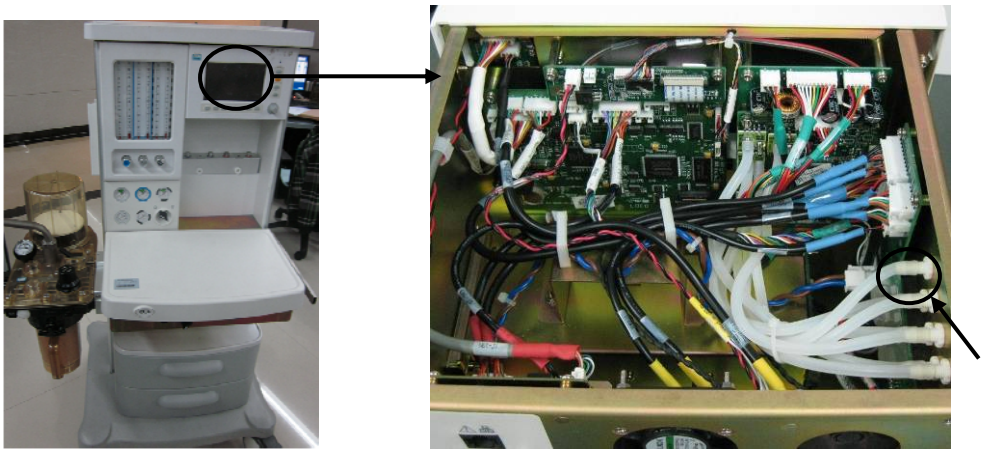


6.2.15 Remove the Power Board and Fan

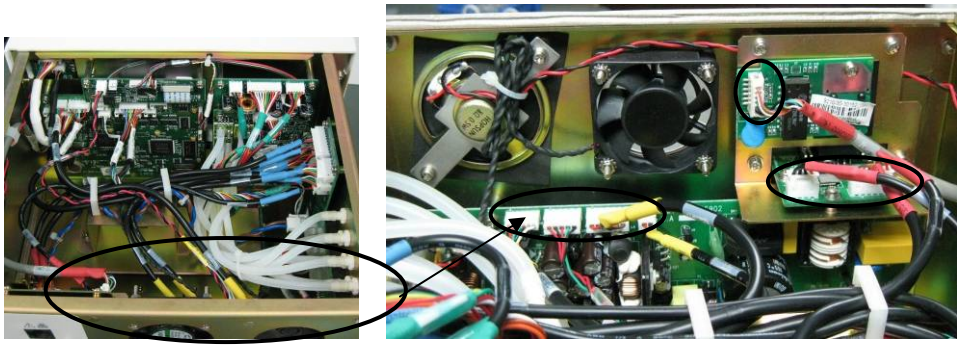
1. Remove the top plate assembly.
2. Remove the upper rear plate.
3. Disconnect the speaker cable from the keypad board.



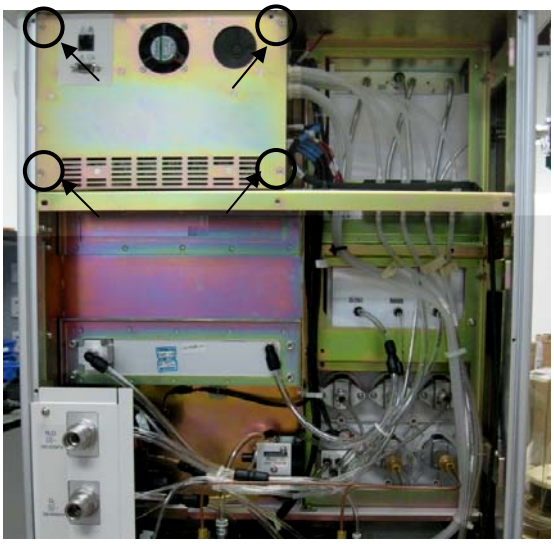
4. Disconnect the power board cable from the power signal conversion board.



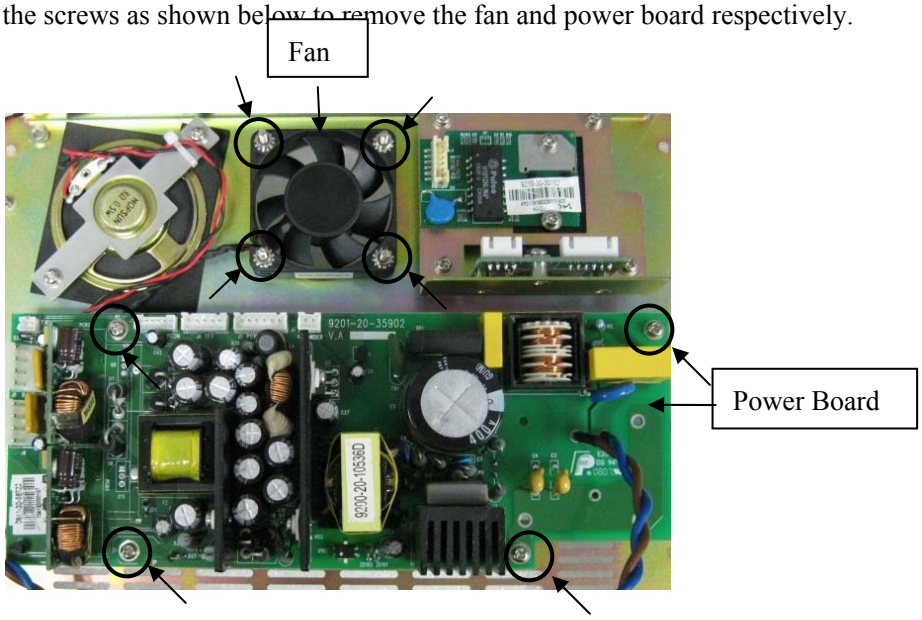
5. Disconnect the cables from the power board, network conversion board and calibration power interface board.



6. Unscrew the four screws fastening the ventilator rear cover plate as shown below to remove the cover plate.



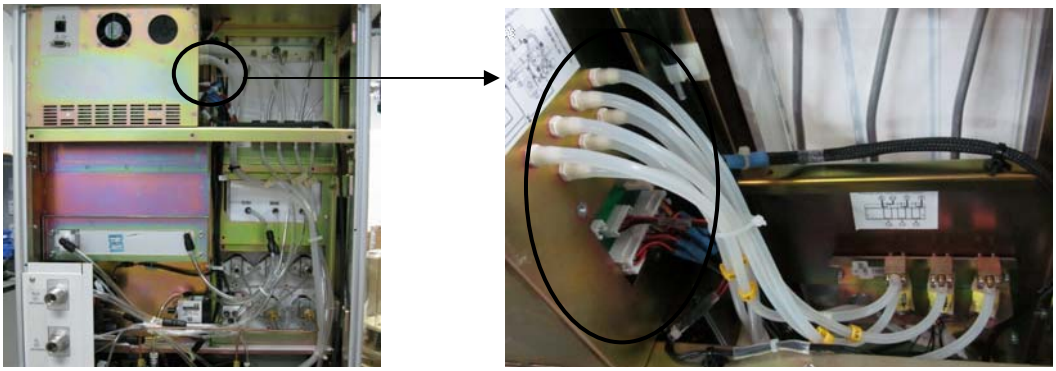
7. Unscrew the screws as shown below to remove the fan and power board respectively.



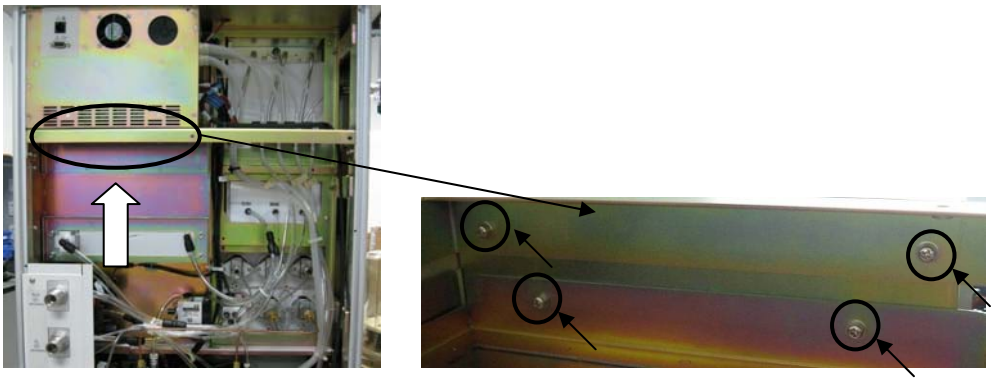
6.2.16 Remove the Display, Encoder and Keypad Board

6.2.16.1 Remove the Ventilator Assembly

1. Remove the top plate assembly.
2. Remove the upper rear plate.
3. Disconnect the cables and tubes from the ventilator assembly.

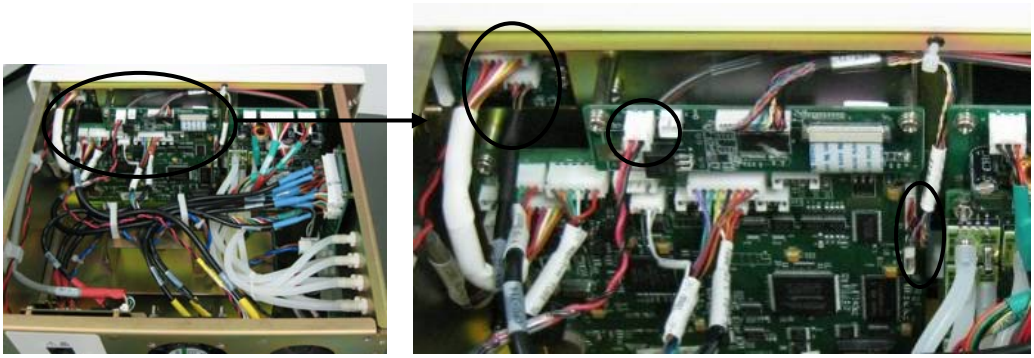


4. Unscrew the four screws fastening the ventilator assembly.

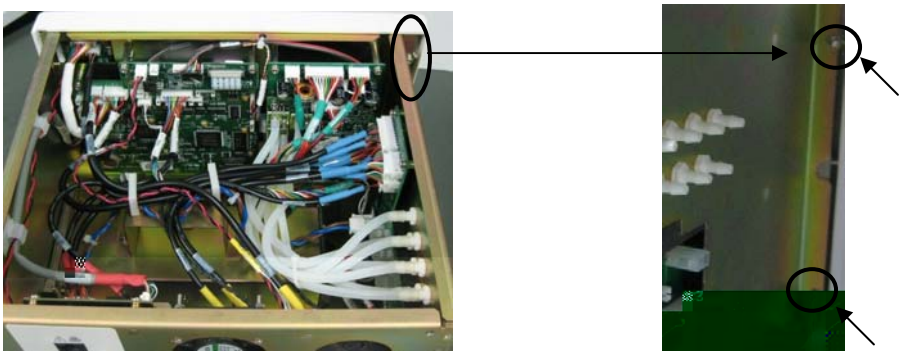


6.2.16.2 Remove the 7″ Display, Encoder and Keypad Board

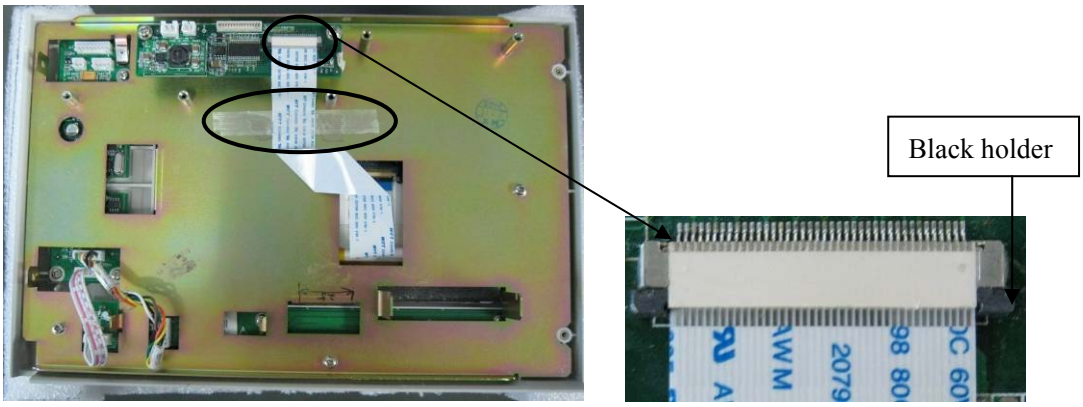
1. Disconnect the following cables: those connected to the keypad board, those on the left side of the 7″ display conversion board, and those on the upper right corner of the main control board.



2. Unscrew the two screws as shown below to remove the display panel assembly.

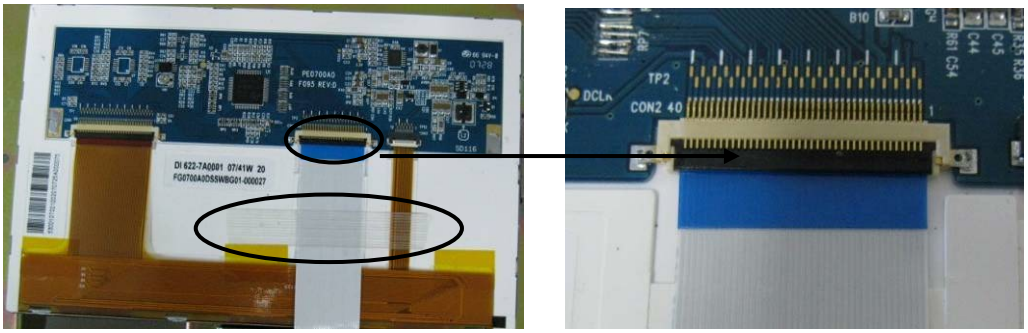


3. Disconnect the data line from the 7″ display conversion board. Peel the fiber adhesive tape fastening the data line. Note: when disconnecting the data line, you must push out the black holder parallel to the conversion board.

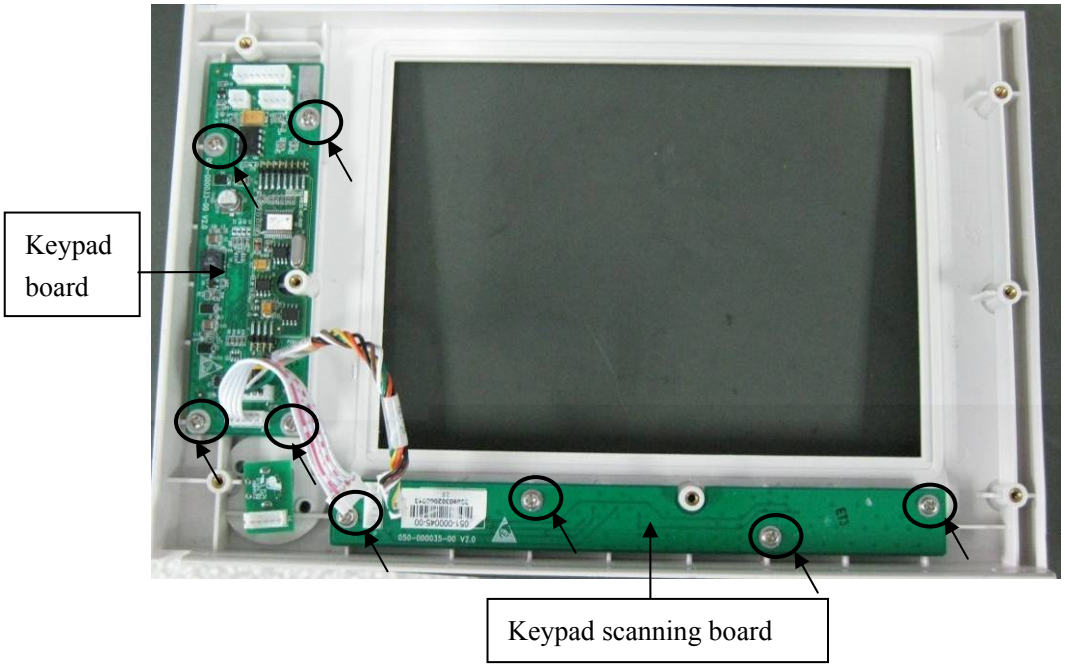


4. Disconnect the cables from the keypad scanning board. Unscrew the five screws as shown below to remove the metal sheet and then the display and panel.

5. Peel the fiber adhesive tape fastening the data line. Disconnect the data line from the 7″ display to remove the display. Note: when disconnecting the data line, you must lift the black fixer.



6. Unscrew the screws as shown below to remove the keypad board and keypad scanning board respectively.

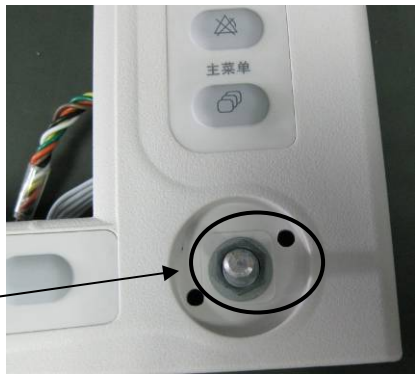


7. Insert two small-sized allen wrenches into the small holes beside the encoder to force out the encoder knob.

Encoder

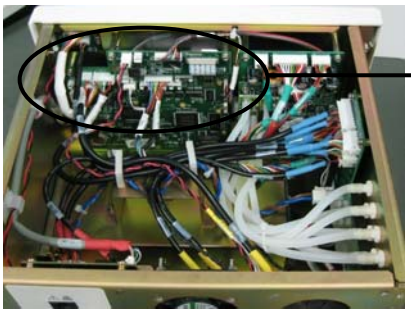
Encoder knob

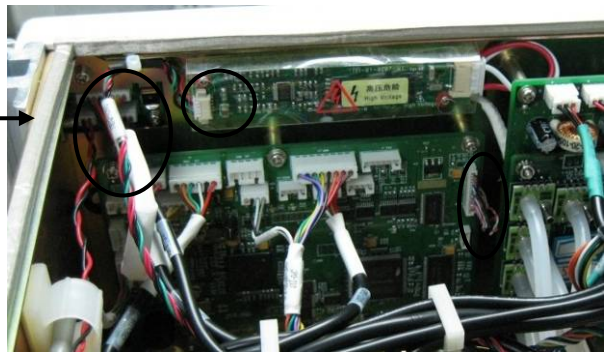
8. Loosen the nut as shown below to remove the encoder.



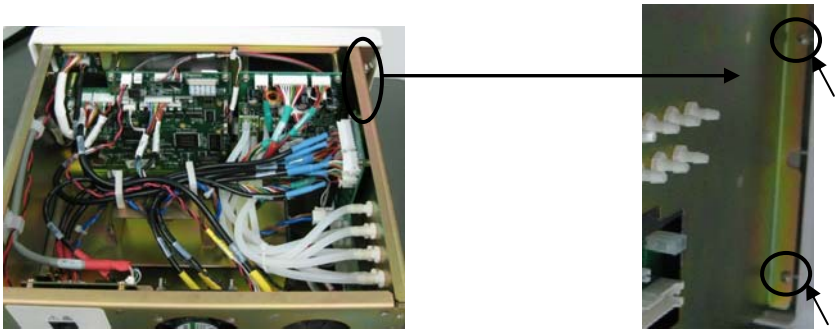
6.2.16.3 Remove the 8″ Display, Encoder and Keypad Board

1. Disconnect the following cables: those connected to the keypad board, those on the left side of the inverter, and those on the upper right corner of the main control board.

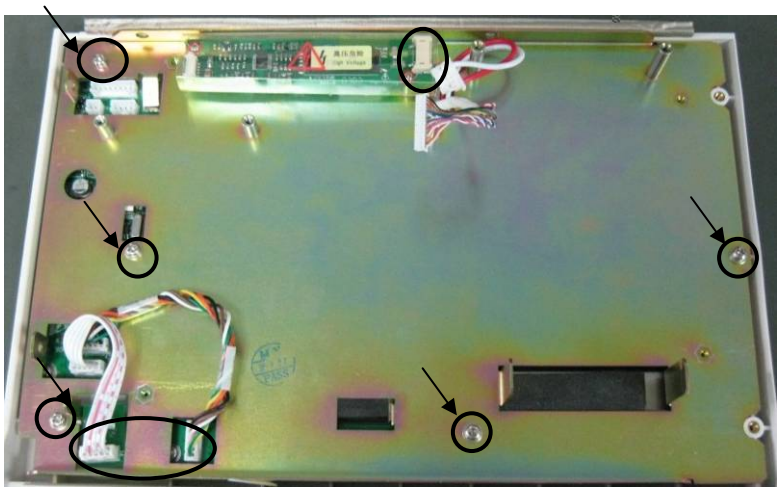




2. Unscrew the two screws as shown below to remove the display panel assembly.

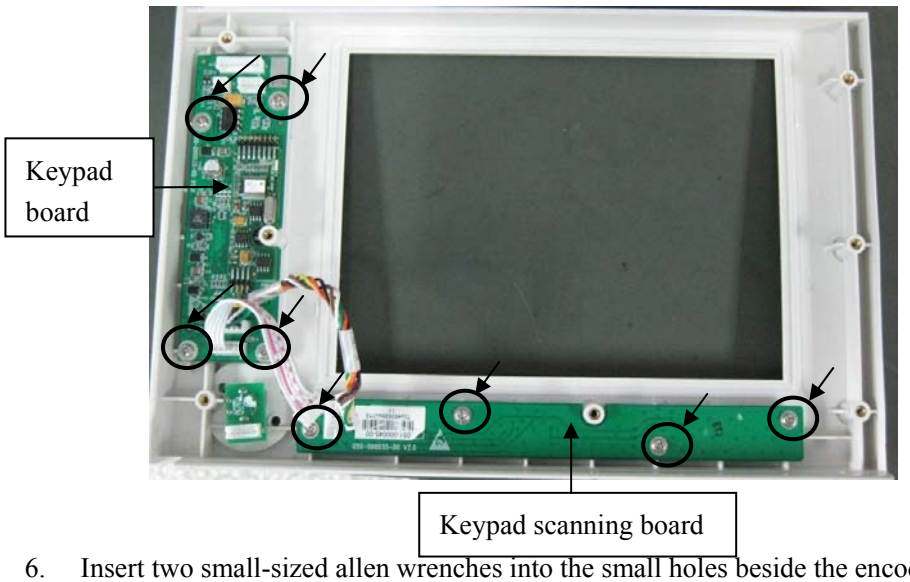


3. Disconnect the cables on the right side of the inverter and those from the keypad scanning board. Unscrew the five screws fastening the metal sheet to remove the panel assembly.



4. Unscrew the four screws as shown below to remove the display.

5. Unscrew the screws as shown below to remove the keypad board and keypad scanning board respectively.

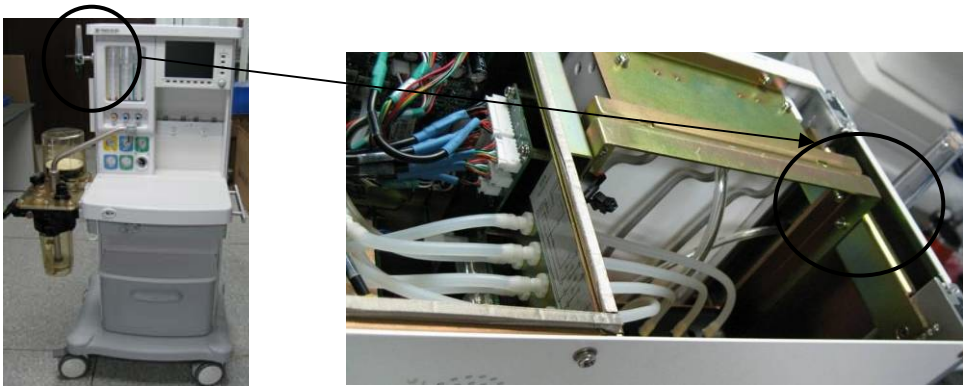


6. Insert two small-sized allen wrenches into the small holes beside the encoder to force out the encoder knob.

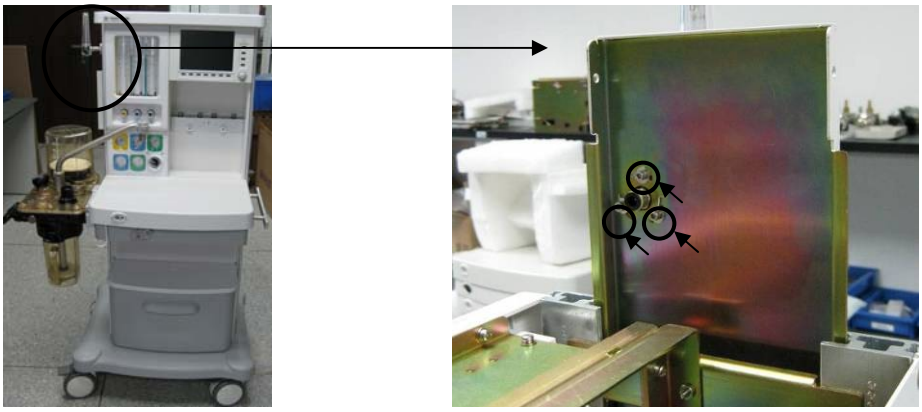
7. Loosen the nut as shown below to remove the encoder.

6.2.17 Remove the Auxiliary O2 Supply Assembly

1. Remove the top plate assembly.
2. Disconnect the tubes from the auxiliary O2 supply assembly.



3. Pull out the upper cover plate on the left side of the machine. Unscrew the three screws to remove the auxiliary O2 supply assembly.

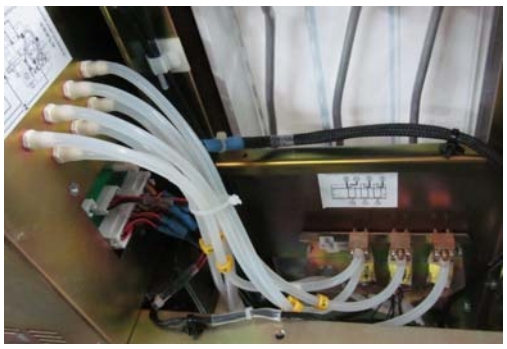


6.2.18 Remove the Flowmeter Assembly

1. Remove the upper rear plate.
2. Disconnect the tubes from the flowmeter assembly. Unscrew the four screws as shown below to remove the flowmeter assembly.

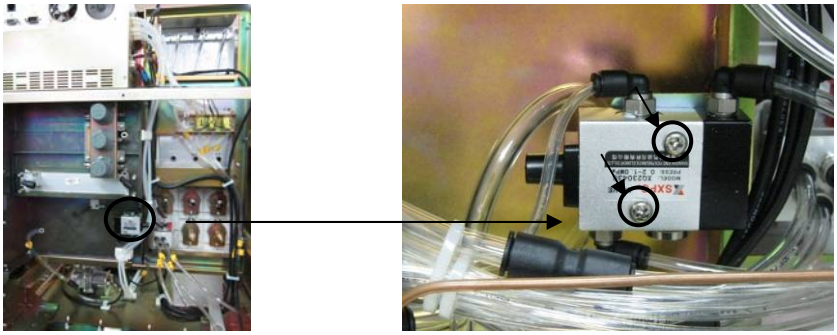
6.2.19 Remove the Three-way Valve Assembly

1. Remove the upper rear plate.
2. Disconnect the tubes and cables from the three-way valve assembly. Unscrew the three screws as shown below to remove the three-way valve assembly.



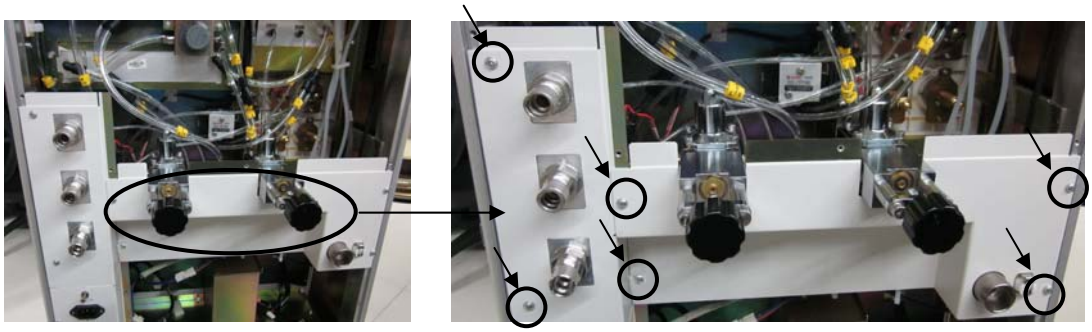
6.2.20 Remove the O2-N2O Cut-off Valve Assembly

1. Remove the upper rear plate.
2. Disconnect the tubes from the O2-N2O cut-off valve assembly. Unscrew the two screws as shown below to remove the O2-N2O cut-off valve assembly.

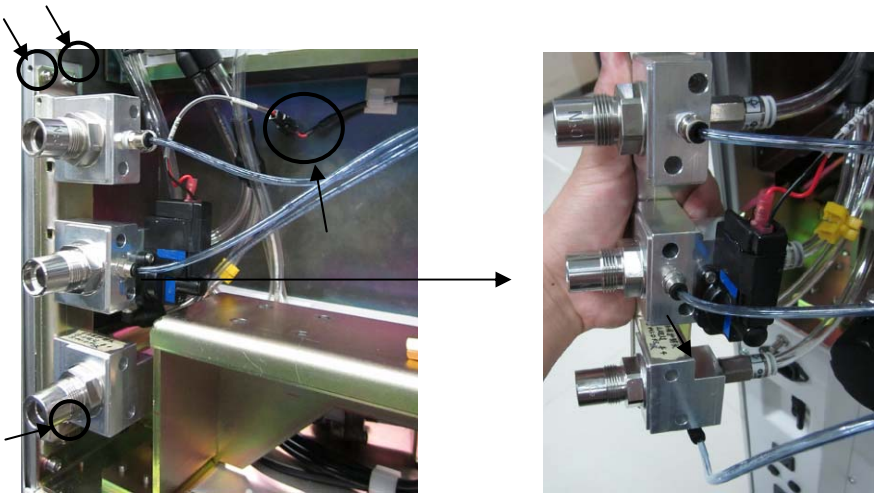


6.2.21 Disassemble the Gas Supply Inlet Assembly

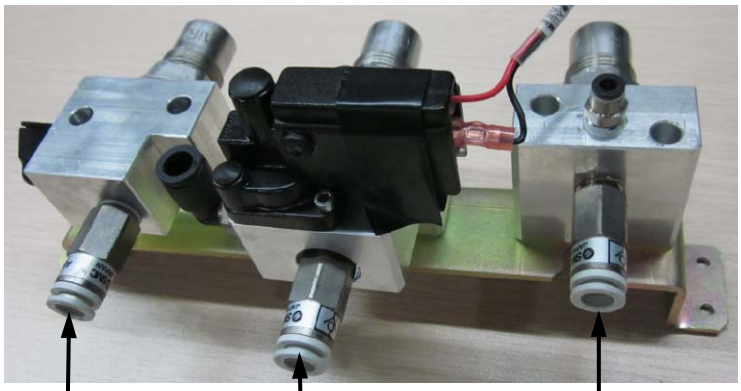
1. Remove the upper rear plate.
2. Unscrew the six screws as shown below to remove the gas supply block plate and cylinder block plate.



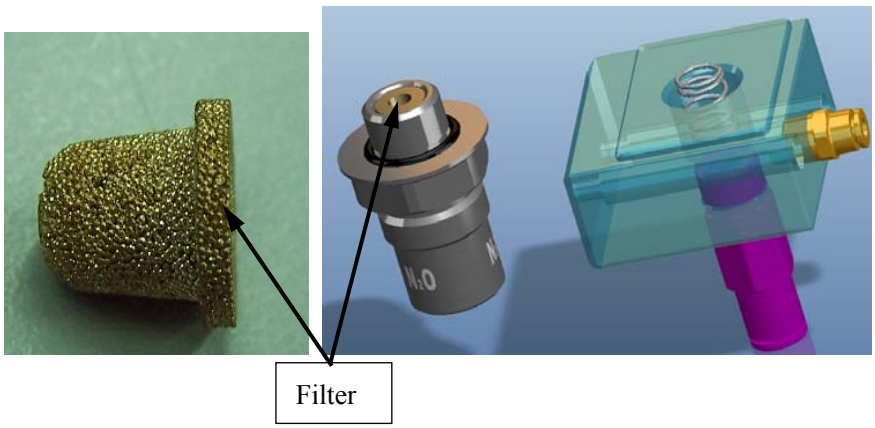
3. Remove the cables of gas supply inlet assembly and the three screws fixing the gas supply mounting panel to remove the gas supply inlet assembly. The remove the tubes from the gas supply inlet assembly.



4. Unscrew the two screws on the gas supply inlet assembly to remove the O2/N2O/Air supply inlet assembly from the gas supply mounting panel (take N2O supply inlet assembly for an example).

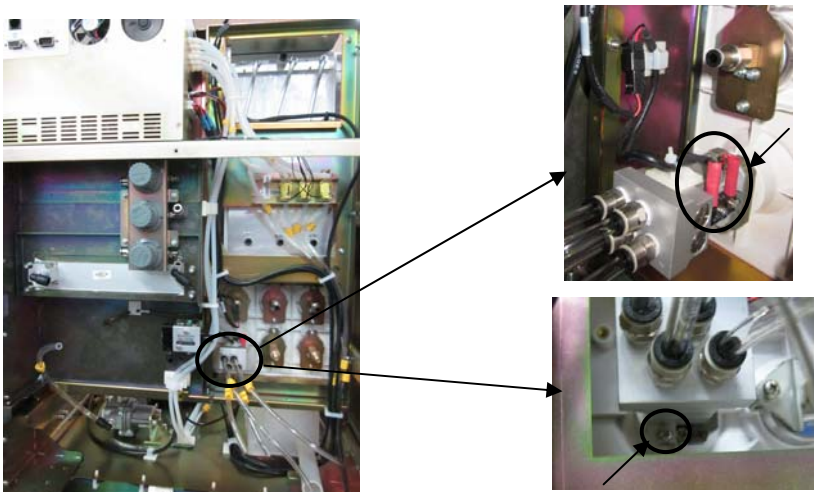


5. Replace the filter on the gas supply inlet assembly.



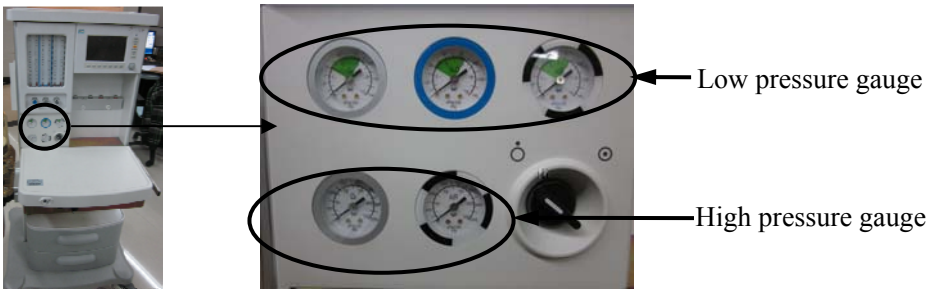
6.2.22 Remove the System Switch Assembly

1. Remove the upper rear plate.
2. Disconnect the tubes and cables from the system switch. Unscrew the two screws to remove the system switch assembly.



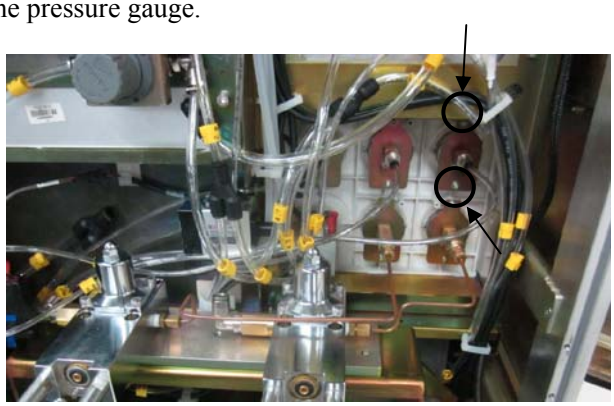
6.2.23 Remove the Pipeline Pressure Gauges

1. Find the corresponding pressure gauge by referring to the gauge label on the front panel of the machine.
2. Pry up and remove the gauge overlay by using the tweezers.



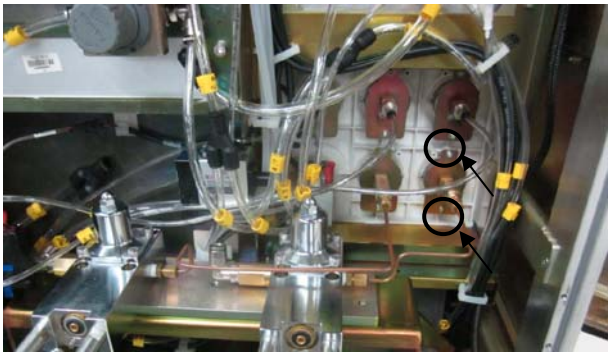
6.2.23.1 Remove the Low Pressure Gauge

1. Remove the upper rear plate.
2. Disconnect the tubes from the pressure gauge. Remove the two screws as shown below to remove the pressure gauge.



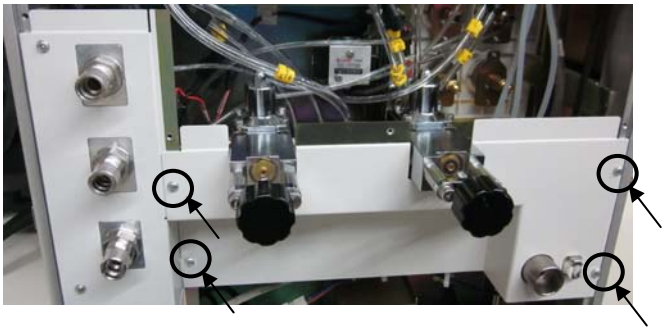
6.2.23.2 Remove the High Pressure Gauge

1. Remove the upper rear plate.
2. Remove the connector between the yellow copper tube and cylinder yoke. Remove the two screws on the high pressure gauge to remove the pressure gauge (with yellow copper tube).

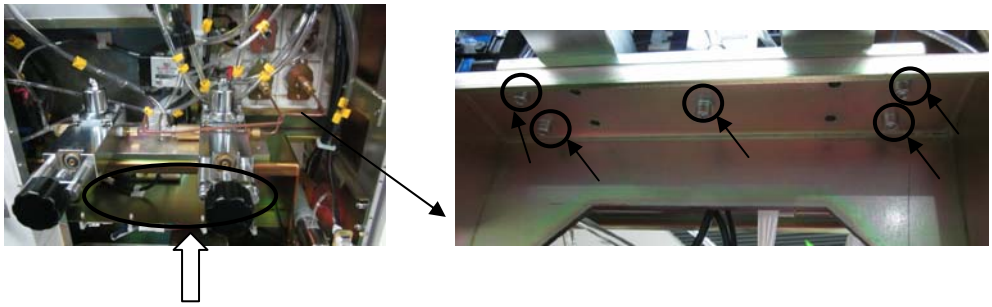


6.2.24 Remove the High Pressure Cylinder Yoke

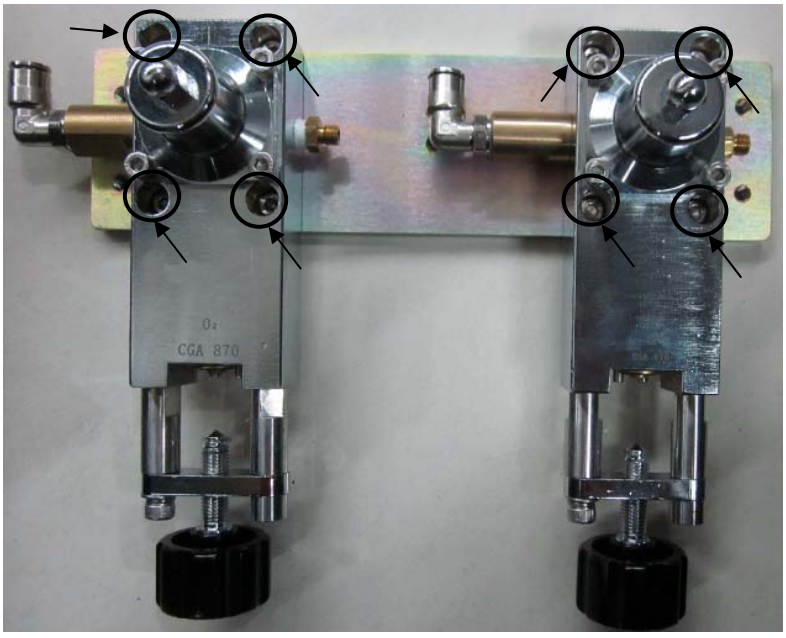
1. Remove the upper rear plate.
2. Remove the four screws fixing the cylinder assembly cover plate to remove the cover plate.



3. Disconnect the tubes from the high pressure cylinder yoke. Remove the connector connected to the yellow copper tube. Unscrew the five screws as shown below to remove the cylinder yoke support (with cylinder yoke).

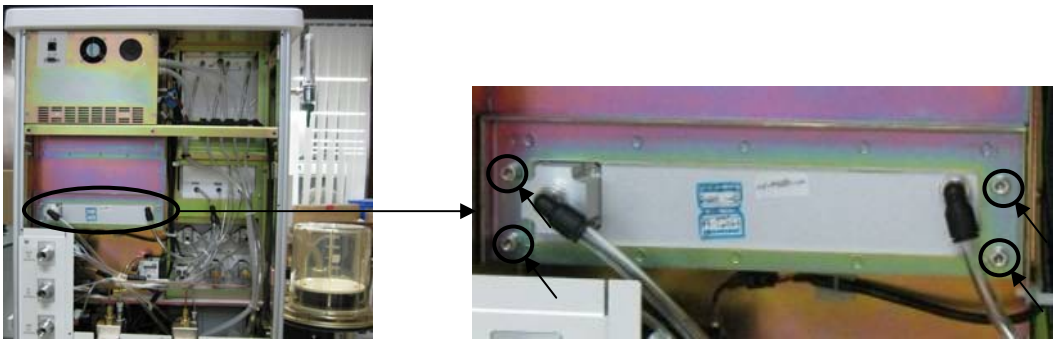


4. Unscrew the four screws to remove the cylinder yoke.



6.2.25 Remove the Vaporizer Manifold

1. Remove the upper rear plate.
2. Disconnect the tubes from the vaporizer manifold. Unscrew the four screws to remove the vaporizer manifold.

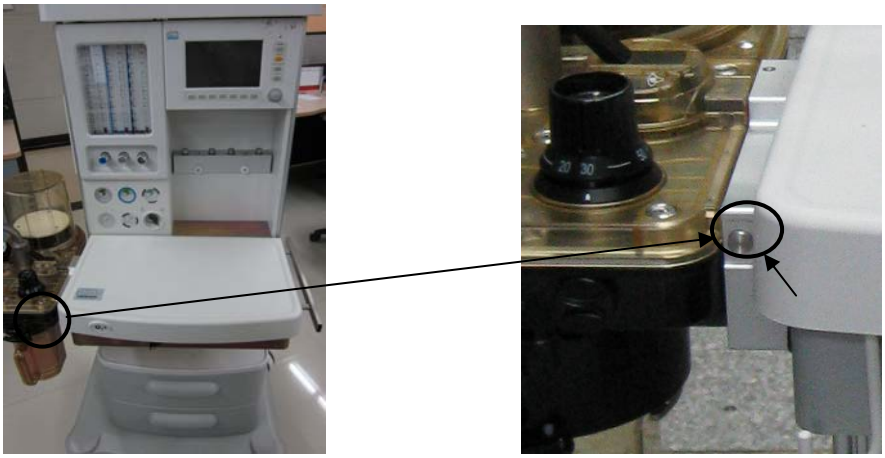


6.2.26 Remove the Worktable Cover Plate Assembly

Unscrew the four screws as shown below to remove the worktable cover plate.

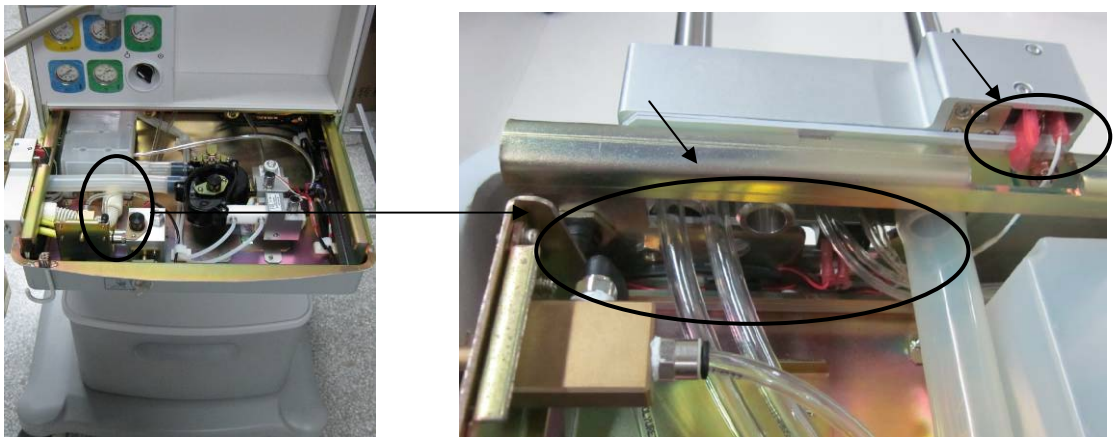
6.2.27 Remove the Patient Circuit

Press and hold the button to remove the patient circuit, as shown below.

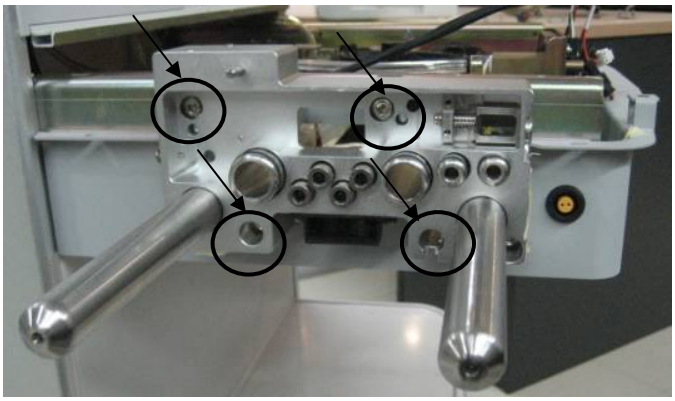


6.2.28 Remove the Circuit Adapter

1. Remove the patient circuit.
2. Remove the worktable cover plate.
3. Disconnect the cables and tubes from the circuit adapter.

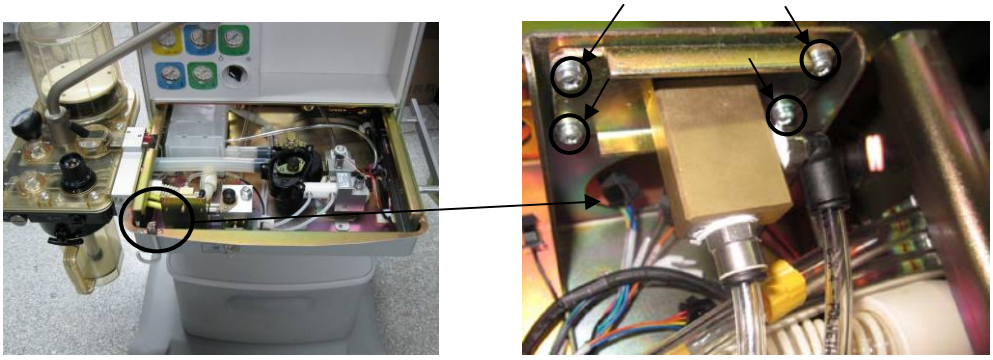


4. Unscrew the four screws as shown below to remove the circuit adapter.



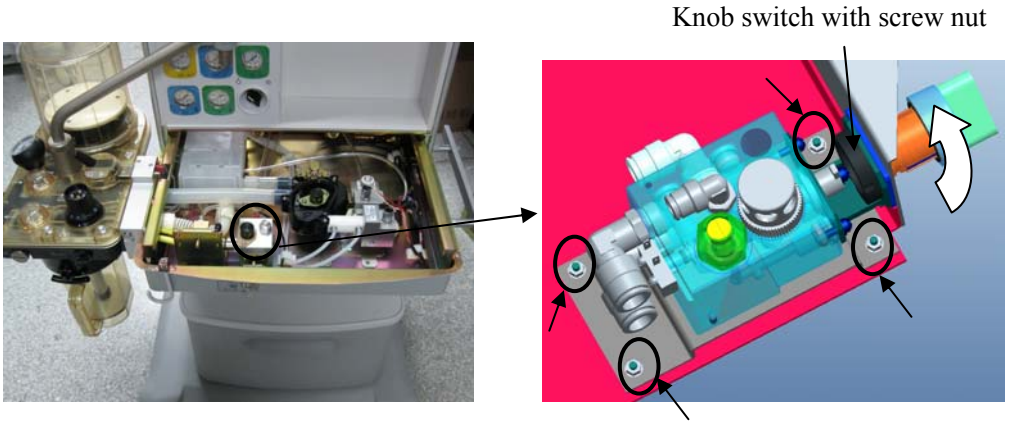
6.2.29 Remove the O2 Flush Button Assembly

1. Remove the worktable cover plate.
2. Disconnect the tubes from the O2 flush button assembly. Unscrew the four screws as shown below to remove the assembly.

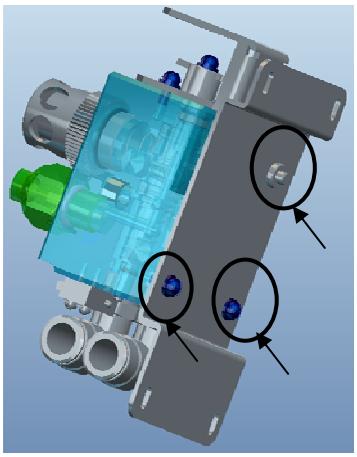


6.2.30 Remove the ACGO Assembly

1. Remove the worktable cover plate.
2. Disconnect the tubes and cables from the ACGO assembly. Loosen the knob switch with screw nut as per the direction shown in the picture to remove the knob switch. Then remove the four nuts fixing the ACGO assembly to remove the ACGO assembly (with metal sheet) (pay attention to the travel of knob switch when restoring the installation).

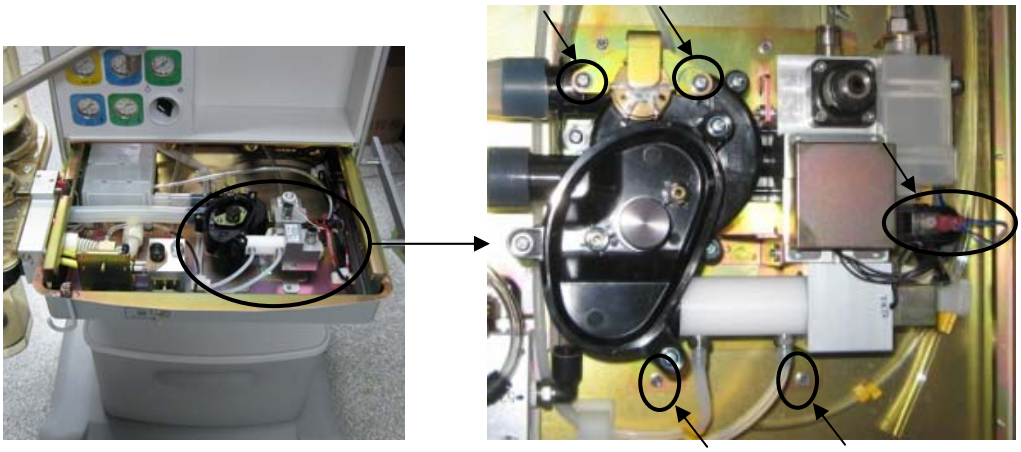


3. Remove the three screws fixing the metal sheet (one screw of them can be removed from the inside of the ACGO) to remove the ACGO assembly.



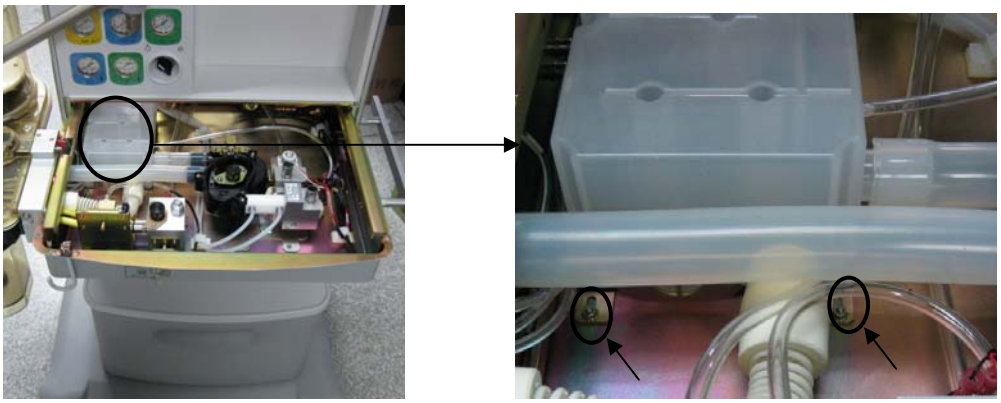
6.2.31 Remove the Expiratory Valve Assembly

1. Remove the worktable cover plate.
2. Disconnect the tubes and cables from the expiratory valve assembly. Unscrew the four nuts to remove the assembly.



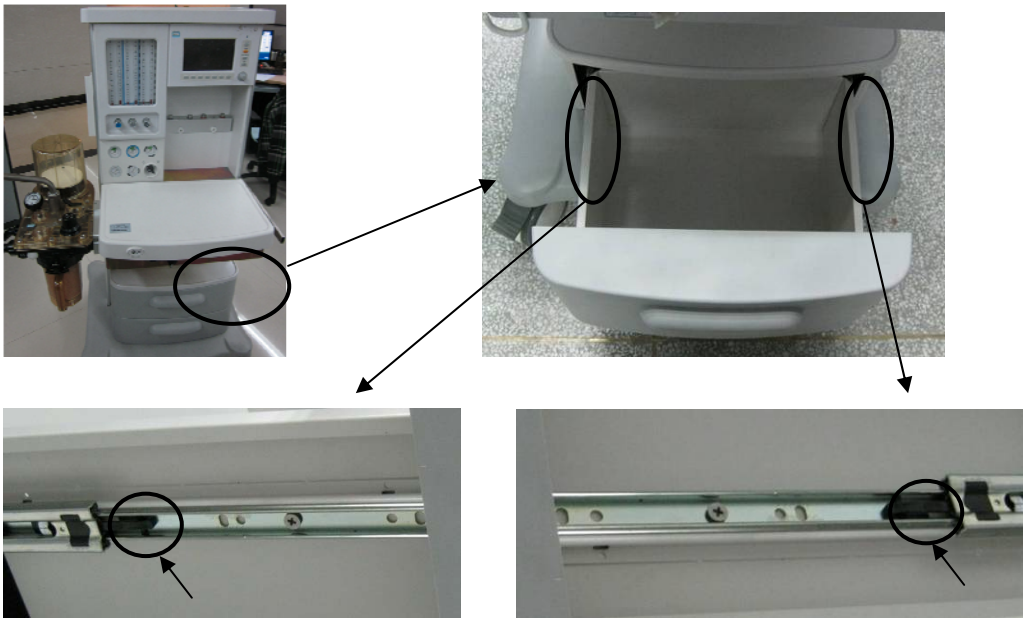
6.2.32 Remove the Gas Reservoir Assembly

1. Remove the worktable cover plate.
2. Disconnect the tubes from the gas reservoir. Unscrew the two nuts as shown below to remove the gas reservoir assembly.



6.2.33 Remove the Drawer Assembly

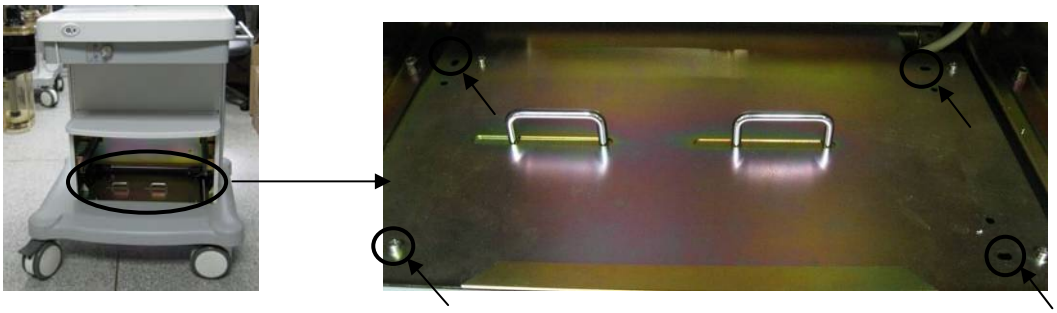
Pull out the drawer. Press and hold the black buttons on the left and right rails as shown below to remove the drawer assembly.



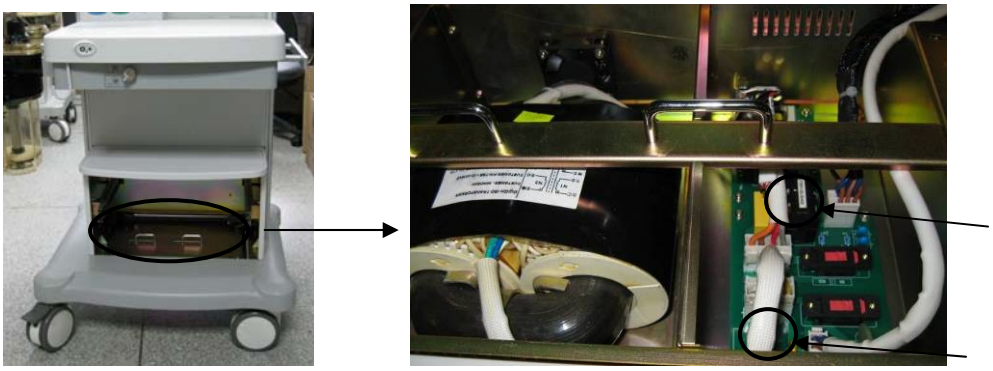
6.2.34 Disassemble the Isolation Transformer

6.2.34.1 Remove the Isolation Transformer Assembly

1. Remove the drawer assembly.
2. Unscrew the four screws as shown below to remove the cover plate for the isolation transformer.

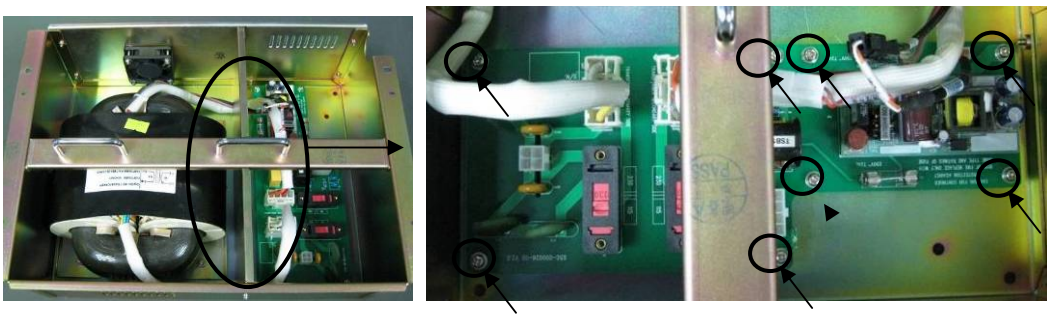


3. Disconnect the cables between the auxiliary output assembly and the isolation transformer assembly to take out the isolation transformer assembly.



6.2.34.2 Remove the Drive Board for the Isolation Transformer

Disconnect the three cables from the drive board. Unscrew the eight screws as shown below to remove the drive board.



6.2.34.3 Remove the Isolation Transformer

1. Unscrew the four screws fastening the handle for the isolation transformer to remove the handle. Unscrew the four screws fastening the isolation plate for the isolation transformer to remove the isolation plate.

2. Disconnect the three cables from the drive board for the isolation transformer. Unplug the connector to the fan connection line. Unscrew the four screws as shown below to remove the isolation transformer.

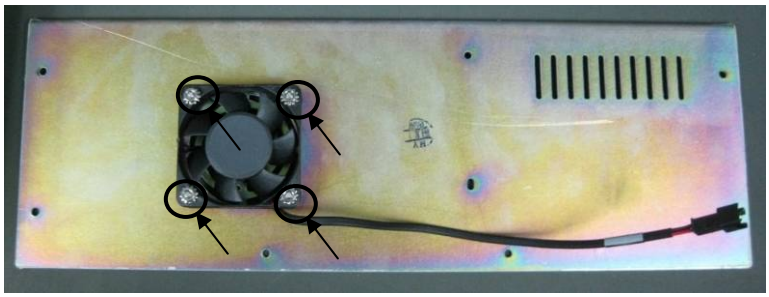
6.2.34.4 Remove the Fan for the Isolation Transformer

1. Unscrew the four screws fastening the handle for the isolation transformer to remove the handle. Unscrew the four screws fastening the isolation plate for the isolation transformer to remove the isolation plate.

2. Unplug the connector to the fan.

3. Unscrew the four screws as shown below to remove the rear plate fastening the bottom housing.

4. Unscrew the four nuts as shown below to remove the fan.



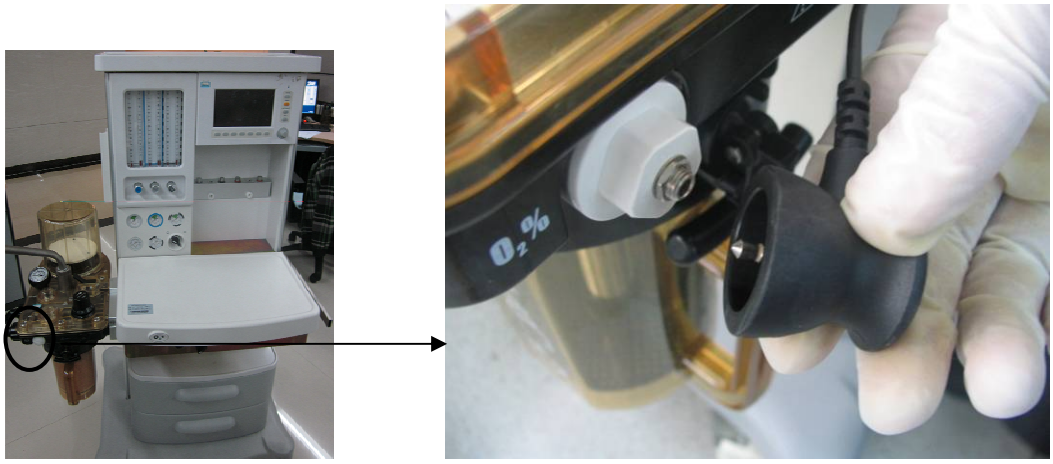
6.2.35 Remove the Caster

Tilt the anesthesia machine slowly to the floor and then loosen the caster.

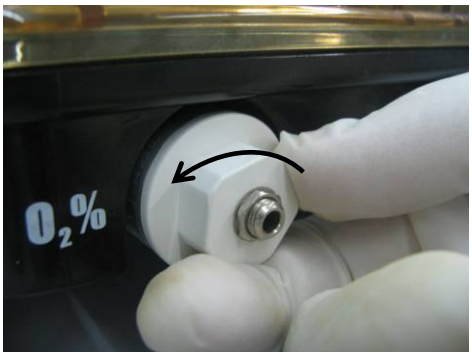
6.3 Disassemble the Breathing System

6.3.1 Remove the O2 Sensor

1. Remove one end of the O_2 sensor cable from the $O_2\%$ connector on the anesthesia machine. Unplug the other end of the cable from the O_2 sensor.



2. Turn the O_2 sensor counterclockwise to take it out.



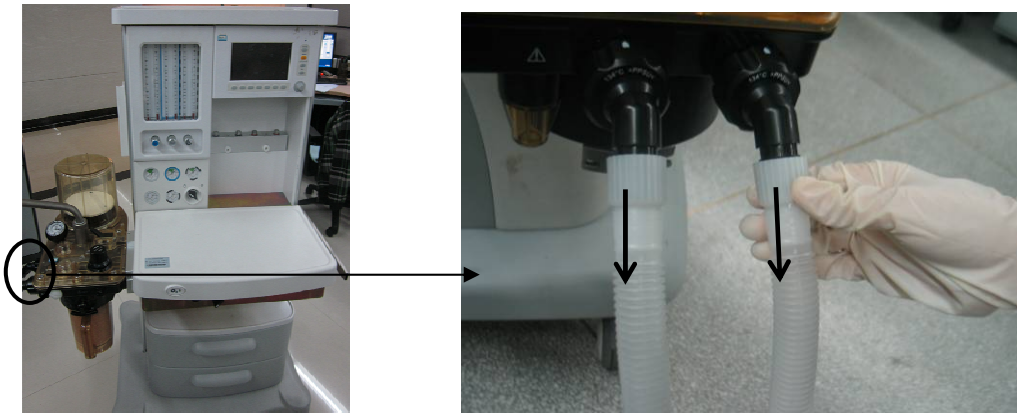
6.3.2 Remove the Breathing Tubes and Y Piece

NOTE

- **When removing the breathing tube, hold the tube connectors at both ends to prevent damage to the tube.**

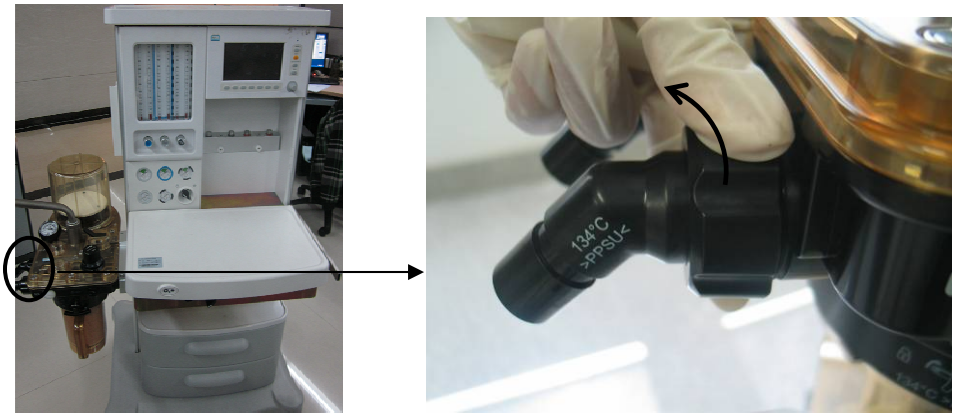
1. Remove the filter from the Y piece.

2. Disconnect the inspiratory and expiratory tubes from their respective connectors on the circuit.



6.3.3 Remove the Flow Sensor

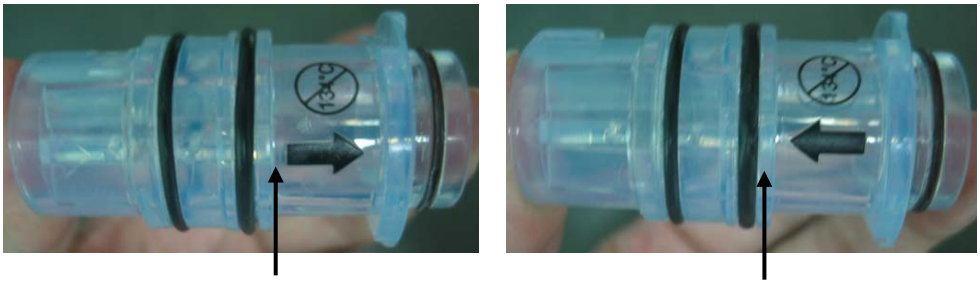
1. Turn the locking nut counterclockwise.



2. Pull out the inspiration/expiration connectors and their locking nuts.

3. Pull out the flow sensor horizontally.

The following picture shows the appearance of inspiratory and expiratory flow sensor assemblies：

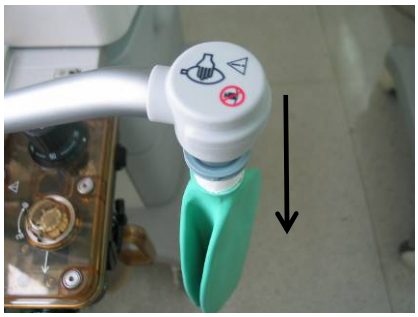


Inspiratory flow sensor assembly

Expiratory flow sensor assembly

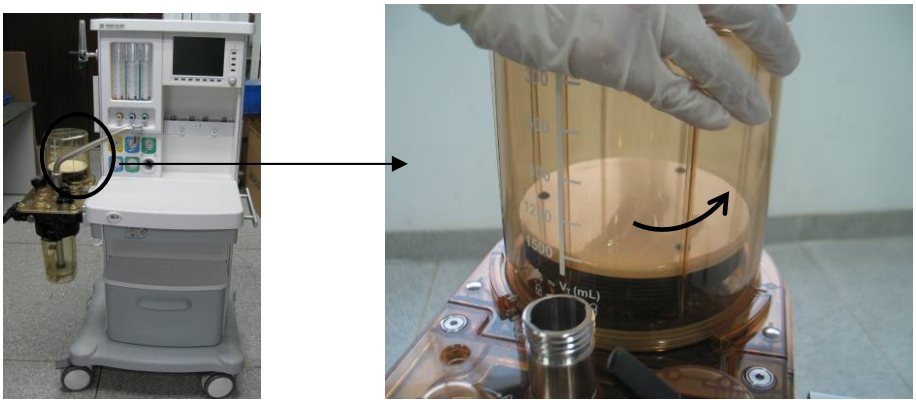
6.3.4 Remove the Manual Bag

Remove the manual bag from the connector on the breathing system as shown below.

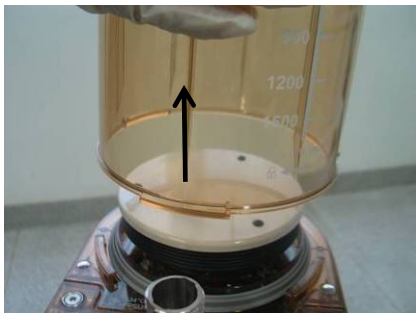


6.3.5 Disassemble the Bellows Assembly

1. Turn the bellows housing counterclockwise.



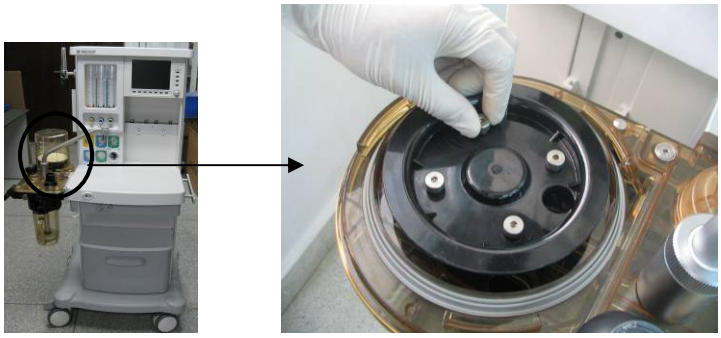
2. Lift off and remove the housing.



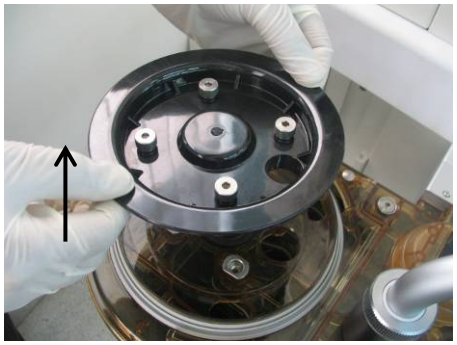
3. Remove the bellows from the bellows base.

6.3.6 Disassemble the Pop-off Valve Assembly

1. Disassemble the bellows assembly.
2. Unscrew the four locking screws.



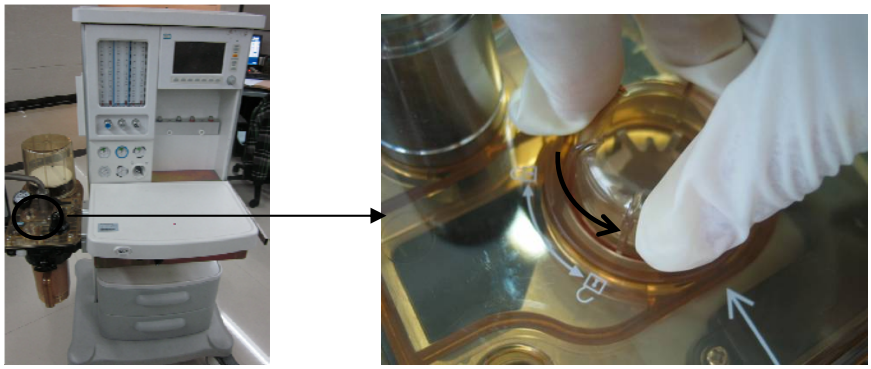
3. Hold and pull up the Pop-off valve cover to remove it.



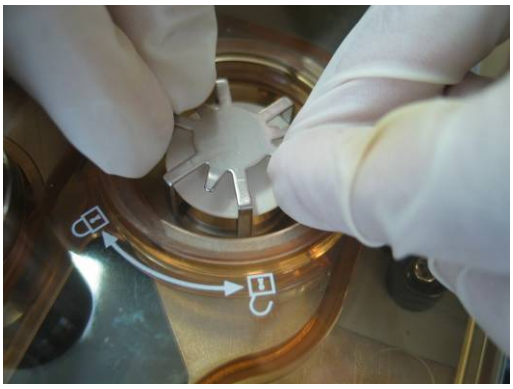
4. Take out the Pop-off valve rubber gasket and metal component.

6.3.7 Disassemble the Expiratory (Inspiratory) Check Valve Assembly

1. Turn the check valve cover counterclockwise to remove it.



2. Pull out the check valve from the breathing system.



The following picture shows the appearance of expiratory (inspiratory) check valve assembly.

6.3.8 Remove the CO2 Absorbent Canister

For WATO EX-25/30/35 anesthesia machine:

1. Hold and pull up the rotary handle for 90 degrees.

2. Turn the rotary handle fo

For WATO EX-20 anesthesia machine:

1. Turn the CO2 absorbent canister counterclockwise.

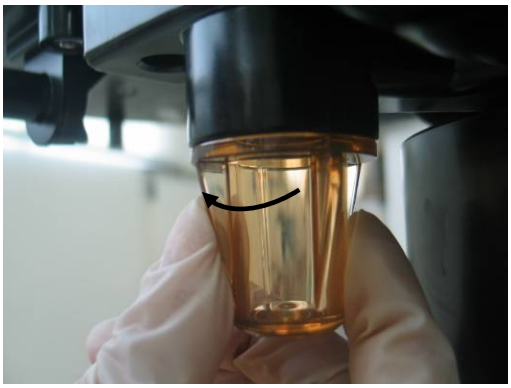
2. Remove the CO2 absorbent canister downwards.

⚠WARNING

- **Absorbent is a caustic substance and is a strong irritant to eyes, skin and the respiratory system. Affected parts should be flushed with water. If irritate continues after flushed by water, seek medical assistance immediately.**

6.3.9 Remove the Water Collection Cup

1. Hold the water collection cup and turn it clockwise.

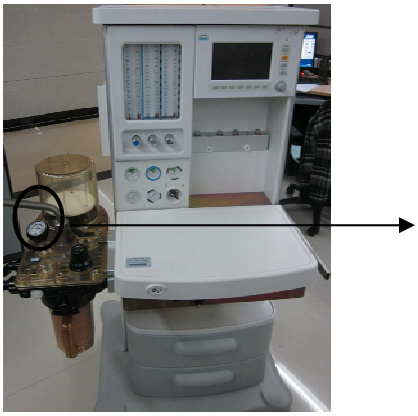


2. Remove the water collection cup.

The following picture shows the appearance of water collection cup.

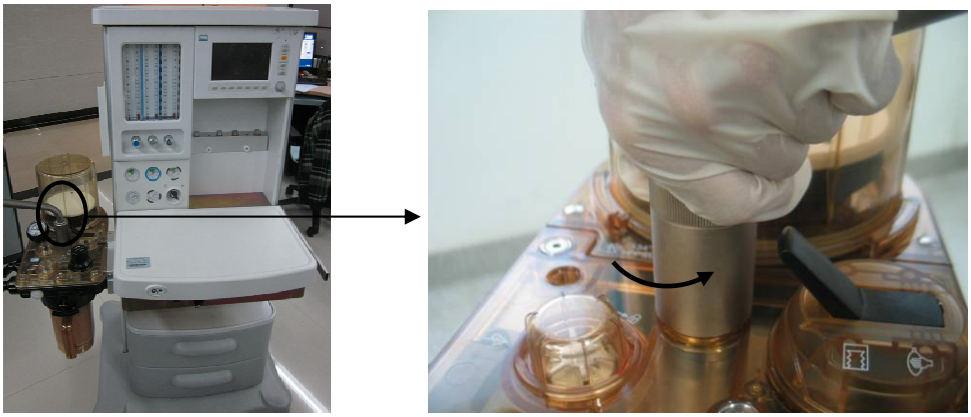
6.3.10 Remove the Airway Pressure Gauge

Pull out the airway pressure gauge as shown below.

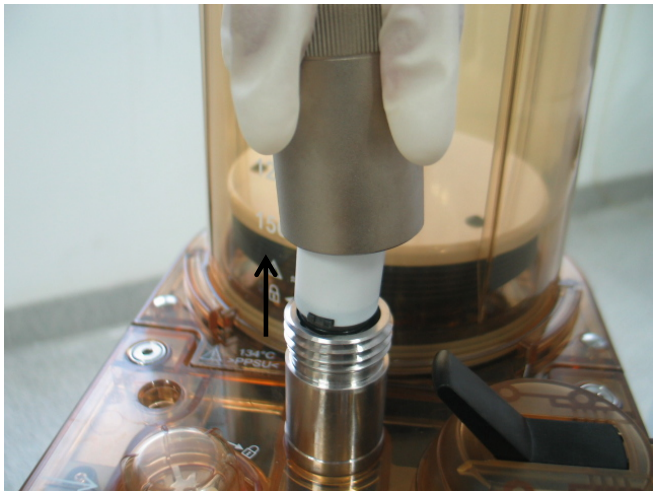


6.3.11 Remove the Bag Arm

1. Loosen the locking nut counterclockwise.



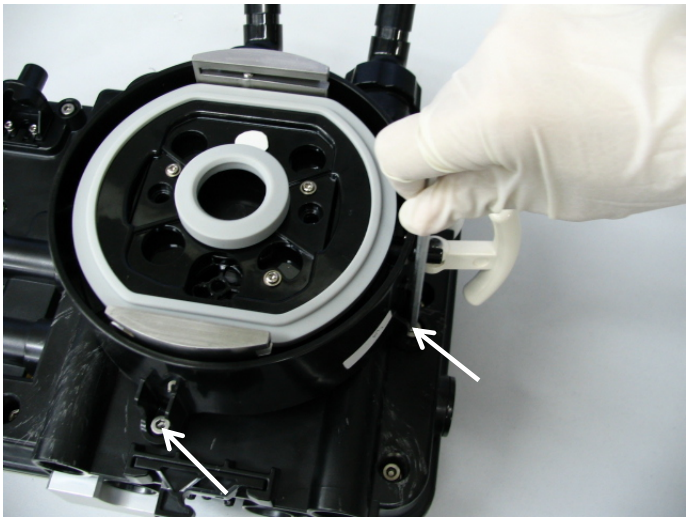
2. Remove the bag arm from the breathing system.

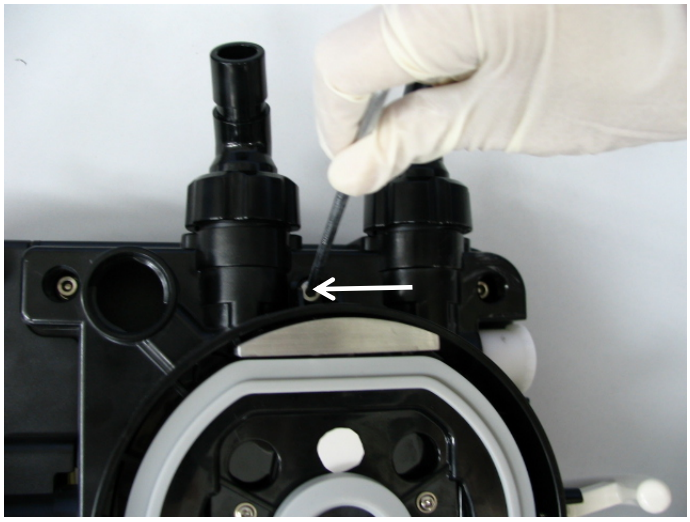


6.3.12 Disassemble the CO2 Absorbent Canister Connection Block Assembly

1. Refer to ***6.3.1*** through ***6.3.11*** to remove the O2 sensor, breathing tubes, manual bag, bellows assembly, CO2 absorbent canister, airway pressure gauge, and bag arm.
2. Refer to ***6.2.27*** to remove the patient circuit.
3. Turn over the circuit.

4. Unscrew the three screws fastening the lifting device.





5. Remove the lifting device from the circuit.

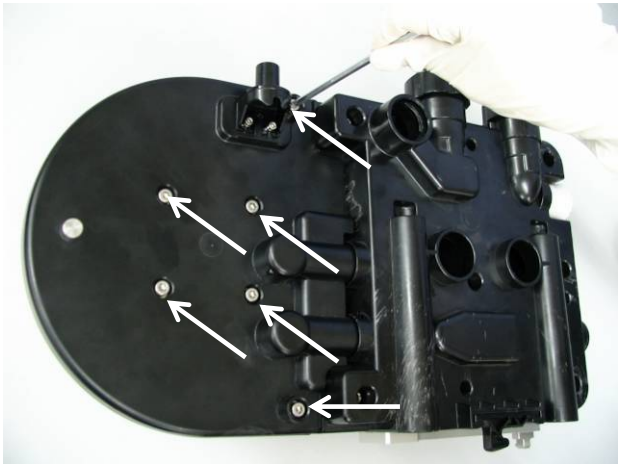
6. Turn over the lifting device. Loosen the two screws as shown below by using the allen wrench.

7. Pull up forcibly to separate the CO2 absorbent canister connection block assembly.

8. Pull up to take out the lifting device.

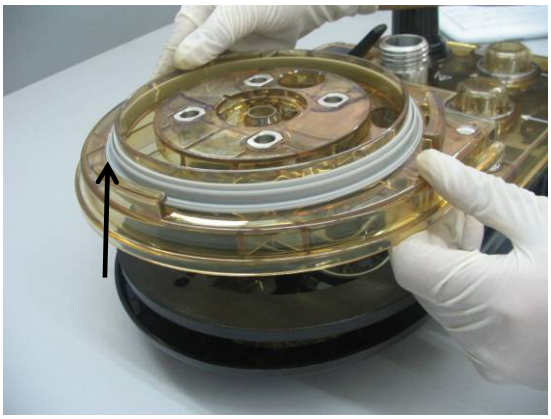
6.3.13 Remove the Upper Cover 2 and Lower Cover 2 Assemblies

1. Refer to ***6.3.1*** through ***6.3.11*** to remove the O2 sensor, breathing tubes, manual bag, bellows assembly, CO2 absorbent canister, airway pressure gauge, and bag arm.
2. Refer to ***6.2.27*** to remove the patient circuit.
3. Refer to ***6.3.12*** to remove the lifting device.
4. Loosen the six screws as shown below by using the allen wrench.



5. Loosen the nut counterclockwise as shown below.

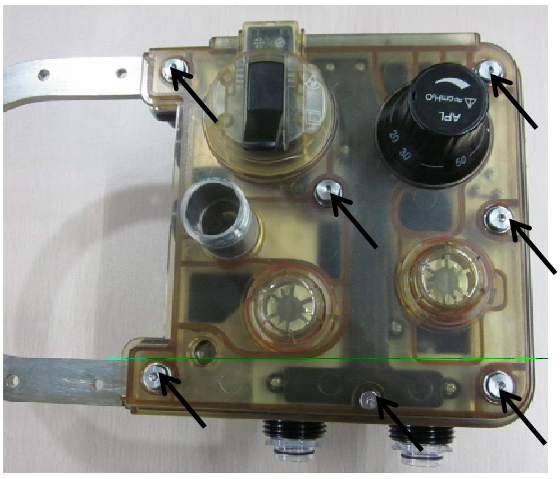
6. Turn over the circuit. Pull up to take out the upper cover 2 assembly.



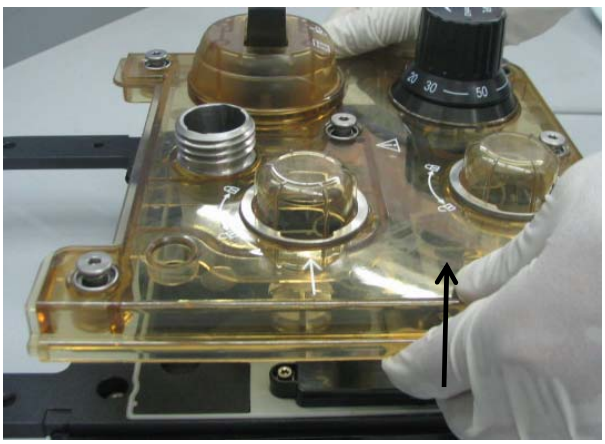
7. Pull leftwards to take out the lower cover 2 assembly.

6.3.14 Remove the Upper Cover Assembly, Median Plate Assembly, and Lower Cover Assembly

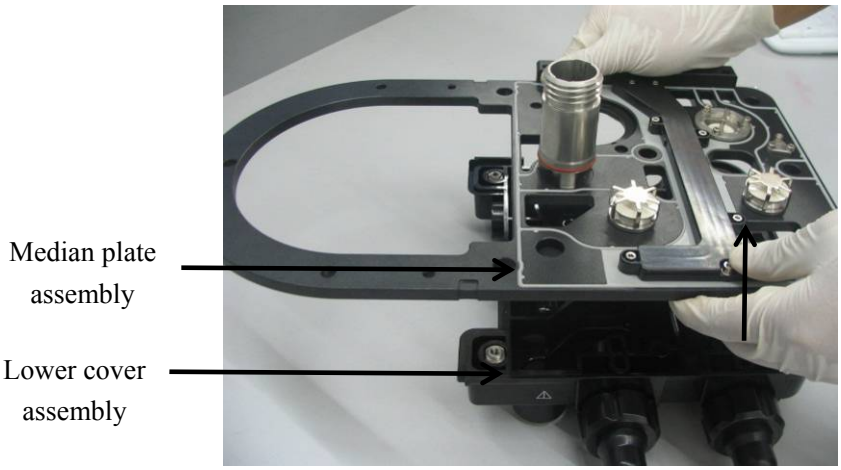
1. Refer to ***6.3.13*** to remove the upper cover 2 and lower cover 2 assemblies.
2. Loosen the seven screws as shown below by using the Allen wrench and cross screwdriver.



3. Hold the upper cover assembly firmly and pull up to take it out.

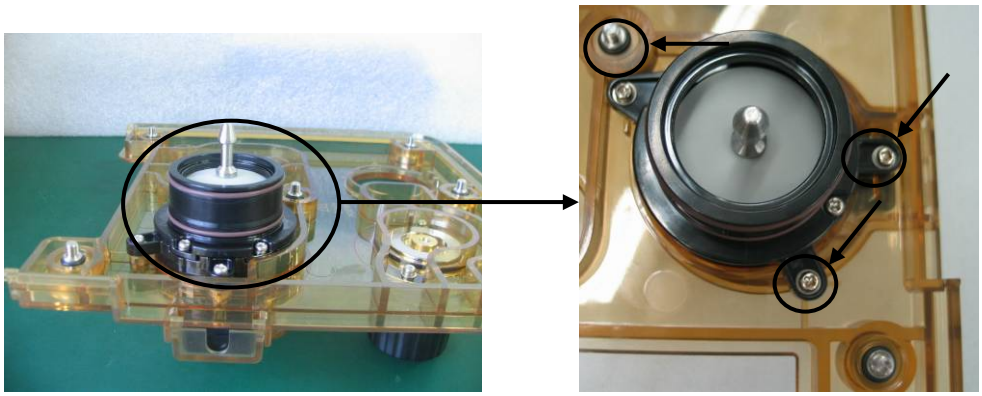


4. Pull up the median plate assembly to separate it from the lower cover assembly.

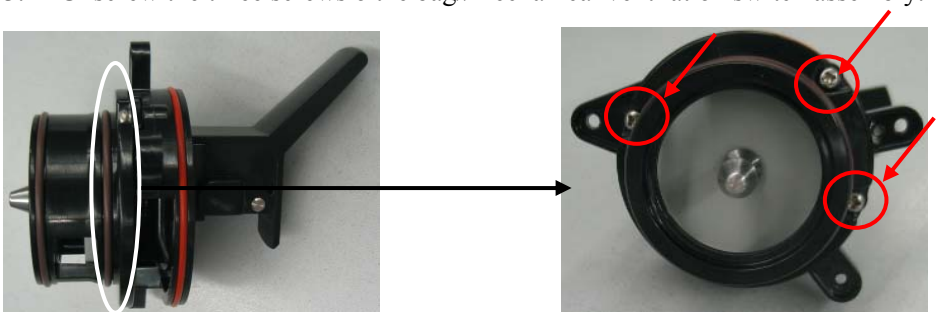


6.3.15 Disassemble the Bag/vent switch Assembly

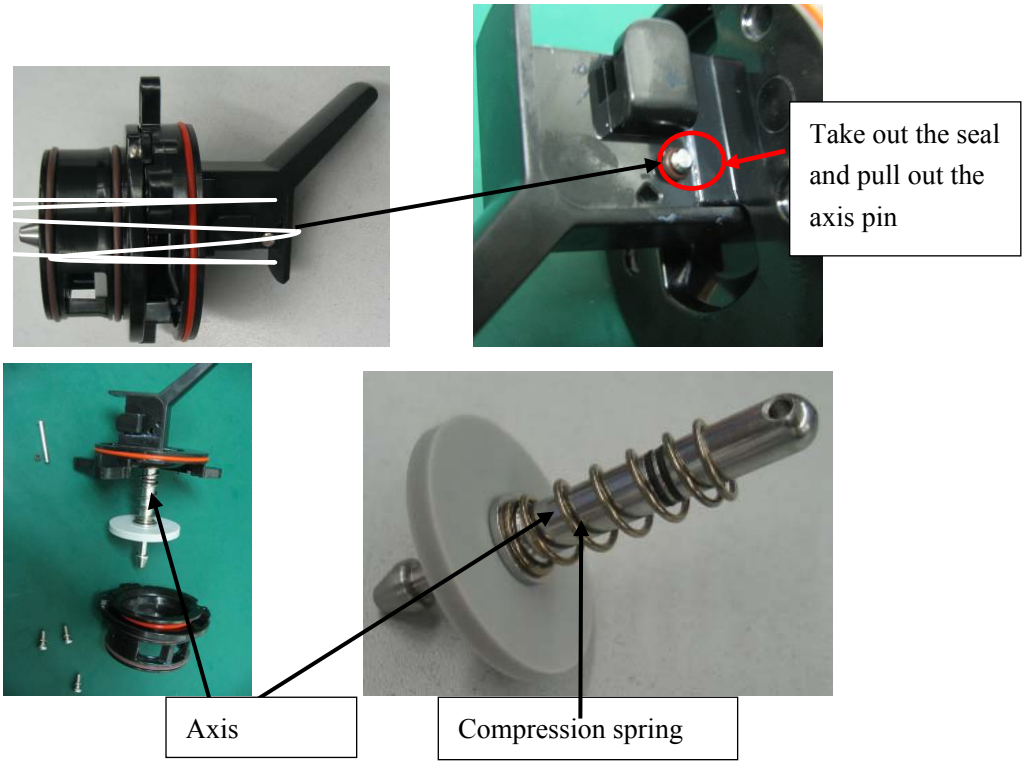
1. Remove the upper cover assembly.
2. Turn over the upper cover assembly and unscrew the three screws fastening the Bag/vent switch assembly.



3. Unscrew the three screws o the bag//mechanical ventilation switch assembly.



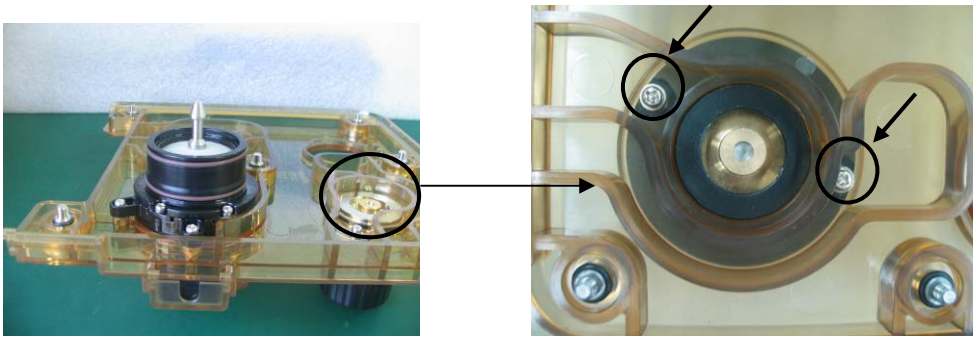
4. Take out the seal and pull out the axis pin to remove the axis.



5. Remove the compression spring and replace the two seals (0030-10-13077).

6.3.16 Remove the APL Valve Assembly

1. Remove the upper cover assembly.
2. Unscrew the two screws as shown below to pull out the APL valve assembly.



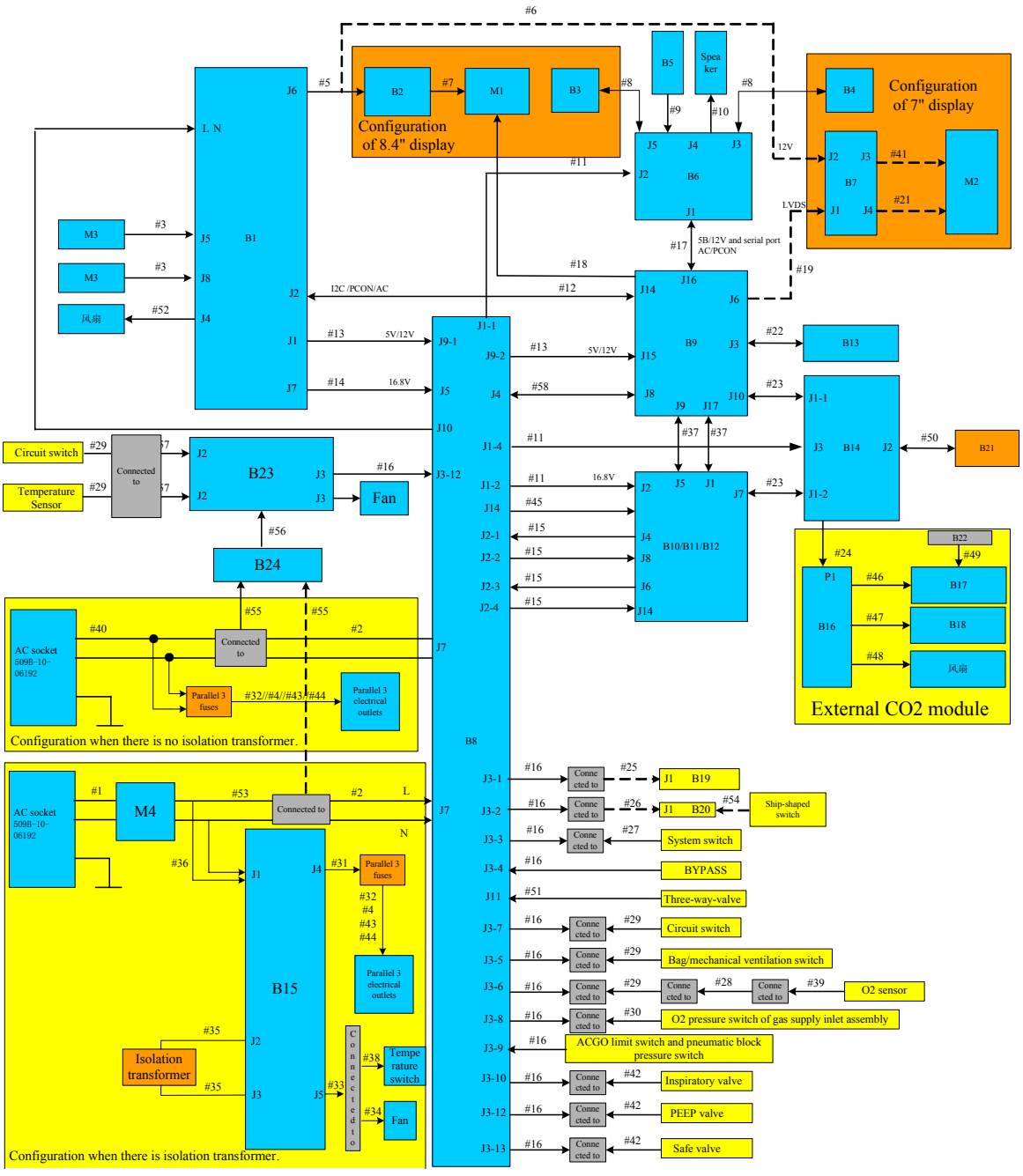
The following picture shows the appearance of APL valve assembly.-

6.4 Electrical and Pneumatic Connections

After parts disassembling and replacing, refer to the following to re-install and re–connect the parts.

6.4.1 Electrical Connections

Electrical Circuit Diagram



Wiring

S/N	P/N	Description
1	009-000057-00	AC power cable (with isolation transformer)
2	009-000058-00	AC power cable for the power board
3	9201-30-35926	Power cable for the lithium battery

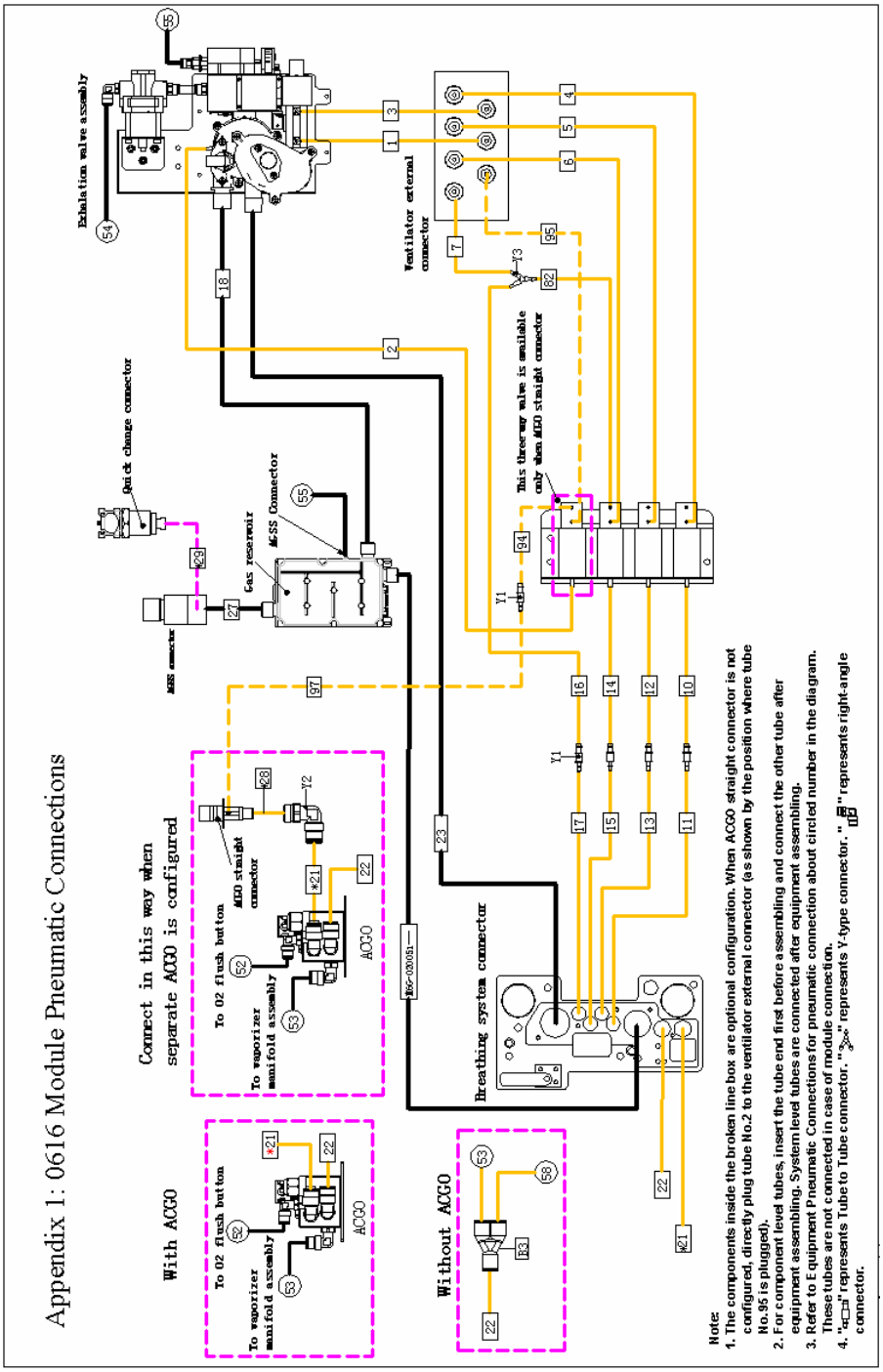
S/N	P/N	Description
4	0621-20-69609	European standard socket connection line
5	009-000070-00	Inverter drive line
6	009-000071-00	12V power cable for the 7" display conversion board
7	8000-21-10239	Connection line for the TFT display backlight board
8	009-000045-00	Drive line for the keypad scanning board
9	9200-21-10460	Encoder connection line
10	9200-21-10633	2.25" speaker and connection line
11	009-000046-00	Power cable for the keypad board etc.
12	009-000047-00	Power board control communication cable
13	009-000048-00	5V/12V power cable
14	009-000049-00	16.8V power cable
15	009-000044-00	Monitor board connection line
16	009-000072-00	Power signal connection line
17	009-000050-00	Keypad board communication cable
18	009-000069-00	8" TFT display data line
19	009-000073-00	7" display LVDS data line
21	009-000199-00	FPC 7" display LVTTL data line
22	009-000051-00	Internal network cable
23	009-000052-00	CO2 connection line for flow calibration
24	009-000053-00	CO2 module external cable
25	009-000059-00	Flowmeter backlight connection line
26	009-000060-00	Table toplight connection line
27	0621-20-69494	System switch connection line B
28	0601-21-78956	Connection line for the circuit internal O2 sensor
29	0621-20-78593	Connection line for the circuit internal switch
30	0621-20-69588	Connection line for the flowmeter inlet pressure switch
31	0621-20-69606	Power cable for the auxiliary output
32	0621-20-69608	National standard socket connection line
33	009-000062-00	Connection line for fan and temperature switch
34	0611-20-58667	Transformer cooling fan and connection line
35	TSB1-20-20394	Isolation transformer
36	009-000063-00	AC power cable B for the isolation transformer
37	009-000100-00	Communication cable between the main control board and monitor board
38	0621-20-78594	Isolation transformer temperature switch line
39	0601-20-78941	Connection line for the circuit external O2 sensor
40	009-000368-00	0616 AC power cable
41	009-000074-00	7" display backlight drive line
42	009-000066-00	Connection line for NORGREN pneumatic block
43	009-000067-00	American standard socket connection line

S/N	P/N	Description
44	009-000068-00	British and Indian standard socket connection line
45	009-000198-00	Circuit switch/bypass line
46	009-000054-00	CO2 module internal power supply and communication cable
47	009-000055-00	Connection line between the CO2 module and the LED indicator on the front panel
48	6200-21-11608	Fan connection line
49	M02A-20-25934	Watertrap connection line
50	009-000056-00	Connection line between the calibration power interface board and VT
51	009-0000061-00	Connection line for the three-way valve assembly
52	8002-20-36195	Fan and connection line
53	009-000076-00	Connection line between the breaker and power board
54	009-000075-00	Table toplight switch line
B1	051-000117-00	Power board PCBA
B2	0000-10-11020	Inverter
B3	051-000045-00	8.4" display keypad scanning board
B4	051-000044-00	7" display keypad scanning board
B5	0010-30-43089	Copper axis encoder board
B6	051-000043-00	Keypad board
B7	051-000041-00 or 051-000138-00	0616 7" display conversion board PCBA
B8	051-000042-00	Power signal conversion board
B9	0621-30-78696	Main control board
B10	0621-30-78632	Signal detection board
B11	0621-30-78634	Valve drive board
B12	0621-30-78636	Auxiliary monitor board
B13	9210-30-30152	Network conversion board
B14	051-000046-00	Calibration power interface board
B15	051-000036-00	Drive board for the isolation transformer
B16	051-000047-00	CO2 module signal conversion board
B17	M02B-30-64513	CO2 module main unit
B18	6200-20-11585	Indicator board
B19	051-000040-00	Flowmeter backlight board
B20	0621-30-69356	Table toplight board
B21	\	VT
B22	\	CO2 watertrap
M1	0000-10-10772	LCD TFT 8.4" 800*600 3.3V
M2	0000-10-11182 or 021-000007-00	LCD TFT 7.0" 800*480 LED
M3	M05-010001-06	Li-ion 11.1V4400mAhLI23S001A
M4	M07-00086S---	SWITCH breaker 250V 7.5A welded terminal

6.4.2 Pneumatic Connections

6.4.2.1 Pneumatic Connection A: Module Pneumatic Connections

Connection Diagram



Tubing

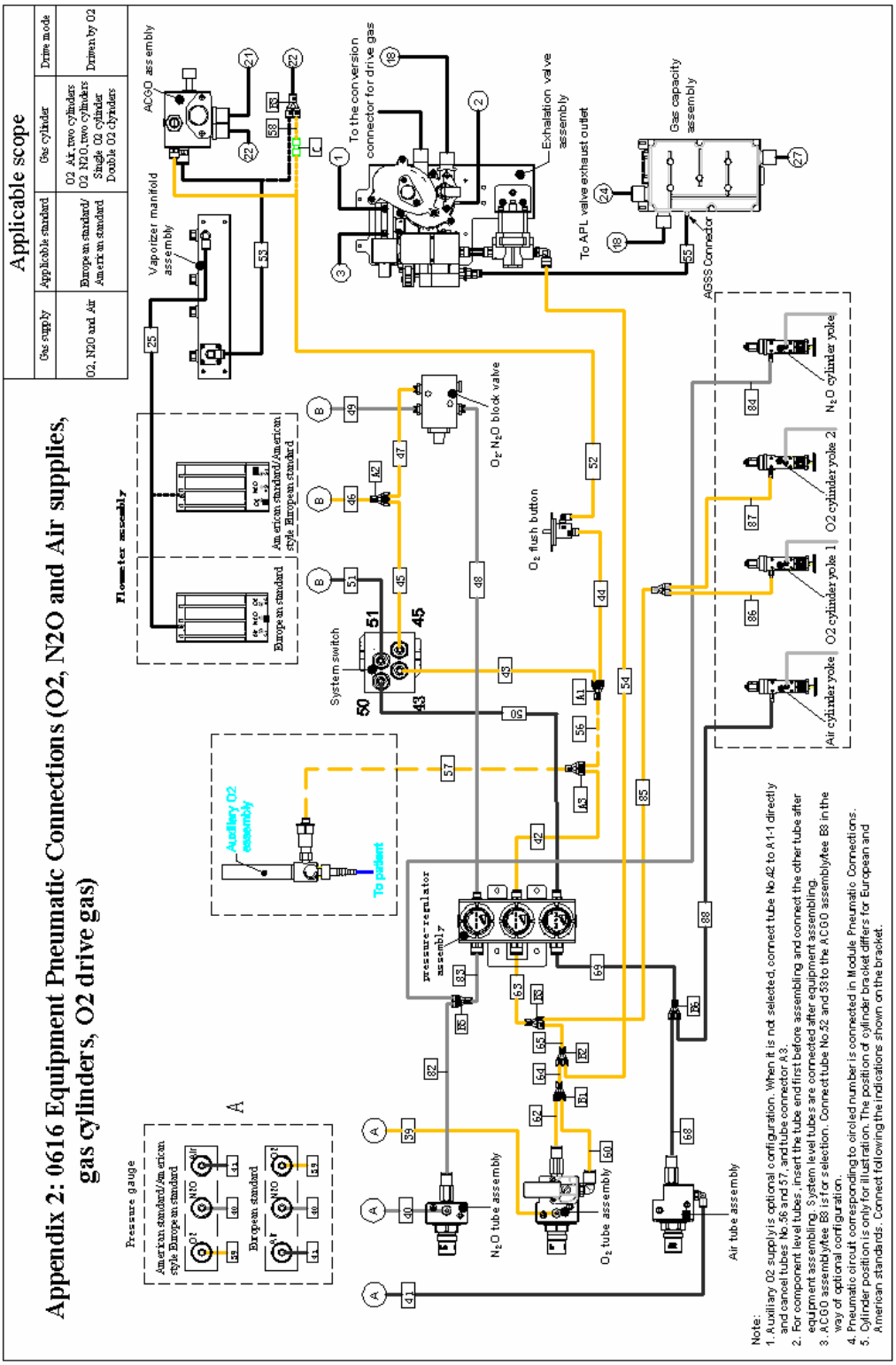
0616 tube No. reference table (module pneumatic diagram）				
Tube No.	**Length(mm)**	**DiameterΦ(mm)**	**P/N**	**Remark**
1	1100	Tube 5.6*2.4	A21-000007---	/
2	800	Tube 5.6*2.4	A21-000007---	/
3	1080	Tube 5.6*2.4	A21-000007---	/
4	315	Tube 5.6*2.4	A21-000007---	/
5	270	Tube 5.6*2.4	A21-000007---	/
6	255	Tube 5.6*2.4	A21-000007---	/
7	190	Tube 5.6*2.4	A21-000007---	/
10	80	Tube 5.6*2.4	A21-000007---	/
12	80	Tube 5.6*2.4	A21-000007---	/
14	80	Tube 5.6*2.4	A21-000007---	/
16	125	Tube 5.6*2.4	A21-000007---	/
11	590	PU tube 4*2.5	M6G-020046---	/
13	550	PU tube 4*2.5	M6G-020046---	/
15	550	PU tube 4*2.5	M6G-020046---	/
17	550	PU tube 4*2.5	M6G-020046---	/
18	90	Silicone tube 25*20	M6G-020018---	/
21	225/60	PU tube 10*7	082-000519-00	The length is 60mm when separate ACGO is configured.
22	225/150	PU tube 10*7	082-000519-00	The length is 150mm when ACGO is not configured.
23	240	Silicone tube 25*20	M6G-020018---	/
82	65	Tube 5.6*2.4	A21-000007---	/
27	125	Silicone tube 25*20	M6G-020018---	/
28	100	PU tube 10*7	082-000519-00	Only available when separate ACGO is configured.
29	80	MPF tube 2*3.5	M6G-020005---	Only available when AG module is configured.
Select the following tubes when ACGO straight connector (with ACGO pressure monitoring) is configured				
94	150	Tube 5.6*2.4	A21-000007---	/
95	230	Tube 5.6*2.4	A21-000007---	/
97	750	PU tube 4*2.5	M6G-020046---	/

Notes:

1. When a tube whose length is ≥300mm is selected, the tolerance requirement is ±10mm. When a tube whose length is ≤300mm is selected, the tolerance requirement is ±5mm.
2. Y1 indicates connector: StraightReduction,1/8"&3/32"ID,P/N:M90-100027---
3. Y2 indicates connector: Tube to Tube right angle connector 3102-10-00,P/N:M6Q-030082---
4. Y3 indicates connector: connector.Y,200Barb,1/8"ID,White Nylon,P/N:M90-100030---

6.4.2.2 Pneumatic Connection B: Pneumatic Connections (O2, N2O and Air supplies, gas cylinders, O2 drive gas)

Connection Diagram



Tubing

0616 tube No. reference table (configured with O2, N2O and Air supplies, cylinders, and O2 as the drive gas)				
Tube No.	**Length (mm)**	**DiameterΦ(mm)**	**P/N**	**Remark**
25	600	PU tube 8*5.5	M6G-020045---	/
39	510/380	PU tube 4*2.5	M6G-020046---	The length is 510mm for European standard and 380mm for American standard/American European standard.
40	420	PU tube 4*2.5	M6G-020046---	/
41	440/570	PU tube 4*2.5	M6G-020046---	The length is 440mm for European standard and 570mm for American standard/American European standard.
42	120/60	PU tube 6*4	M6G-020026---	The length is 60mm when auxiliary O2 supply assembly is configured.
43	160	PU tube 6*4	M6G-020026---	/
44	620	PU tube 6*4	M6G-020026---	/
45	200	PU tube 6*4	M6G-020026---	/
46	110	PU tube 6*4	M6G-020026---	/
47	210	PU tube 6*4	M6G-020026---	/
48	300	PU tube 4*2.5	M6G-020046---	/
49	280	PU tube 4*2.5	M6G-020046---	/
50	280	PU tube 6*4	M6G-020026---	/
51	280	PU tube 6*4	M6G-020026---	/
52	250/75	PU tube 6*4	M6G-020026---	The length is 75mm when ACGO is not configured.
53	630	PU tube 8*5.5	M6G-020045---	/
54	280	PU tube 8*5.5	M6G-020045---	/
55	460	PU tube 6*4	M6G-020026---	/
56	60	PU tube 6*4	M6G-020026---	Only available when auxiliary O2 supply is configured.
57	380	PU tube 6*4	M6G-020026---	Only available when auxiliary O2 supply is configured.
58	200	PU tube 8*5.5	M6G-020045---	/
60	150	PU tube 8*5.5	M6G-020045---	/
62	120	PU tube 8*5.5	M6G-020045---	/
63	70	PU tube 8*5.5	M6G-020045---	/
64	70	PU tube 8*5.5	M6G-020045---	/
65	100	PU tube 8*5.5	M6G-020045---	/

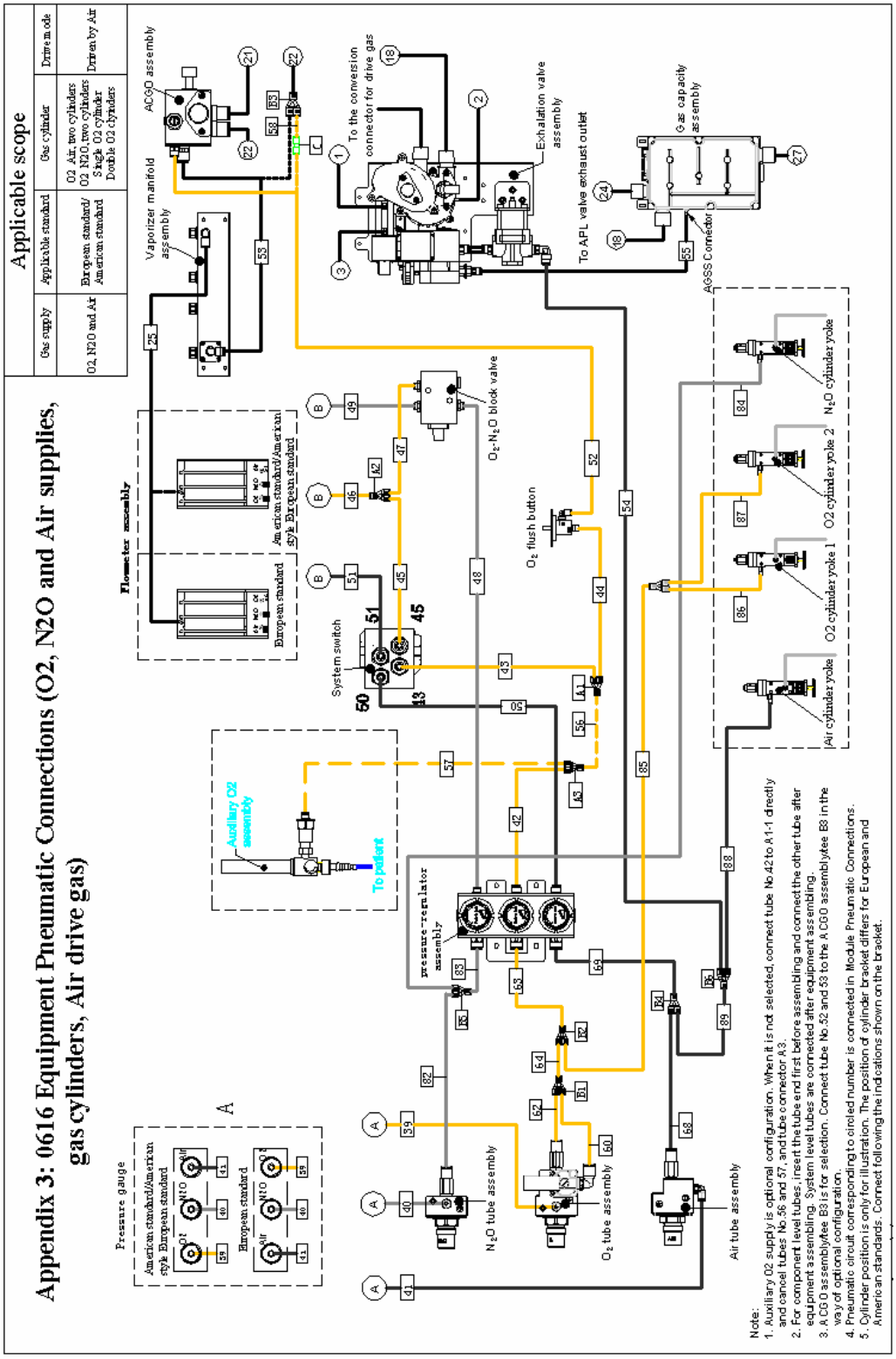
Select the following tubes when O2 and Air cylinders are configured				
68	280	PU tube 8*5.5	M6G-020045---	/
69	100	PU tube 8*5.5	M6G-020045---	/
85	300/230	PU tube 8*5.5	M6G-020045---	The length is 300mm for European standard and 230mm for American standard/American European standard.
88	125/240	PU tube 8*5.5	M6G-020045---	The length is 125mm for European standard and 240mm for American standard/American European standard.
Select the following tubes when O2 and N2O cylinders are configured				
82	300	PU tube 8*5.5	M6G-020045---	/
83	100	PU tube 8*5.5	M6G-020045---	/
84	270/370	PU tube 8*5.5	M6G-020045---	The length is 270mm for European standard and 370mm for American standard/American European standard.
85	300/230	PU tube 8*5.5	M6G-020045---	The length is 300mm for European standard and 230mm for American standard/American European standard.
Select the following tubes when only one O2 cylinder is configured				
85	300/230	PU tube 8*5.5	M6G-020045---	The length is 300mm for European standard and 230mm for American standard/American European standard.
Select the following tubes when two O2 cylinders are configured				
85	80	PU tube 8*5.5	M6G-020045---	/
86	135	PU tube 8*5.5	M6G-020045---	/
87	205	PU tube 8*5.5	M6G-020045---	/

Notes:

1. When N2O cylinder is not configured, connect the N2O supply inlet assembly directly to the pressure regulator assembly. The tubes used and their Nos. are same to those in Appendix 2 (tube No.: 61#, tube length: 460±10mm, diameter: 8*5.5).
2. When Air cylinder is not configured, connect the Air supply inlet assembly directly to the pressure regulator assembly. The tubes used and their Nos. are same to those in Appendix 2 (tube No.: 66#, tube length: 380±10mm, diameter: 8*5.5).
3. When only one O2 cylinder is configured, insert tube 85# directly into the connector of O2 cylinder yoke 1.
4. A indicates connector: Tube to Tube Y piece 3140-06-00,P/N:M6Q-030024---, indicated by A1 and A2 in the diagram.
5. B indicates connector: Tube to Tube Y piece 3140-08-00,P/N:M6Q-030025--, indicated by B1 and B2 in the diagram (P/N of B3 is 082-000448-00).
6. C and C2 indicate connector: different diameter Tube to Tube, straight connector, 3106-06-08,P/N:M6Q-030051---

6.4.2.3 Pneumatic Connection C: Pneumatic Connections (O2, N2O and Air supplies, gas cylinders, Air drive gas)

Connection Diagram



Tubing

0616 tube No. reference table (configured with O2, N2O and Air supplies, cylinders, and Air as the drive gas)				
Tube No.	**Length (mm)**	**DiameterΦ(mm)**	**P/N**	**Remark**
25	600	PU tube 8*5.5	M6G-020045---	/
39	510/380	PU tube 4*2.5	M6G-020046---	The length is 510mm for European standard and 380mm for American standard/American European standard.
40	420	PU tube 4*2.5	M6G-020046---	/
41	440/570	PU tube 4*2.5	M6G-020046---	The length is 440mm for European standard and 570mm for American standard/American European standard.
42	120/60	PU tube 6*4	M6G-020026---	The length is 60mm when auxiliary O2 supply assembly is configured.
43	160	PU tube 6*4	M6G-020026---	/
44	620	PU tube 6*4	M6G-020026---	/
45	200	PU tube 6*4	M6G-020026---	/
46	110	PU tube 6*4	M6G-020026---	/
47	210	PU tube 6*4	M6G-020026---	/
48	300	PU tube 4*2.5	M6G-020046---	/
49	280	PU tube 4*2.5	M6G-020046---	/
50	280	PU tube 6*4	M6G-020026---	/
51	280	PU tube 6*4	M6G-020026---	/
52	250/75	PU tube 6*4	M6G-020026---	The length is 75mm when ACGO is not configured.
53	630	PU tube 8*5.5	M6G-020045---	/
54	280	PU tube 8*5.5	M6G-020045---	/
55	460	PU tube 6*4	M6G-020026---	/
56	60	PU tube 6*4	M6G-020026---	Only available when auxiliary O2 supply is configured.
57	380	PU tube 6*4	M6G-020026---	Only available when auxiliary O2 supply is configured.
58	200	PU tube 8*5.5	M6G-020045---	/
60	150	PU tube 8*5.5	M6G-020045---	/
62	120	PU tube 8*5.5	M6G-020045---	/
63	70	PU tube 8*5.5	M6G-020045---	/
64	135	PU tube 8*5.5	M6G-020045---	/

68	280	PU tube 8*5.5	M6G-020045---	/
69	100	PU tube 8*5.5	M6G-020045---	/
Select the following tubes when O2 and Air cylinders are configured				
85	300/230	8*5.5	M6G-020045---	The length is 300mm for European standard and 230mm for American standard/American European standard.
88	120/290	8*5.5	M6G-020045---	The length is 120mm for European standard and 290mm for American standard/American European standard.
89	120	8*5.5	M6G-020045---	/
Select the following tubes when O2 and N2O cylinders are configured				
82	280	8*5.5	M6G-020045---	/
83	85	8*5.5	M6G-020045---	/
84	270/370	PU tube 8*5.5	M6G-020045---	The length is 270mm for European standard and 370mm for American standard/American European standard.
85	300/230	8*5.5	M6G-020045---	The length is 300mm for European standard and 230mm for American standard/American European standard.
elect the following tubes when only one O2 cylinder is configured				
85	300/230	8*5.5	M6G-020045---	The length is 300mm for European standard and 230mm for American standard/American European standard.
Select the following tubes when two O2 cylinders are configured				
85	80	8*5.5	M6G-020045---	/
86	135	8*5.5	M6G-020045---	/
87	205	8*5.5	M6G-020045---	/

Notes:

1. When N2O cylinder is not configured, connect the N2O supply inlet assembly directly to the pressure regulator assembly. The tubes used and their Nos. are same to those in Appendix 2 (tube No.: 61#, tube length: 460±10mm, diameter: 8*5.5).
2. When Air cylinder is not configured, insert tube 54# into B4-3 directly.
3. When only one O2 cylinder is configured, insert tube 85# directly into the connector of O2 cylinder yoke 1.
4. A indicates connector: Tube to Tube Y piece 3140-06-00,P/N:M6Q-030024---, indicated by A1 and A2 in the diagram.
5. B indicates connector: Tube to Tube Y piece 3140-08-00,P/N:M6Q-030025--, indicated by B1 and B2 in the diagram (P/N of B3 is 082-000448-00).
6. C and C2 indicate connector: different diameter Tube to Tube, straight connector, 3106-06-08,P/N:M6Q-030051---.