GE Healthcare

# ZY9100 Anesthesia Machine
## Technical Reference Manual

# ZY9100 Anesthesia Machine

# Important

The information contained in this technical reference manual pertains only to those models of products which are marketed by GE Healthcare as of the effective date of this manual or the latest revision thereof. This Technical Reference manual was prepared for exclusive use by GE Healthcare service personnel in light of their training and experience as well as the availability to them of parts, proper tools and test equipment. Consequently, GE Healthcare provides this Technical Reference manual to its customers purely as a business convenience and for the customer's general information only without warranty of the results with respect to any application of such information. Furthermore, because of the wide variety of circumstances under which maintenance and repair activities may be performed and the unique nature of each individual's own experience, capacity, and qualifications, the fact that customer has received such information from GE Healthcare does not imply in any way that GE Healthcare deems said individual to be qualified to perform any such maintenance or repair service. Moreover, it should not be assumed that every acceptable test and safety procedure or method, precaution, tool, equipment or device is referred to within, or that abnormal or unusual circumstances, may not warrant or suggest different or additional procedures or requirements.

This manual is subject to periodic review, update and revision. Customers are cautioned to obtain and consult the latest revision before undertaking any service of the equipment. Comments and suggestions on this manual are invited from our customers. Send your comments and suggestions to the Manager of Technical Communications, GE Healthcare, Ohmeda Drive, PO Box 7550, Madison, Wisconsin 53707.

**CAUTION** Servicing of this product in accordance with this technical reference manual should never be undertaken in the absence of proper tools, test equipment and the most recent revision to this service manual which is clearly and thoroughly understood.

# Technical Competence

The procedures described in this technical reference manual should be performed by trained and authorized personnel only. Maintenance should only be undertaken by competent individuals who have a general knowledge of and experience with devices of this nature. No repairs should ever be undertaken or attempted by anyone not having such qualifications.

GE Healthcare strongly recommends using only genuine replacement parts, manufactured or sold by GE Healthcare for all repair parts replacements.

Read completely through each step in every procedure before starting the procedure; any exceptions may result in a failure to properly and safely complete the attempted procedure.

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# 1 Introduction

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# 1.1 What this manual includes

This manual covers the service information for the ZY9100 anesthesia machine and ventilator. It details the following components:

- Ventilator
- Gas delivery
- Breathing system
- Frame

## 1.2 Standard service procedures

### 1.2.1 User's Reference Manual

Some sections of this manual refer you to the User's Reference Manual for the ZY9100 anesthesia machine. To expedite repairs, you must have and be familiar with the User's Reference Manual.

Refer to the User's Reference Manual for further information about the operation of the system.

### 1.2.2 Software versions

The revision level is displayed on the ventilator startup menu. This manual includes test and calibration procedures for Revision 3.x software.

### 1.2.3 Ventilator tests

Service calibration functions let GE Healthcare trained users and service personnel perform ventilator setup functions, tests, calibration, and measurements from the front panel display.

Normal operational tests, calibration, and troubleshooting can be performed on your ventilator without removing components from the system. Repair may require removing the ventilator components from the anesthesia machine.

**WARNING** Section 4, "Service Tests and Calibration" must be performed whenever an internal component of the ventilator is accessed to verify that all critical parts of the ventilator are still operational and within specification.

**WARNING** After the ventilator has been serviced, perform Section 3 "Checkout Procedure" to verify the entire Anesthesia System is functioning properly before the system can be returned to clinical use.

# 1.3 What is a ZY9100?

The ZY9100 anesthesia machine is developed and manufactured by GE Healthcare. It is a mobile anesthesia machine with anesthesia, respiration, and monitoring integrated in a single unit. It can be used to perform closed circuit or semi-closed circuit anesthesia and respiration control for children and adults.

**Note** Configurations available for this product depend on local market and standards requirements. Illustrations in this manual may not represent all configurations of the product. The ZY9100 product is not suitable for use in an MRI environment.

# 1.4 Configuration options

## 1.4.1 Standard configuration

The standard configuration includes the following items:

- Ventilator
- Vaporizer manifold (two vaporizer connections)
- Serial Interface - RS232
- Three large drawers
- Breathing circuit

## 1.4.2 Options

Options include the following items:

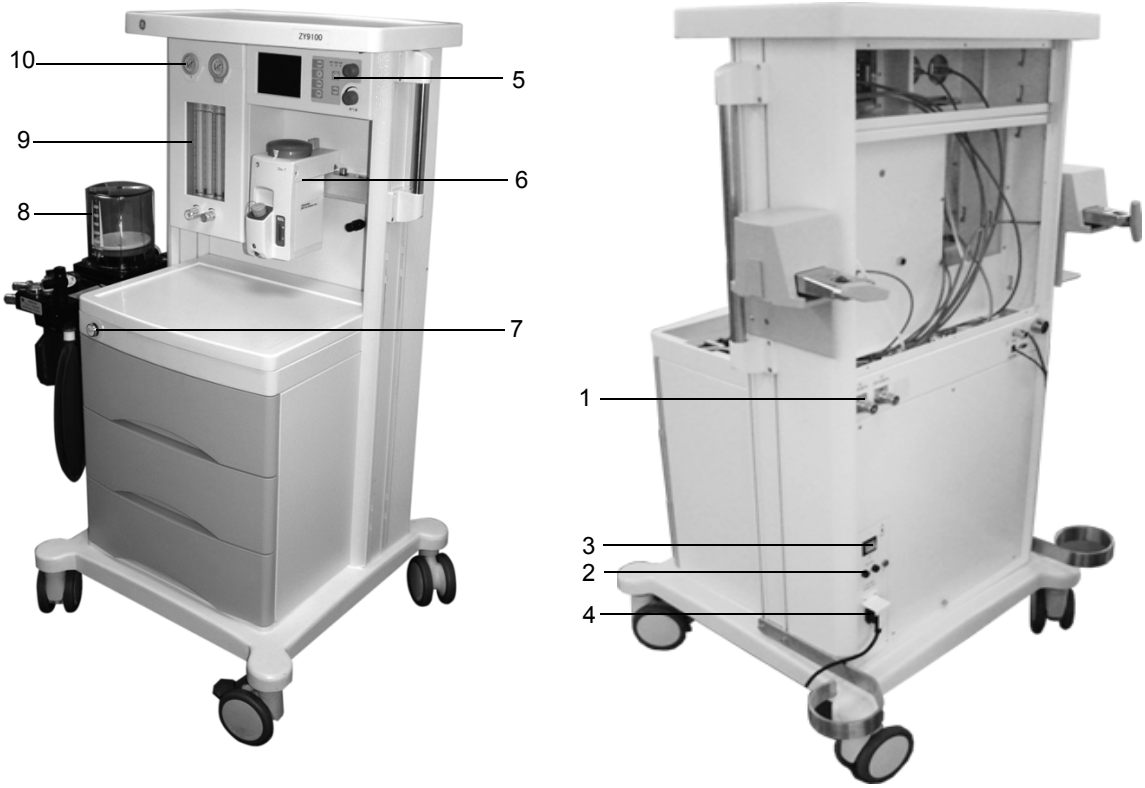
- Gas cylinder configurations:
  No cylinders
  One $O_2$ cylinder
  Two $O_2$ cylinders
  One $O_2$ and one $N_2O$ cylinder

**Note** If configured for cylinders, one $O_2$ is always required (cannot have two $N_2O$ cylinders.

- Gas scavenging (adjustable passive)

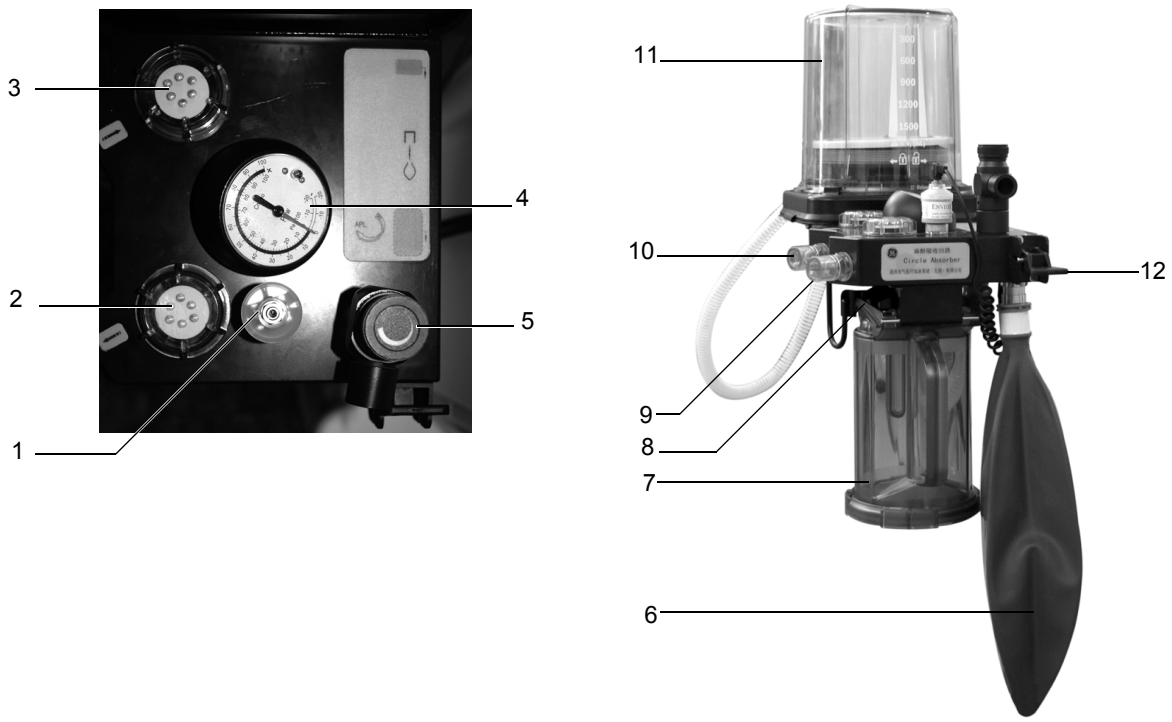
| Model | Vaporizer Equipped |
|---|---|
| ZY9100A1 | One enflurane or isoflurane |
| ZY9100A2 | One enflurane and one isoflurane |
| ZY9100B1 | One enflurane or one isoflurane |
| ZY9100B2 | One enflurane and one isoflurane |

# 1.5 System components



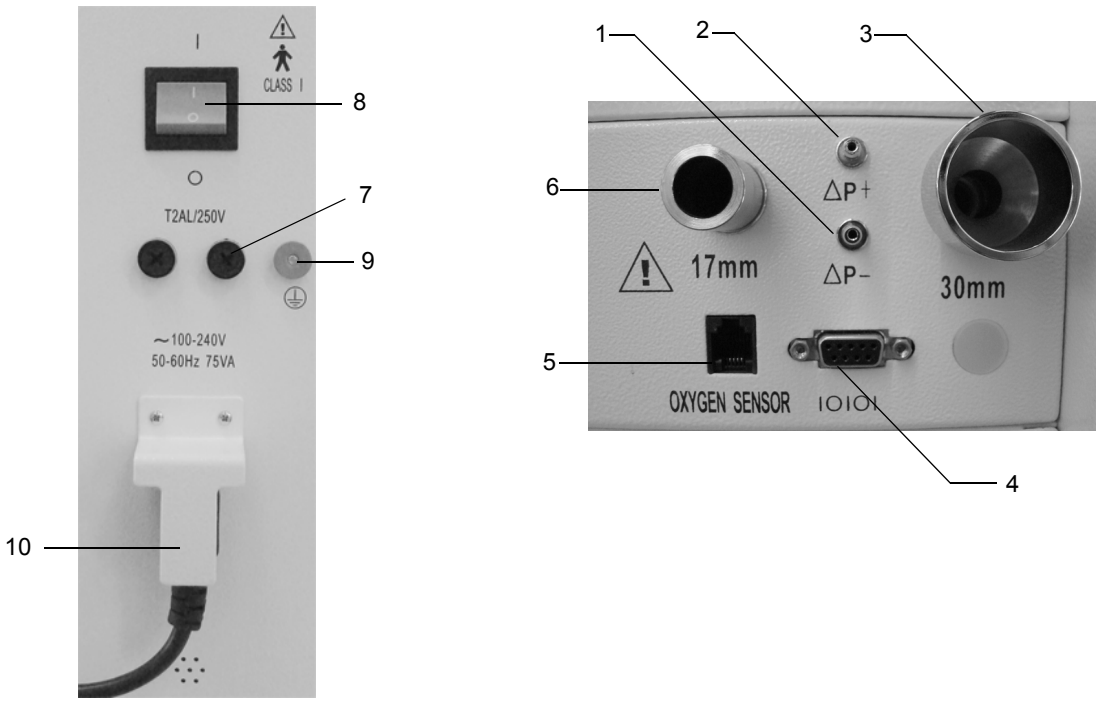

1. Pipeline gas inlet port(s)
2. Fuse sockets
3. Power switch
4. Mains power inlet
5. System display
6. Vaporizer(s)
7. $O_2$ flush button
8. Breathing system
9. Flowmeters/flowtubes
10. Pressure gauge

*Figure 1-1 • ZY9100 Anesthesia Machine*




1. $O_2$ sensor
2. Inspiratory check valve
3. Expiratory check valve
4. Airway pressure gauge
5. APL (adjustable pressure limiting) valve
6. Manual ventilation bag
7. Absorber canister
8. Canister release
9. Inspiratory port
10. Expiratory port
11. Bellows assembly
12. Manual/Mechanical ventilation switch

*Figure 1-2 • ZY9100 Breathing System*




1. Flow transducer and patient airway pressure transducer port
2. Flow transducer and patient airway pressure transducer port
3. Exhaust gas outlet
4. Communications port
5. $O_2$ sensor socket
6. Drive gas port
7. Fuse sockets
8. Power switch
9. Equipotential connector
10. Mains power inlet

*Figure 1-3 • ZY9100 Rear Panels*

## 1.6 Symbols used in the manual or on the equipment

Warnings and cautions tell you about the dangerous conditions that can occur if you do not follow all instructions in this manual. Read and follow all warnings and cautions carefully.

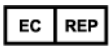
**WARNING** Warnings tell about a condition that can cause injury to the operator or the patient.

**CAUTION** Cautions tell about a condition that can cause damage to the equipment.

A Note provides additional information, tips and recommendations.

Other symbols replace words on the equipment or in manuals. No one device uses all of the symbols. These symbols include:

| | | | |
|---|---|---|---|
|  | ON (power) |  | OFF (power) |
|  | Lock |  | Unlock |
|  | Menu |  | Alarm silence |
| **FREQ** | Breathing frequency | **I:E** | Inspiratory-Expiratory Rate |
|  | Inspiratory flow |  | Expiratory flow |
| $O_2$% | $O_2$ sensor connection | $O_2$+ | $O_2$ flush button |
|  | Manual ventilation mode |  | Mechanical ventilation mode |
|  | Type B equipment |  | Equipotential |
|  | Direct current |  | Alternating current |

| | | | |
|---|---|---|---|
|  | Earth ground |  | Frame or chassis ground |
|  | Protective earth ground |  | Fuse |
|  | Read top of the float | 134°C | Autoclavable |
|  | Serial Number |  | Stock number |
|  | Systems with this mark agree with the European Council directive (93/42/EEC) for Medical Devices when they are used as specified in their User's Reference manuals. The xxx is the certification number of the Notified Body used by GE Healthcare's Quality Systems. |  | Indicates that the waste of electrical and electronic equipment must not be disposed as unsorted municipal waste and must be collected separately. Please contact an authorized representative of the manufacturer for information concerning the decommissioning of equipment. |
|  | Manufacturer |  | Date of manufacture |
|  | GOST R Russian certification |  | Authorized representative of the European Community |
|  | Attention, refer to product instructions, IEC 60601-1 |  | Caution, ISO 7000-0434 |

# 2 Theory of Operation

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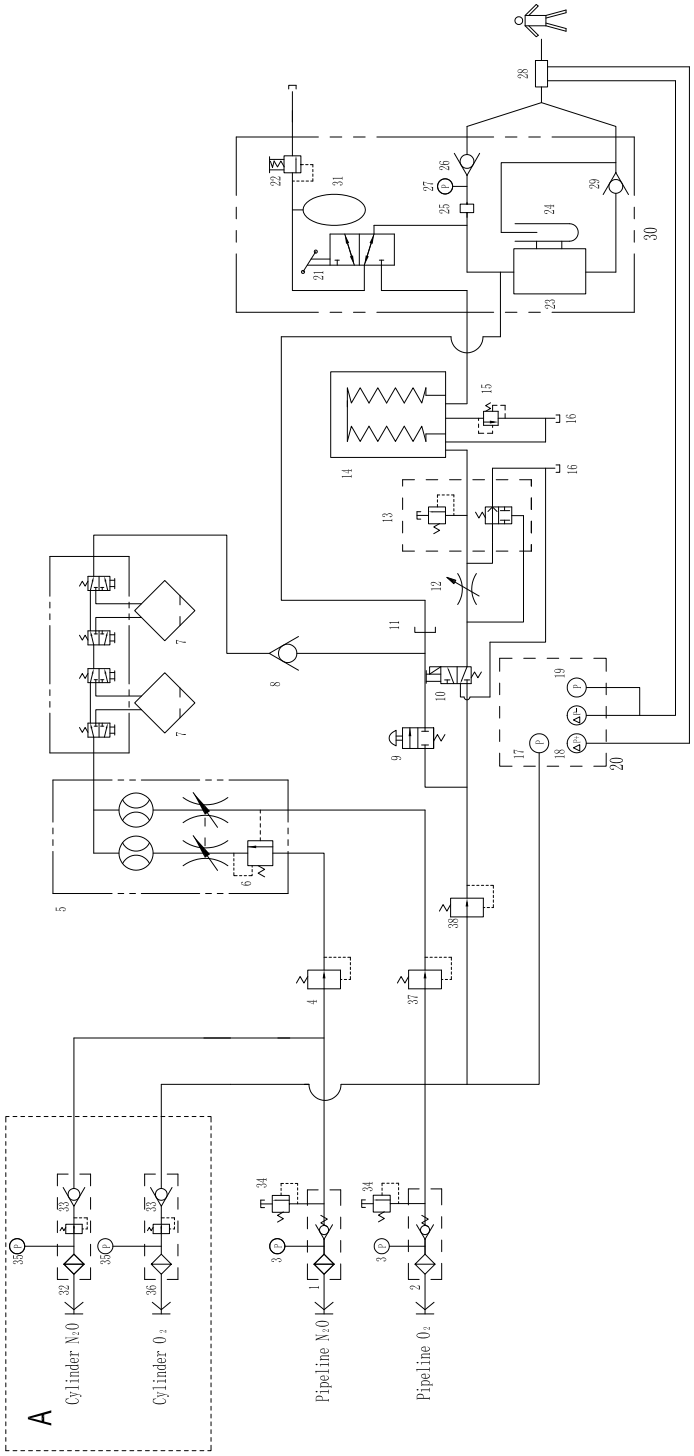
# 2.1 Theory overview

This section describes:

- The flow of gas through the anesthesia machine.
- The flow of gas through the breathing system.
- Electrical connections and the function of electrical components.
- RS-232 communication protocol.

# 2.2 Gas flow through the anesthesia machine



1. $N_2O$ pipeline inlet
2. $O_2$ pipeline inlet
3. Pipeline airway pressure gauge
4. $N_2O$ pressure regulator
5. Flow control and mixer
6. $O_2$ proportional control (balance regulator)
7. Vaporizers
8. Fresh gas Check valve
9. $O_2$ flush valve
10. Solenoid valve
11. Fresh gas outlet
12. $V_T$ control valve
13. Exhalation valve
14. Bellows assembly
15. Pop-off valve
16. Drive gas exhaust
17. Gas inlet pressure transducer
18. Flow sensor
19. Paw transducer
20. Control board
21. Manual/mechanical ventilation switch
22. APL valve
23. Absorber canister
24. Reservior
25. $O_2$ sensor
26. Inspiratory check valve
27. Pressure guage
28. Flow sensor adapter
29. Expiratory check valve
30. Breathing circuit
31. Manual ventilation bag
32. $N_2O$ cylinder gas inlet valve
33. Check valve
34. Safety pressure relief valve
35. Cylinder gas pressure guage
36. $O_2$ cylinder gas inlet valve
37. Cylinder pressure regulator
38. Drive gas pressure regulator

*Figure 2-1 • ZY9100 System pneumatic diagram*

## 2.2.1 Overview

### Gas supplies

Gas enters the system through a pipeline or cylinder connection. All connections have indexed fittings, filters, and check (one-way) valves. Gauges show the cylinder and pipeline pressures.

A regulator decreases the cylinder pressures to the appropriate system pressure. A pressure relief valve helps protect the system from high pressures.

To help prevent problems with the gas supplies:

- Install yoke plugs on all empty cylinder connections.
- When a pipeline supply is connected, keep the cylinder valve closed.

### $O_2$ flow

O2 is supplied by regulated gas cylinders or the medical gas pipelines in the hospital.A low-pressure regulator decreases the pressure for the flush valve.

When pushed, the flush valve supplies high flows of $O_2$ to the common gas outlet.

A low-pressure regulator supplies a constant $O_2$ pressure to the flow control valve.

A sensor on the main board monitors the $O_2$ supply pressure. If the pressure is too low, an alarm appears on the ventilator.

### $N_2O$

A hypoxic guard on the N2O and O2 flow control helps keep the O2 concentration higher than 25% at the common gas outlet.

A balance regulator controls the flow of $N_2O$ to the flow control valve. Oxygen pressure at a control port adjusts the output of the regulator. This stops flow during an $O_2$ supply failure and ensures that the hypoxic gas pressures decrease with the $O_2$ supply pressure.

### Mixed gas

The mixed gas goes from the flowmeter outlet through the vaporizer that is in use, through the common gas check valve, to the common gas outlet, and into the breathing system. A pressure relief valve is located between the common gas check valve and the common gas outlet to prevent the delivery of high pressures to the breathing system.

## 2.2.2 Power switch

The power switch has two positions: On and Off.

**In the Off position**

The switch:

- Turns off the ventilator (electrical).

**In the On position**

The switch:

- Turns on the ventilator (electrical).

### 2.2.3 Flow control

Needle valves (one for each gas) adjust gas flow. Clockwise rotation decreases flow. Counterclockwise increases flow. A hypoxic guard system sets the maximum ratio of $N_2O$ to $O_2$.

**WARNING** The hypoxic guard sets a minimum $O_2$ concentration in the common gas stream.

### 2.2.4 Hypoxic guard system

The hypoxic guard is an internal system that is not serviceable. It helps control an approximate minimum 1 to 3 ratio of flow between $O_2$ and $N_2O$. When engaged the $O_2$ and $N_2O$ knobs turn together:

- An increase in $N_2O$ flow causes an increase in $O_2$ flow.
- A decrease in $O_2$ flow causes a decrease in $N_2O$ flow.

Higher concentrations of $O_2$ are possible when the hypoxic guard is not engaged: either by reducing the $N_2O$ flow below the point of engagement or by increasing $O_2$ flow above the point of engagement.

When the $N_2O$ flow is below the point of engagement, increasing the $N_2O$ flow turns the $O_2$ sprocket without changing the $O_2$ flow. Once the guard is engaged, turning the $N_2O$ flow control counterclockwise (increase in $N_2O$ flow) also turns the $O_2$ knob counterclockwise (increase in $O_2$ flow) to maintain a nominal 25% minimum $O_2$ concentration.

Decreasing the $N_2O$ flow from the engagement point rotates the $O_2$ sprocket away from the tab on the $O_2$ knob, increasing the $O_2$ flow.

# 2.3 Flow through the breathing system

## 2.3.1 Overview of flow paths

This section looks at three types of flow paths. Refer to Figure 2-1 for a graphic representation.

- **Ventilation paths:** How gas flows from the drive source (bag or bellows) to and from the patient.
- **Common gas paths:** Common gas can flow from the machine interface directly to the patient through the inspiratory check valve, or through the absorber into the expiratory flow.
- **Scavenged gas paths:** APL or pop-off valve.

## 2.3.2 Manual ventilation

### Manual inspiration

The Manual/Mechanical ventilation switch on the breathing system closes the ventilator path. Manual ventilation must be selected on the display as well.

Gas flows from the bag into the breathing circuit module, and through a unidirectional valve (inspiratory check valve) to the patient.

During inspiration, common gas flows from the machine into the inspiratory limb, upstream of the inspiratory check valve.

### Manual exhalation

The Manual/Mechanical ventilation switch on the breathing system keeps the ventilator path closed. Manual ventilation must be selected on the display as well.

Gas flows from the patient, through the absorber, through a unidirectional valve (expiratory check valve), and into the bag.

During exhalation, common gas flows backwards through the Manual/Mechanical ventilation switch into the bag.

### APL valve

The APL valve sets a pressure limit for manual ventilation.

As the APL knob is turned, it puts more or less force on the APL disc and seat. If the circuit pressure is too high, the disc and seat inside the diaphragm opens and vents gas to the scavenging system.

## 2.3.3 Mechanical ventilation

### Mechanical inspiration

The Manual/Mechanical ventilation switch on the breathing system closes the manual path. Pilot pressure closes the exhalation valve. Mechanical ventilation must be selected on the display as well.

Drive gas pushes down on the outside of the bellows. Gas flows from the inside of the bellows, through the absorber, and through a unidirectional valve (inspiratory check valve) to the patient.

During inspiration, common gas flows into the inspiratory limb, upstream of the inspiratory check valve.

### Mechanical exhalation

The Manual/Mechanical ventilation switch on the breathing system keeps the manual path closed. Drive gas flow stops and the exhalation valve opens. Exhaled gas flows from the patient, through a unidirectional valve (expiratory check valve), through the absorber, and into the bellows. Residual drive gas flows out of the bellows housing to the scavenging system.

During exhalation, common gas flows backwards through the Manual/Mechanical ventilation switch into the bellows.

### Pop-off valve

The pop-off valve limits the pressure inside the bellows to 2.5 $cmH_2O$ above the drive gas pressure. This normally occurs when the bellows reaches the top of the housing at the end of exhalation.

Excess gas vents to the scavenging port through the pop-off valve and the exhalation valve.

# 2.4 ZY9100 Ventilator

The ZY9100 Ventilator is a microprocessor based, electronically-controlled, pneumatically-driven ventilator with built in monitoring systems for inspired oxygen, airway pressure and exhaled volume. The ventilator is designed to be used as a medical device assisting in the delivery of anesthesia and is part of the ZY9100 Anesthesia Machine.

## 2.4.1 Features

- Sensors in the breathing circuit are used to monitor patient ventilation and measure inspired oxygen concentration.
- User settings and microprocessor calculations control breathing patterns.
- Mechanical ventilation is started by pushing the bellows key on the display and selecting the bellows with the Manual/Mechanical ventilation switch on the breathing system.
- An RS-232 serial digital communications port connects to and communicates with external devices.

## 2.4.2 Safety features

- Airway overpressure protection linked to the high Paw setting.
- Volume over-delivery limits.
- Proprietary hose connections and fixed manifolds.
- 150 psi burst overpressure protection.

# 2.5 ZY9100 Ventilator components

Components of the ventilator are found in different locations on the anesthesia machine. The ventilator package consists of:

- Ventilator display
- Pneumatic engine
- Ventilator control electronics
- Ventilator power supply

## 2.5.1 Ventilator control electronics

The ventilator power supply components are found in the electrical enclosure at the back of the machine.

The ventilator power supply components include a 24 volt power supply, charge board, and batteries.

The power supply receives AC power from the machine's AC Inlet module through inline fuses, and a separate line filter. It converts AC power to DC power that feeds into the charge board.

All the power necessary to operate the ventilator and light package comes from the power circuits. The digital circuits control the operation of the ventilator.

Two 12 volt batteries provide backup power to operate the ventilator in case of mains power failure.

## 2.5.2 Control panel and display

The control panel on the ZY9100 Ventilator is mounted above the mounting brackets for the vaporizer. The ventilator display includes five submodules:

- The color liquid crystal display
- The keyboard front panel
- A rotary encoder (control knob)
- Inspiratory flow adjustment knob

*Figure 2-2 • ZY9100 Display module*

The keyboard and rotary encoder are used to control the operation of the ventilator. The front panel uses a three step — selection, change, and approve — setting scheme to prevent unwanted selections. The speaker on the rear panel supplies audio alarms to the operator.

Primary controls are: ventilation mode, I:E ratio, respiratory frequency (FREQ), and inspiratory flow ($V_T$).

## 2.5.3 Pneumatic vent engine

The pneumatic vent engine consists of:

- Solenoid valve
- Flow control needle valve ($V_T$)
- Exhalation/overpressure relief valve

The exhalation valve is usually open. During inspiration, gas pressure supplied by the solenoid valve causes the exhalation valve to close. During exhalation, the gas pressure is vented to scavenging allowing the exhalation valve to open.

If the pressure of the gas is more than 60 $cmH_2O$ the overpressure relief valve opens.

# 2.6 Electrical

The electrical systems perform their functions through the following printed circuit boards:

- Main board
- Charge board
- Alarm board
- Interface board
- Top light board
- Display board
- Indicator board
- Driver board
- Inverter board

The ZY9100 anesthesia machine electrical system consists of:

- Display — This provides the user interface to the ventilator software controls.
- Power — A switching power supply is used to convert 100-240VAC / 50Hz-60Hz mains power to 24V DC to power the ventilator and to charge the back-up batteries.

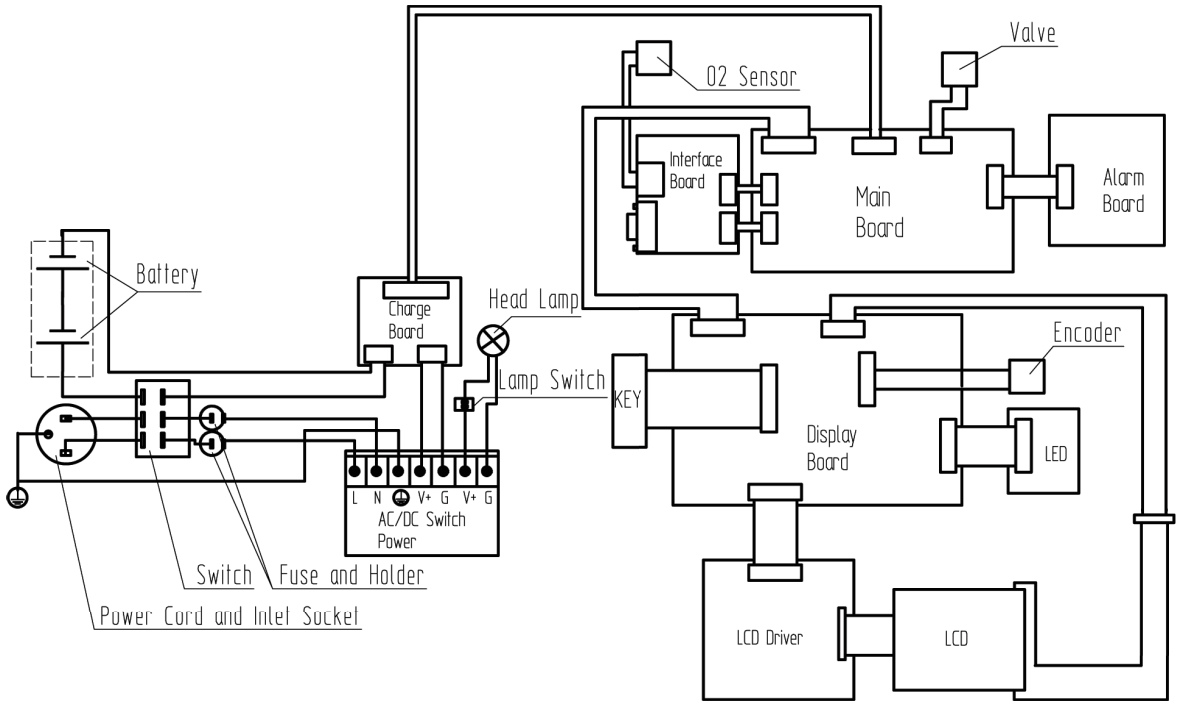
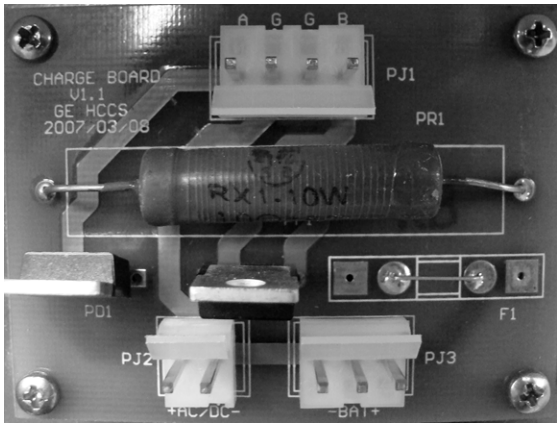



*Figure 2-3 • ZY9100 Electronic block diagram*

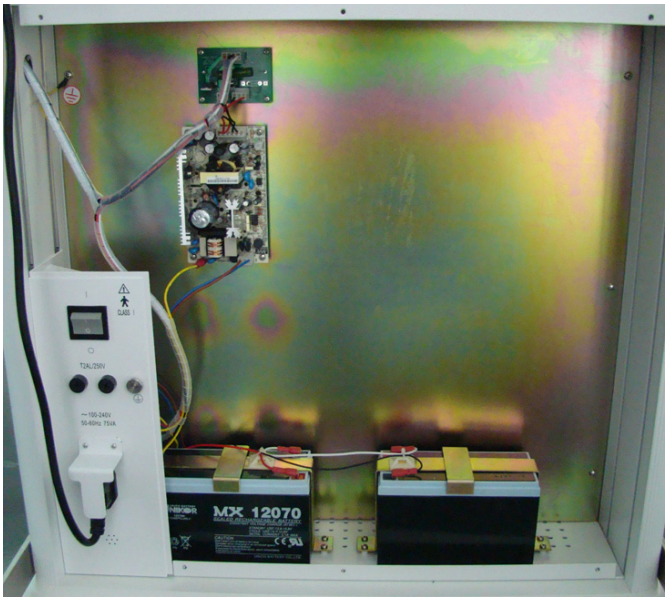
## 2.6.1 Power supply

ZY9100 machines use a universal power supply for AC to DC conversion. The conversion output supplies 27V DC. This is provided to the charge board and the task light board.

When connected to AC, the charge board provides power to the batteries and to the main board.




In case of AC supply loss, power is provided to the main board by the batteries through the charge board. Battery charge level is then shown on the display screen. The ventilator controls and alarms are powered by the battery, but the task light is not.



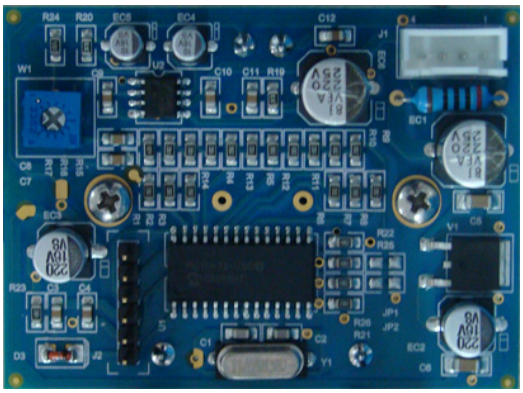
## 2.6.2 Alarm and signal switch

The alarm and data distribution functions are accomplished by the following:

- Alarm board
- Interface board

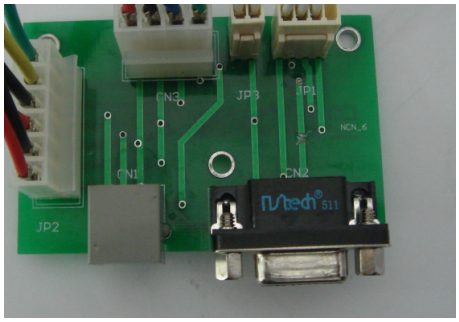
### Alarm board

The alarm board uses an oscillating circuit to generate audio alarms when they are received from the main board.



### Interface board

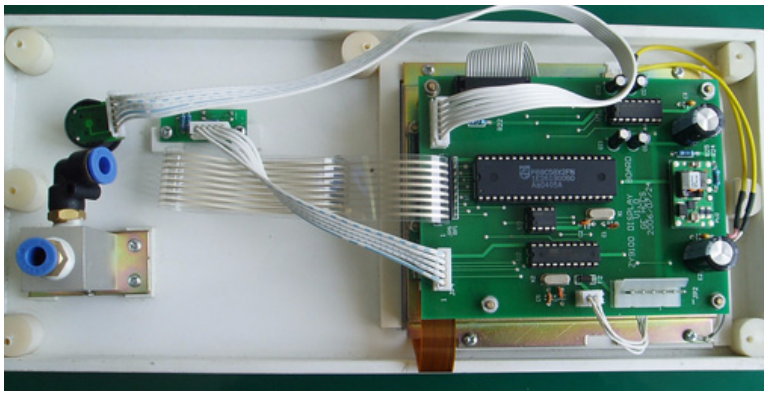
The interface board is used to distribute signals and provides an RS-232 communications port for the user. Refer to Section 2.8 for information on port protocol.



## 2.6.3 Display

The display provides the user interface. It consists of the following:

- LCD display
- Display board
- Inverter board (mounted under the display board)
- Indicator board
- Driver board (mounted under the display board)



The display board is connected to the control knob (encoder) and the main board.

The display is controlled by the driver board. The display board transmits information to the driver board, and the indicators are controlled by the display board.

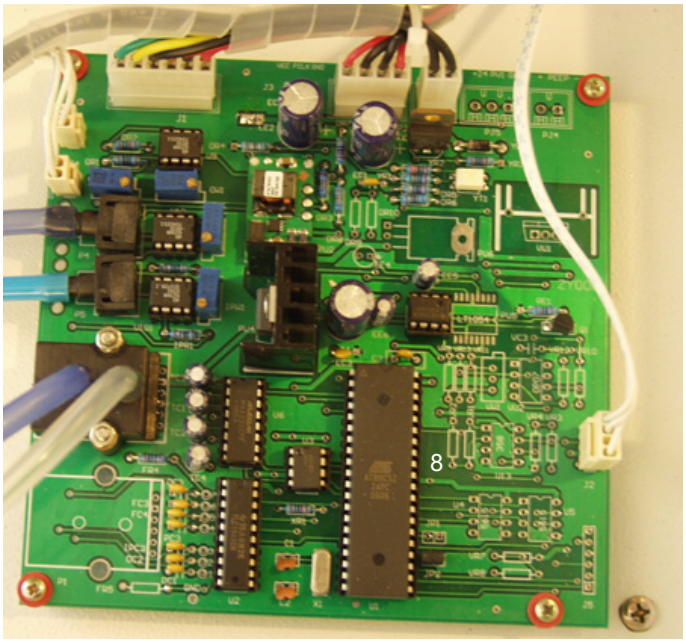
JP2 of the display board is connected to JP1 of the main board, and by using 89C58 it completes the transmission of signals with the main board through the RS-232 serial port.

## 2.6.4 Control

System control is performed by the main board.

The main board gathers and processes signals for flow, pressure, and $O_2$% through the A/D circuit. Based on the ventilator settings, it controls the solenoid valve through the D/A switch circuit. It transmits signals to the display through the RS-232 serial port at 9600 BAUD.

The airway pressure and oxygen supply are fed to the main board to monitor pressure. Connector interfaces with the display board provides power to the main board. This board interfaces with the task light.



# 2.7 Pneumatic subsystems

The mechanical subsystems for the ventilator include:

- Pressure regulator valve (4)
- Solenoid valve (7) and $V_T$ control valve (15)
- Safety pressure relief (18) and exhalation valve (19)
- Pop-off valve (20)

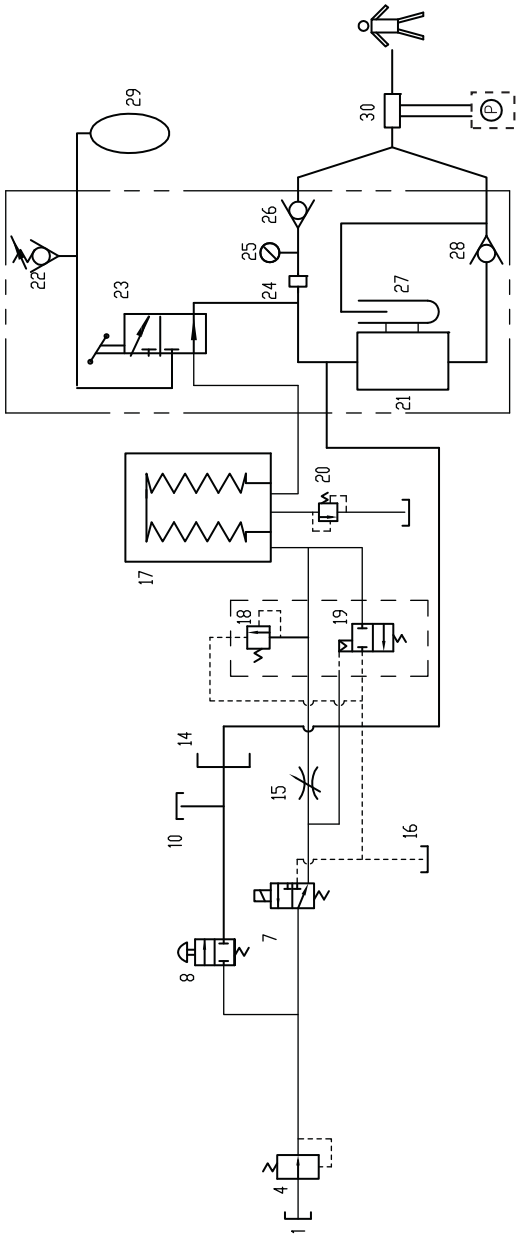
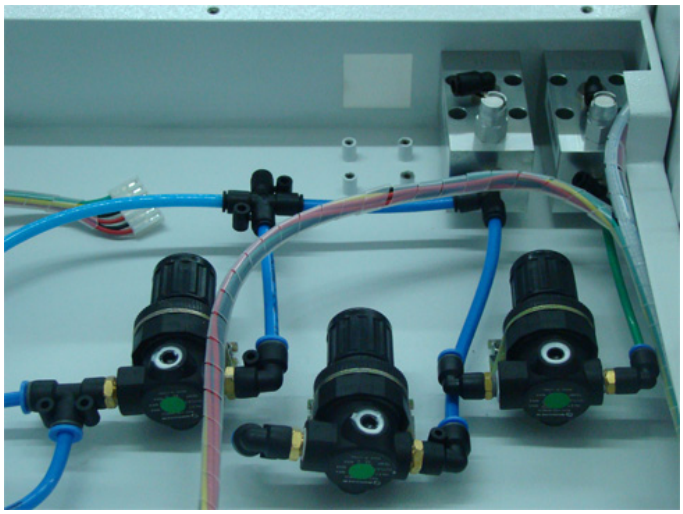



*Figure 2-4 • ZY9100 Ventilator mechanical subsystems*

## 2.7.1 Pressure regulators

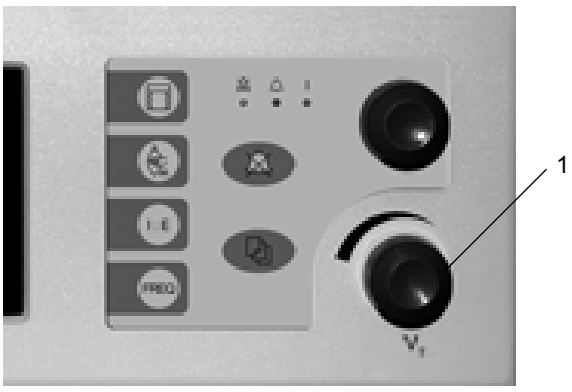
The ZY9100 contains up to three low-pressure regulators. One regulator supplies oxygen to the flowmeter assembly. A second regulator provides oxygen for the $O_2$ flush valve and the ventilator drive gas. If the machine includes nitrous oxide, the $N_2O$ regulator supplies gas to the flowmeter assembly.

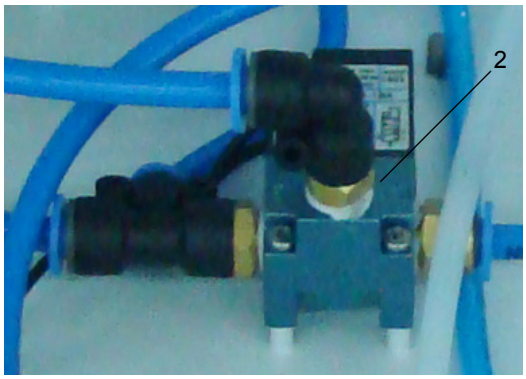


## 2.7.2 Solenoid valve and $V_T$ control valve

The $V_T$ control valve, located on the display module, is used to set the amount of drive gas delivered to the bellows housing through the exhalation/overpressure relief valve.

The solenoid valve is used to open and close the $O_2$ drive gas supply to the ventilator.




1. $V_T$ control valve
2. Solenoid valve

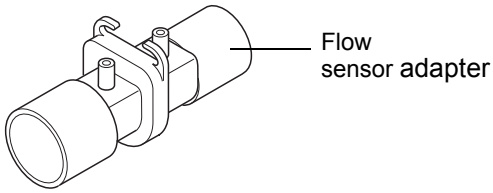
## 2.7.3 Pop-off valve

The bellows assembly is the connection between the drive gas and patient airway in the respiration system. The pop-off valve of the bellows assembly controls the pressure in the respiration circuit and discharges the excessive gas from the patient through the exhaust gas outlet.


The pop-off valve limits the pressure inside the bellows to 2.5 $cmH_2O$ above the drive gas pressure. This normally occurs when the bellows reaches the top of the housing at the end of exhalation.

## 2.7.4 Flow sensor adapter

The flow sensor adapter is installed at the patient's Y-piece connector. The flow sensor adapter monitors the expired $V_T$. When gas flows through the sensor adapter a pressure difference is generated between the two sides of the sensor diaphragm. The pressures are measured and interpreted on the main board in order to calculate the $V_T$ value. The tubes connected to the flow sensor adapter must be connected correctly in order for the volume data to be properly measured and displayed. The tube nearest the patient must be connected to the port marked "+" on the rear of the machine.



# 2.8 RS-232 Communication protocol

Communication of the display and control data is done through a serial port.

Set up of the serial port: 9600bps, 8 bit, 1 stop

Data set format: every set has 13 bytes

| D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

D0: The original sign of the set; fixed at 0AAH.

D1: Data set types:

- 03H refers to waveform, alarm data, and set parameters. this set is transmitted once every 50 ms.
- 04H refers to measured data. The set is transmitted 25 ms after the end of the respiration.

D11: Checkout value; D11 = (the sum of D1 to D10) or 0FH.

D12: The end sign of the set, fixed at 055H.

When D1 = 03H:

| | | |
|---|---|---|
| D2 | Pawi | Instantaneous airway pressure value (unit: hPa) |
| D3 | ALARM2 | Alarm byte 2 |
| D4 | FLOWi | Instantaneous flow value (unit: L/min) |
| D5 | VTi | Instantaneous tidal volume value (unit: 10mL1) |
| D6 | ALARM1 | Alarm byte 1 |
| D7 | O2 | Value of O2 concentration (unit: %) |
| D8 | STATUS | Status byte |
| D9 | PNO | Set parameter number |
| D10 | PVALUE | Set parameter value |

When D1 = 04H:

| | | |
|---|---|---|
| D2 | VT | Tidal volume measured value (unit: 10 ml) |
| D3 | MVH | Minute ventilation volume value (unit: 10 ml/min) |
| D4 | MVL | Minute ventilation volume value (unit: 10 ml/min) |
| D5 | PEAK | Peak airway pressure measure value (unit: hPa) |
| D6 | PMean | Mean pressure measured vlaue (unit: hPa) |
| D7 | PEEP | PEEP measured value (unit: hPa) |
| D8 | Pplat | Platform pressure measured value (unit: hPa) |
| D9 | CL | Compliance measured value (unit: L/kPa) |
| D10 | Freq | Frequency actual measured value (unit: times/ min) |

**Note** When M-904E, D4, D5, and D7 are not used.

When ZY9100, D5 is not used.

## Definition of STATUS

| | | |
|---|---|---|
| BIT0 | -- | Standby |
| BIT1 | -- | Standby |
| BIT2 | -- | Standby |
| BIT3 | -- | Standby |
| BIT4 | Trigger Flag | Trigger status symbol. 0 no trigger; 1 trigger. |
| BIT5 | PawSign | Airway pressure symbol. 0 for positive; 1 for negative. |
| BIT6 | FlowSign | Flow speed symbol. 0 for positive; 1 for negative. |
| BIT7 | IE Flag | Inhalation and exhalation status symbol. 0 for inhalation; 1 for exhalation. |

**Note** When M-904, BIT 4, BIT 5, and BIT 6 are not used.

## ALARM1 Definition

| | | |
|---|---|---|
| BIT0 | NOGAS | Insufficient gas source alarm. |
| BIT1 | AC Fail | AC failure alarm. |
| BIT2 | Battery Low | Low battery alarm. |
| BIT3 | Paw High | High Paw alarm. |
| BIT4 | Paw Low | Low Paw alarm. |
| BIT5 | VT High | High tidal volume alarm. |
| BIT6 | VT Low | Low tidal volume alarm. |
| BIT7 | O2 High | High O2% alarm. |

**Note** When M-904, BIT 5, BIT 6, and BIT 7 are not used.

## ALARM2 Definition

| | | |
|---|---|---|
| BIT0 | O2 Low | Low O2% alarm. |
| BIT1 | MV High | High minute ventilation value alarm. |
| BIT2 | MV Low | Low minute ventilation value alarm. |
| BIT3 | No O2 Sensor | No O2 sensor alarm. |
| BIT4 | Sustained Paw | Continuous high Paw alarm. |
| BIT5 | -- | Standby |
| BIT6 | -- | Standby |
| BIT7 | -- | Standby |

**Note** When M-904, BIT0, BIT1, BIT2, and BIT3 are not used.

## PNO definition

| Number | Description |
|---|---|
| 1 | FREQ: Respiration Frequency default value (unit: times/min). |
| 2 | RATIO: Inspiration and exhalation ratio set value x 10. If it is 20, it means that the inspiration/exhalation ratio is 1:2.0. |
| 3 | TRG: Triggering sensitivity set value (unit: -hPa). |
| 4 | VT: Tidal volume set value (unit: 10 ml). ZY9100 does not use. |
| 5 | CLT: Compliant compensation set value (unit: %). ZY9100 does not use. |
| 6 | SIGH: Sigh times set value (unit: times). ZY9100 does not use. |
| 7 | TIP: Platform time percentage set value (unit: %). ZY9100 does not use. |
| 8 | PEEP: PEEP set value (unit: -hPa). ZY9100 does not use. |
| 9 | PH: Paw alarm upper limit (unit: hPa). |
| 10 | PL: Paw alarm lower limit (unit: hPa). |
| 11 | VTH: Tidal volume alarm upper limit (unit: 10 ml). |
| 12 | VTL: Tidal volume alarm lower limit (unit: 10 ml). |
| 13 | MVH: Minute ventilation alarm upper limit (unit: L/min). |
| 14 | MVL: Minute ventilation alarm lower limit (unit: L/min). |
| 15 | O2H: O2% upper limit (unit: %). |
| 16 | O2L: O2% lower limit (unit: %). |
| 17 | PAWGAIN: Airway pressure gain (unit: -). System parameter. |
| 18 | PAWZERO: Airway pressure zero (unit: -). System parameter. |
| 19 | VTGAIN: Tidal volume gain (unit: -). System parameter. |
| 20 | VTZERO: O2 density zero (unit: -). System parameter. |
| 21 | O2GAIN: O2% gain (unit: -). System parameter. |
| 22 | O2ZERO: O2density zero (unit: -). System parameter. |
| 23 | PEEPZERO: PEEP zero (unit: -). System parameter. |
| 24 | PMAX: Pmax set value in PC mode (unit: -). ZY9100 does not use. |
| 25 | SETTING: Model set value (unit: -). 1 for ZY9100. |
| 26 | MUTE: Mute set value (unit: -). 0 for no mute; 1 for mute. |

# 3 Checkout Procedure

**In this section**


3.1 Post-service checkout . . . . . 3-3
3.2 Inspect the system . . . . . 3-4
3.3 Power failure test . . . . . 3-5
3.4 Pipeline and cylinder tests . . . . . 3-6
3.5 Safety pressure relief valve test . . . . . 3-7
3.6 Flow control tests . . . . . 3-8
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3.13 Electrical safety tests . . . . . 3-20

**WARNING** After any repair or service of the anesthesia system, complete all tests in this section.

Before performing the tests in this section:

- Complete all necessary calibrations and subassembly tests. Refer to the individual procedures for a list of necessary calibrations.
- Completely reassemble the system.

If a test failure occurs, make appropriate repairs and test for correct operation.

## 3.1 Post-service checkout

After servicing the ZY9100 Anesthesia system run the ***Service*** menu tests pertinent to the components replaced. Perform calibration on the flow sensor, pressure sensitivity, and the flow valve.

Then, complete the checkout procedure for the entire machine in the following sections.

## 3.2 Inspect the system

**CAUTION** The upper shelf weight limit is 20 kg (45 lb).

**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.

Before testing the system, make sure that:

- The equipment is not damaged.
- Components are correctly attached.
- The breathing circuit is correctly connected, not damaged.
- Pipeline gas supplies are connected.
- Cylinder valves are closed.
- Models with cylinder supplies have a cylinder wrench attached to the system.
- Models with cylinder supplies have a reserve supply of $O_2$ connected to the machine during system checkout.
- The power cord is connected to a wall outlet.
- The casters are not loose and the brakes are set and prevent movement.

## 3.3 Power failure test

1. Connect the power cord to the mains outlet. Set the power switch to On. The power indicator on the top right corner of the display comes on when AC power or the battery is connected.
   - If the power indicator is on and the “On Battery, power Ok?” message displays:
     — Verify AC power to the machine
     — Check the fuses in the AC inlet assembly
   - If the power indicator is not lit:
     — Check the battery for charge
     — Check the battery connection from the charge board to the system
2. Unplug the power cord with the system turned on.
3. Make sure that the power failure alarm comes on.
4. Make sure the following message is on the ventilator display: ‘On Battery, power OK?’
5. Connect the power cable again.
6. Make sure the alarm cancels.

## 3.4 Pipeline and cylinder tests

**CAUTION** To prevent damage:

- Open the cylinder valves slowly.
- Do not force the flow controls.

If your system does not use cylinder supplies, do not do steps 2 and 3.

1. Disconnect the pipeline supplies and close all cylinder valves. If the pipeline and the cylinder pressure gauges are not at zero, bleed all gasses from the system.
   - Connect an $O_2$ supply.
   - Set the power switch to On.
   - Set the flow controls to mid range.
   - Make sure that all gauges but $O_2$ are at zero.
   - Disconnect the $O_2$ supply.
   - Make sure that the $O_2$ gauge goes to zero. As pressure decreases, alarms for low $O_2$ supply pressure should occur. Note: Other ventilator alarms will activate.
   - Reconnect the $O_2$ supply. $O_2$ pressure should show on the gauge and the alarm should deactivate.
   - Turn the power switch to Off.
2. Make sure that the cylinders are full:
   - Open each cylinder valve, one at a time.
   - Make sure that each cylinder has sufficient pressure. If not, close the applicable cylinder valve and install a full cylinder.
3. Test one cylinder at a time for high pressure leaks:
   - Turn the flow control knobs fully clockwise to stop gas flow.
   - Open the cylinder.
   - Record the cylinder pressure.
   - Close the cylinder valve.
   - Record the cylinder pressure after one minute. If the pressure has decreased more than 5000 kPa (725 psi), leak must be repaired.
     Install a new cylinder gasket and do this step again.
   - Repeat step 3 for each cylinder. For $N_2O$ cylinder, if the pressure has decreased more than 690 kPa (100 psi), leak must be repaired.
     Install a new cylinder gasket and do this step again.
4. Connect the pipeline supplies one at a time and ensure that the corresponding gauge indicates pipeline pressure.

## 3.5 Safety pressure relief valve test

This test uses the ventilator drive gas to pressurize the breathing circuit. The airway pressure gauge is used to verify the opening pressure of the relief valve.

1. Remove the bellows and reinstall the bellows housing. The bellows mounting rim, latch, and relief valve must remain in place.
2. Connect the patient circuit to the breathing system.
3. Remove the flow sensor from the patient circuit.
4. Set the Manual/Mechanical ventilation to mechanical.
5. Set the power switch to On.
6. Push the control knob on the display to exit ***Standby*** mode.
7. Push the bellows key to start mechanical ventilation.
8. Set **FREQ** to 4 and **I:E** to 1.0.
9. Use a test plug or your thumb to block the patient Y-connection.
10. Adjust $\mathbf{V_T}$ until the pressure during inspiration exceeds the opening pressure of the relief valve.
11. Verify that the maximum reading on the airway pressure gauge is between 54 and 60 $cmH_2O$.

## 3.6 Flow control tests

**WARNING** Nitrous oxide ($N_2O$) flows through the system during this test. Use a safe and approved procedure to collect and remove it.

1. Set up the gas scavenging system.
   - Attach a patient circuit and plug the patient port.
   - Attach a bag to the bag port (or plug the bag port).
   - Set the Manual/Mechanical ventilation switch to manual.
   - Adjust the APL valve to minimum.
2. Connect the pipeline supplies or slowly open the cylinder valves.
3. Turn all flow controls fully clockwise (zero flow).
4. Set the power switch to On, push the control knob one time to enter ***Normal*** mode, and push the bag key on the display.
5. Adjust $O_2$ flow to 0.5 L/min.
6. Confirm that the $O_2$ sensor measures 21% in room air and 100% in pure $O_2$. If not, calibrate the $O_2$ sensor.
7. Set the flow controls to mid range of each flowtube and make sure that the flowtube floats rotate and move smoothly.

**Note** If the system does not include $N_2O$, skip steps 8 and 9.

8. Check the proportioning system concentration (increasing $N_2O$ flow). Observe the following precautions:
   - Start with all valves at the minimum setting.
   - Adjust only the $N_2O$ flow control.
   - Increase the $N_2O$ flow as specified in the following table and make sure the $O_2$ concentration is in range.

**Note** Allow the $O_2$ monitor to stabilize. At the lower flows, the $O_2$ monitor may take up to 90 seconds to stabilize.

- If you overshoot a setting, turn the $O_2$ flow control clockwise until the $N_2O$ flow decreases to the previous setting before continuing the test.

| Set the $N_2O$ flow (L/min) | Measured $O_2$ |
|---|---|
| 0.15 | 21% minimum |
| 0.5 | 21% minimum |
| 0.8 | 21% to 30% |
| 1.0 | 21% to 30% |
| 2.0 | 21% to 30% |
| 6.0 | 21% to 30% |
| 9.0 | 21% to 30% |

9. Check the proportioning system concentration (decreasing $O_2$ flow). Observe the following precautions:
   - Start with the $N_2O$ valve at the maximum setting.
   - Adjust only the $O_2$ flow control.
   - Decrease the $O_2$ flow as specified in the table and make sure

the $O_2$ concentration is in the allowed range.

**Note** Allow the $O_2$ monitor to stabilize. At the lower flows, the $O_2$ monitor may take up to 90 seconds to stabilize.

- If you overshoot a setting, turn the $N_2O$ flow control counterclockwise until the $O_2$ flow increases to the previous setting before continuing the test.

| Set the $O_2$ flow (L/min) | Measured $O_2$ |
|---|---|
| 3.0 | 21% to 30% |
| 2.0 | 21% to 30% |
| 1.0 | 21% to 30% |
| 0.3 | 21% to 30% |

- If both tests meet the criteria, calibration is correct (go to the next step). If either test fails to meet the criteria, replace the flowtube module.

**Note** Adjusting the regulator pressure is not recommended. It has little effect on proportioning.

10. Set the power switch to Off.
11. Turn all of the flow controls fully clockwise (closed).

# 3.7 $O_2$ supply alarm test

1. Set all flow controls to 3 L/min.
2. Stop the $O_2$ supply. (Disconnect the pipeline supply or close the cylinder valve.)
3. Make sure that:
   - The Low $O_2$ alarm occurs.
   - The $N_2O$ (if equipped) and $O_2$ flows stop. The $O_2$ flow stops last.
4. Turn all of the flow controls fully clockwise (closed).
5. Reconnect the pipeline supplies.

## 3.8 Flush flow test

1. Set the Manual/Mechanical ventilation switch to mechanical.
2. Attach a patient circuit and plug the patient port.
3. Make sure that the bellows is completely collapsed.
4. Measure the amount of time it takes to fill the bellows when the $O_2$ flush button is fully and continuously depressed.
5. Repeat the above measurement two more times (deflate bellows by removing the plug from the patient port).
6. The bellows should fill in approximately 2.0 seconds.
7. **Possible Cause of Failure:**
   - Large leak (if long filling time).
   - The setting of the pressure regulator is incorrect.
   - The pressure regulator is incorrectly connected.

## 3.9 Vaporizer back pressure test

**WARNING** Anesthetic agent vapor comes out of the common gas outlet during this test. Use a safe, approved procedure to remove and collect the agent.

1. Set up the gas scavenging system.
   - Attach a patient circuit and plug the patient port.
   - Attach a bag to the bag port (or plug the bag port).
   - Adjust the APL valve to minimum.
2. Set the Manual/Mechanical ventilation switch to manual.
3. Set the power switch to On and push the bag key on the display.
4. Set the $O_2$ flow to 6 L/min.
5. Make sure that the $O_2$ flow stays constant and the float moves freely.
6. Adjust the vaporizer concentration for each step from 0 to 1%. The $O_2$ flow must not decrease more than 1 L/min through the full range. If the $O_2$ flow decreases more than 1 L/min:
   - Install a different vaporizer and try this step again.
   - If the $O_2$ flow decreases less than 1 L/min with a different vaporizer, the malfunction is in the first vaporizer.
   - If the $O_2$ flow also decreases more than 1 L/min with a different vaporizer, the malfunction is probably in the ZY9100 system.
7. **Possible Cause of Failure:**
   - Vaporizer manifold port valve.
8. Complete steps 4 through 6 for each vaporizer and vaporizer position.
9. Set the power switch to Off.
10. Turn all of the flow controls fully clockwise (closed).

## 3.10 Low-pressure leak test

**Note** Perform either the “Negative low-pressure leak test” or the “ISO or BSI standard low-pressure leak test.” It is not necessary to perform both tests.

**WARNING** Do not use a system with a low-pressure leak. Anesthetic gas will leak into the atmosphere, before reaching the breathing circuit.

### Negative low-pressure leak test

1. Test the leak test device:
   - Put your hand on the inlet of the leak test device. Push hard for a good seal.
   - Squeeze the bulb to remove all air from the bulb.
   - If the bulb completely inflates in less than 60 seconds, replace the leak test device.
2. Turn off all vaporizers.
3. Test the anesthesia machine for low-pressure leaks:
   - Turn all flow controls fully clockwise (closed). Do not over tighten.
   - Connect the test device to the common gas outlet.
   - Compress and release the bulb until it is empty.
   - The vacuum causes the floats to move. This is usual. If the bulb completely inflates in 30 seconds or less, there is a leak in the low-pressure circuit.
4. Test each vaporizer for low-pressure leaks:
   - Set the vaporizer to 1%.
   - Repeat step 3.
   - Set the vaporizer to Off.
   - Test the remaining vaporizers.
5. Disconnect the test device.

**WARNING** Agent mixtures from the low-pressure leak test stay in the system. Always flush the system with $O_2$ after the low-pressure leak test (1 L/min for one minute).

Turn off all vaporizers at the end of the low-pressure leak test.

6. Flush the system with $O_2$:
   - Set the $O_2$ flow to 1 L/min.
   - Continue the $O_2$ flow for one minute.
   - Turn the $O_2$ flow control fully clockwise (closed).

## ISO or BSI standard low-pressure leak test

**CAUTION** Do the positive pressure leak test at the common gas outlet only.

1. Turn all flow controls fully clockwise (closed).
2. Remove the cap from the common gas outlet by turning the knurled ring clockwise and then pulling the cap off.


3. Connect the test device to the common gas outlet.
   - Test device ref:
     1001-8976-000 (4 kPa)
     1001-8975-000 (25 kPa)


4. Keep the flowmeter of the test device vertical for accurate results.
5. Fully open the needle valve on the test device (counterclockwise).

**CAUTION** If the needle valve is not fully open, this test can damage the pressure gauge on the test device.

6. Open the $O_2$ flow control and set a total flow of 0.4 L/min through the flowmeter on the test device.
7. Make sure that the pressure gauge on the test device reads zero and that all other flow controls are fully closed.
8. Close the needle valve on the test device until the test gauge reads:

| | |
|---|---|
| ISO 5358 | 3 kPa |
| BSI 4272.3 | 20 kPa |

9. If the flow through the test device is less than:
   0.35 L/min (ISO) or
   0.3 L/min (BSI)
   there is a low pressure leak in the anesthesia machine.
10. Fully open the needle valve on the test device to decrease the back pressure.
11. Test each vaporizer for low-pressure leaks:
    - Set the vaporizer to 1%.
    - Repeat steps 5 through 8.
    - Turn the vaporizer Off.
    - Test the remaining vaporizers.
12. Remove the test tool.

**WARNING** Agent mixtures from the low-pressure leak test stay in the system. Always flush the system with $O_2$ after the low-pressure leak test (1 L/min for one minute).

Turn Off all vaporizers at the end of the low-pressure leak test.

13. Flush the system with $O_2$:
    - Set the $O_2$ flow to 1 L/min.
    - Continue the $O_2$ flow for one minute.
    - Turn the $O_2$ flow control fully clockwise (closed).

## 3.11 Alarm tests

1. Connect a test lung to the patient connection.
2. Set the power switch to On.
3. Set the Manual/Mechanical ventilation switch to mechanical and push the bellows key on the display.
4. Test the High $O_2$ and Low $O_2$ alarms:
   - Go to the ***Warning*** menu.
   - Remove the $O_2$ sensor from the circuit.
   - Make sure the sensor measures approximately 21% $O_2$ in room air.
   - Set the $O_2$L alarm limit to 50%. Make sure a Low $O_2$ alarm occurs.
   - Set the $O_2$L alarm limit to 20% and make sure that the alarm cancels.
   - Put the $O_2$ sensor back in the circuit.
   - Push the $O_2$ flush button to fill the breathing system.
   - Set the $O_2$H alarm limit to 50%.
   - Set the $O_2$ flow control to 2 L/min.
   - Make sure the High $O_2$ alarm comes On.
   - Set the $O_2$H alarm limit back to 100% and make sure the alarm cancels.
   - After 2 minutes in pure $O_2$, the $O_2$ display reads approximately 98%.
   - Turn the $O_2$ flow control fully clockwise (closed).
5. Test the Low $V_E$ alarm:
   - Go to the ***Warning*** menu.
   - Set the $V_E$L alarm limit to 6.0 L/min.
   - Adjust ventilator settings for $V_E$L below 6.0.
   - Make sure that a Low $V_E$ alarm occurs.
   - Go to the ***Warning*** menu.
   - Set the $V_E$L alarm limit to 0.0.
6. Test the high airway pressure alarm:
   - Set PawH to less than the peak airway pressure.
   - Make sure that the high airway pressure alarm occurs.
   - Set PawH to 40.
7. Test the sustained airway pressure alarm:
   - Set the controls:
     APL valve to fully closed.
     Manual/Mechanical ventilation switch to manual and push the bag key on the display.
   - Mechanical ventilation stops.
   - Close the bag port connector with a test plug.
   - Close the patient connection using the test plug and push the $O_2$ flush button.
   - Make sure that the sustained pressure alarm occurs after

approximately 15 seconds at the sustained pressure limit (6-30 $cmH_2O$ varies with pressure limit).

8. Set the power switch to Off.

# 3.12 Breathing system tests

**WARNING** Objects in the breathing system can stop gas flow to the patient. This can cause injury or death. Do not use a test plug that is small enough to fall into the breathing system.

## 3.12.1 Check valves

1. Make sure that the check valves on the breathing circuit module work correctly:
   - The Inspiratory check valve rises during inspiration and falls at the start of exhalation.
   - The Expiratory check valve rises during exhalation and falls at the start of inspiration.

## 3.12.2 Ventilator bellows

2. Ventilator bellows test:
   - Set the power switch to Off.
   - Set the Manual/Mechanical ventilation switch to mechanical.
   - Turn all flow controls fully clockwise (closed).
   - Use the test plug or your hand to close the breathing circuit at the patient connection.
   - Push the $O_2$ flush button to fill the bellows.
   - The pressure must not increase to more than 15 $cmH_2O$ on the pressure gauge.
   - If the bellows falls more than 100 mL/min (top of indicator), it has a leak.

## 3.12.3 Bag circuit

3. Test the bag or manual circuit for leaks:
   - Set the Manual/Mechanical ventilation switch to manual.
   - Plug the bag port (use your hand or the approved test plug).
   - Close the APL valve.
   - Set the $O_2$ flow to 0.25 L/min.
   - Close the patient connection (using a hand or the approved test plug) and pressurize the bag circuit with the $O_2$ flush button to approximately 30 $cmH_2O$.
   - Release the $O_2$ flush button. The pressure must not decrease. A pressure decrease large enough to see on the gauge indicates an unacceptable leak.

## 3.12.4 APL Valve

4. Test the APL valve:
   - Fully close the APL valve.
   - Set the total fresh gas flow to approximately 3 L/min and make sure that the value on the inspiratory pressure gauge does not exceed 85 $cmH_2O$. Some pressure fluctuation is normal.
   - Fully open the APL valve.
   - Set $O_2$ flow to 3 L/min. Turn any other gases off.
   - Make sure that the value on the inspiratory pressure gauge is

less than approximately 5 $cmH_2O$.

- Push the $O_2$ flush button. Make sure that the value on the inspiratory pressure gauge stays less than 10 $cmH_2O$.
- Set the $O_2$ flow to minimum and make sure that the value on the inspiratory pressure gauge does not decrease below 0 $cmH_2O$.

5. Remove your hand or the test plug from the patient connection.
6. Turn all flow controls fully clockwise (closed).

**WARNING** Make sure that there are no test plugs or other objects caught in the breathing system.

## 3.13 Electrical safety tests

Make sure the system is completely assembled and all accessory devices are connected to electrical outlets.

1. Connect an approved test device (e.g. UL, CSA, or AAMI) and verify that the leakage current is less than 0.5 mA with the power on.
2. Make sure that the resistance to ground is less than 0.2 Ω between an exposed metal surface and the ground pin on the power cord.

# 4 Service Tests and Calibration

## In this section

This section covers calibration procedures for components of the ZY9100 anesthesia machine.


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4.5.4 Calibration of inspired O2% . . . . . 4-14

**WARNING** After adjustments and calibration are completed, always perform the checkout procedure. Refer to Section 3 of this manual.

## 4.1 Cylinder regulators

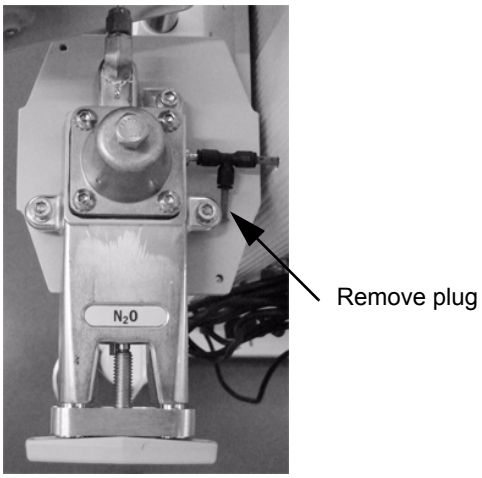
**WARNING** When testing/adjusting $N_2O$ regulators, nitrous oxide flows through the system. Use a safe and approved procedure to collect and remove it.

### 4.1.1 Test setup

**WARNING** Wear safety glasses while a test device is connected to the test port.

**CAUTION** Be careful not to plug the output of the cylinder regulator without having a pressure relief valve in the output circuit.

1. Set the power switch to Off.
2. Disconnect all pipeline supplies.
3. Remove the cylinder regulator cover.
4. Install a full cylinder in the cylinder supply to be tested. It is essential that the cylinder be within 10% of its full pressure.
5. Remove the plug from the test port and connect a test device capable of measuring 689 kPa (100 psi).



## 4.1.2 Testing cylinder regulators

There are two variations of the test procedure for the cylinder regulators:

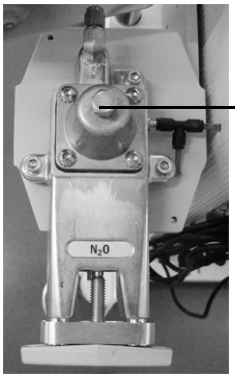
- Test A — For cylinder regulators that supply drive gas to the ventilator (oxygen).
- Test B — For all other gases.

### Test A

**For cylinder regulators that supply drive gas to the ventilator ($O_2$)**:

Under low flow conditions, the output pressure of a properly adjusted/ functioning regulator should fall within specifications listed in step 1. Under high flow conditions, the output pressure should not drop below the specifications in step 2.

1. **Low Flow Test:**
   - Slowly open the cylinder valve.
   - Set the common gas flow for $O_2$ to 0.1 L/min.
   - Close the cylinder valve and allow the pressure to decay to 2068 kPa (300 psi) as indicated on the cylinder gauge (upper limit of the red band). The flow may be temporarily increased to facilitate the decay.
   - When the cylinder pressure reaches 2068 kPa (300 psi) close the $O_2$ flow control valve.
   - Within one minute, the test device must stabilize between 310 to 341 kPa (45.0 to 49.5 psi).
     If the test device pressure does not stabilize within one minute, replace the cylinder supply.
     If the test device stabilizes within one minute, but the readings are not within specifications, readjust the regulator (Section 4.1.3).




2. **High Flow Test:**
   - Slowly open the cylinder valve.
   - Remove the bellows housing.
   - Set the power switch to On. Push the control knob one time to enter ***Normal*** mode.
   - Set **I:E** to 0.5.
   - Set **FREQ** to 4 BPM.
   - Turn inspiratory flow (tidal volume) adjustment fully

counterclockwise (maximum).

- Observe the test device for at least 1 minute (4 inspirations).
- During each inspiration the minimum test device reading observed must be greater than: 207 kPa (30 psi).
- If the test device reading under “high flow” conditions is less than specified, readjust the regulator per the procedure in Section 4.1.3; however, set the regulated pressure higher by the difference noted in this step plus 7 kPa (1 psi). This adjusts the “low flow” regulated output to the high side of the specification so that the “high flow” regulated pressure can fall within the specification.
  If the regulator subsequently fails the “low flow” specification (step 2) because the reading is too high, replace the cylinder supply.

3. Set the power switch to Off.
4. Close the cylinder valve.
5. Bleed the system of all pressure (Section 8.1).
6. Disconnect the test device and plug the test port (pull on the plug to make sure it is locked in the fitting).
7. Replace the bellows housing.
8. After the last regulator has been tested, perform the checkout procedure (Section 3) and replace the cylinder cover.

## Test B

**For all other gases:**

Under low flow conditions, the output pressure of a properly adjusted and functioning regulator should fall within specifications listed in step 2. Under high flow conditions, the output pressure should not drop below the specifications in step 3.

1. If the cylinder supply being tested is $N_2O$, connect a source of $O_2$ to pressurize the balance regulator and allow $N_2O$ to flow.

**2. Low Flow Test:**

- Slowly open the cylinder valve for the regulator being tested.
- Set the flow of the gas being tested to 0.05 L/min.
- Close the cylinder valve and allow the pressure to decay to 2068 kPa (300 psi) as indicated on the cylinder gauge (upper limit of the red band). The flow may be temporarily increased to facilitate the decay.
- When the cylinder pressure reaches 2068 kPa (300 psi), close the flow control valve.
- Within one minute, the test device must stabilize between 310–341 kPa (45.0–49.5 psi).
  If the test device pressure does not stabilize within one minute, replace the cylinder supply.
  If the test device stabilizes within one minute, but the readings are not within specifications, readjust the regulator (Section 4.1.3).

**3. High Flow Test:**

- Slowly open the cylinder valve.
- Set the flow control valve to the maximum indicated flow on the flow tube.
- The test device reading must be greater than 221 kPa (32 psi).
  If the test device reading under “high flow” conditions is less than specified, readjust the regulator per the procedure in Section 4.1.3; however, set the regulated pressure higher by the difference noted in this step plus 7 kPa (1 psi). This adjusts the “low flow” regulated output to the high side of the specification so that the “high flow” regulated pressure can fall within the specification.
  If the regulator subsequently fails the “low flow” specification (step 3) because the reading is too high, replace the cylinder supply.

4. Close the cylinder valve.
5. Bleed the system of all pressure (Section 8.1).
6. Disconnect the test device and plug the test port (pull on the plug to make sure it is locked in the fitting).
7. After the last regulator has been tested, perform the checkout procedure (Section 3).

## 4.1.3 Adjusting cylinder regulators

**Important** Cylinder supplies in a ZY9100 machine must have all high-pressure regulators set to the same pressure range. If a regulator is replaced, the replacement regulator must be set (as required) to the same specification as the one removed.

**Important** Install a full cylinder in the cylinder supply to be adjusted. It is essential that the cylinder be within 10% of its full pressure.

If the cylinder supply being adjusted is $N_2O$, connect a source of $O_2$ and set the $O_2$ flow control to the minimum stop (pilot pressure for low-pressure regulator).

Remove the covers to gain access to the cylinder regulators.

Do not attempt to adjust without flow.

1. Slowly open the cylinder valve.
2. Set and maintain the common gas flow of the gas being tested to 0.01 L/min (or minimum flow for $O_2$).
3. Close the cylinder valve and allow the pressure to decay to 2068 kPa (300 psi) as indicated on the cylinder gauge (upper limit of the red band). The flow may be temporarily increased to facilitate the decay.
4. When the cylinder gauge reaches the upper limit of the red band, adjust the regulator output pressure to:
   327 to 341 kPa (47.5 to 49.5 psi).

**Note** It may be necessary to open the cylinder valve and repeat steps 3 and 4 a number of times to achieve the above setting.

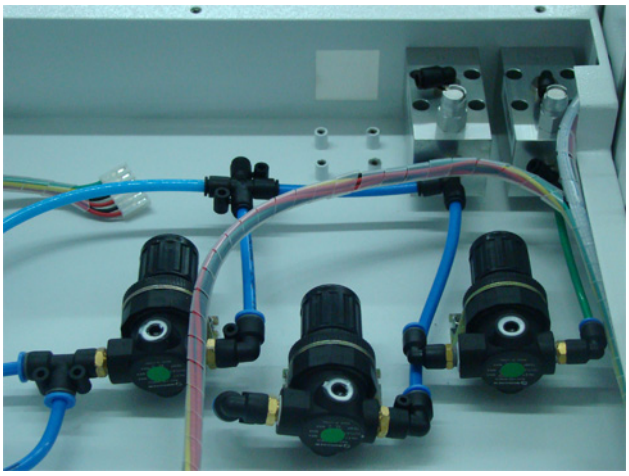
5. Test the regulator settings per the appropriate test in Section 4.1.2.

## 4.2 Low-pressure regulators

**WARNING** When testing $N_2O$ regulators, nitrous oxide flows through the system. Use a safe and approved procedure to collect and remove it.

### 4.2.1 Testing and adjusting low-pressure regulators

1. Bleed the system of all pressure (Section 8.1).
2. Connect a pressure meter to the test plug that is attached to the regulator output on the regulator being tested.



3. Set the flow through the regulator being tested as detailed in the chart.
4. Verify that the output of the tested regulator is within the range listed in the chart.
5. Adjust as necessary.
6. After all regulators have been tested, perform the Post-service checkout (Section 3).

| Regulator | Output | Flow Regulated gas |
|---|---|---|
| $N_2O$ | 260 kPa + 20 kPa | 2 L/min |
| $O_2$ | 220 kPa $\pm$ 20 kPa | 2 L/min |
| $O_2$ Flush | 200 kPa $\pm$ 20 kPa | Flush flow |

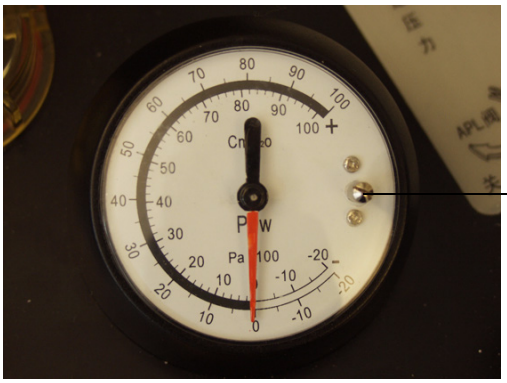
## 4.3 Hypoxic guard calibration

The hypoxic guard is an internal system that is not serviceable. If the hypoxic guard is out of calibration or is misfunctioning, replace the entire flow control assembly.

# 4.4 Airway pressure gauge

## 4.4.1 Zero the pressure gauge

1. Attach a patient circuit to the Breathing System. Leave the patient end open.
2. Set the Manual/Mechanical ventilation switch to manual.
3. Adjust the APL valve to the maximum position.
4. Adjust the pressure gauge to zero. The adjustment screw is on the right side of the gauge.




5. Plug the patient circuit.
6. Press and release the $O_2$ flush button to sweep the needle across the pressure gauge.
7. Remove the plug from the patient circuit to relieve the pressure in the circuit and recheck the zero setting of the pressure gauge.
8. If required, repeat zero and span procedure.

### 4.4.2 Checking the pressure gauge accuracy

The accuracy of the airway pressure gauge is checked by using the following:

- A low-pressure test device (digital manometer or test gauge) with an accuracy of ± 2% of reading
- A test plug
- A negative low-pressure leak test bulb

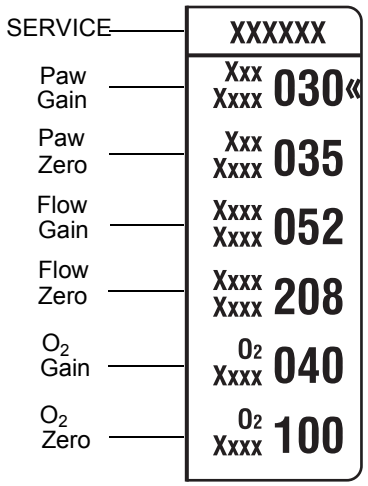
Perform this test with the system in Manual ventilation mode.

1. Make sure the pressure gauge is zeroed (Section 4.4.1).
2. Remove the bag and plug the port.
3. Disconnect the patient circuit from the inspiratory port. Connect the low-pressure test device into the inspiratory port of the breathing circuit.
4. Set the $O_2$ flow to 2.0 L/min.
5. Fully open the APL valve to read 0 $cmH_2O$ at the low-pressure test device. Verify this value is the same at the breathing system pressure gauge $\pm$ 1 $cmH_2O$.
6. Close the APL valve to the point where 40 $cmH_2O$ is read at the low-pressure test device. Verify this value is the same at the breathing system pressure gauge $\pm$ 2 $cmH_2O$.
7. Fully close the $O_2$ flow control and the APL valve. Plug the expiratory port and place a negative low-pressure leak test bulb at the bag port.
8. Squeeze the bulb until -5 $cmH_2O$ is read at the low-pressure test device. Verify this value is the same at the breathing system pressure gauge $\pm$ 2 $cmH_2O$.

# 4.5 Parameter calibration

## 4.5.1 System calibration

1. Use the ***Service*** menu to calibrate the system. Enter the ***Service*** menu by pushing and holding the **Menu** key while turning on the power switch. The ***Service*** menu displays on the screen.




2. Turn the control knob to scroll to the desired parameter, then push the knob to select it.
3. Turn the control knob to adjust the setting, then push to confirm.
4. Verify that the reading displayed for the corresponding parameter is correct on the screen.
5. If additional calibrations are required, repeat steps 2 - 4.
6. Turn the power Off to exit the ***Service*** menu.

## 4.5.2 Paw calibration

To calibrate the airway pressure (Paw):

1. Close all flow control valves.
2. Turn the tidal flow valve fully clockwise (minimum).
3. Connect a patient circuit to the breathing system, with the flow sensor and a fitting with a sample port connected at the patient Y-piece. The patient connection should be open to room air.
4. Zero the pressure test device.
5. Connect the pressure test device to the sample port at the patient Y-piece.
6. Set the Manual/Mechanical ventilation switch to mechanical and push the bellows key on the display. Mechanical mode should be used for this test because the digital readings on the screen update every 3 seconds. In manual mode they update every 20 seconds.
7. Check pressure readings on the ***Normal*** screen. The Paw sweep screen should be a single line and the PEAK should be 0.
8. Adjust Paw Zero on the ***Service*** screen as required. Increasing the calibration setting reduces the displayed value, decreasing the calibration setting increases the displayed value.
9. If unable to zero, adjust the Paw Zero setting to 35 (mid-range) and adjust potentiometer PW2 on the main board while checking pressure readings on the ***Normal*** screen. The Paw sweep screen should be a single line and the PEAK should be 0.
10. Plug the bag port and the patient Y-piece to seal the breathing circuit.
11. Set the Manual/Mechanical switch on the breathing system to Manual (bag mode). Leave the display in Mechanical mode.
12. Use the $O_2$ flow controls and APL valve to pressurize the breathing circuit to 30 $cmH_2O$ on the test device.
13. Check the pressure readings on the ***Normal*** screen.
14. Adjust the Paw Gain as necessary to match the reading on the pressure meter. Increasing the calibration setting increases the displayed value; decreasing the calibration setting decreases the displayed value.
15. After adjustments are done, remove the plugs from the breathing system.
16. Verify that the pressure readings on the display return to zero.

### 4.5.3 $V_T$ calibration

1. To calibrate the tidal volume ($V_T$) set:
   - **I:E** 1:2.0
   - **FREQ** 20
2. Connect the $V_T$ testing instrument to the patient's Y-piece, and connect the test lung to the patient port.
3. Set the $V_T$ value to 200 mL and adjust the Flow Zero parameter value to make the displayed value of $V_T$ the same as the test value ($\leq \pm$ 5% or $\pm$ 20 mL). Increasing the calibration setting reduces the displayed value, decreasing the calibration setting increases the displayed value.
4. Set the $V_T$ value to 800 mL and adjust the Flow Gain parameter value to make the displayed value of $V_{TE}$ the same as the test value ($\leq \pm$ 5% or $\pm$ 20 mL). Increasing the calibration setting reduces the displayed value; decreasing the calibration setting increases the displayed value.
5. Repeat steps 3 and 4 until readings are within tolerances.
6. If the difference between the set value and the displayed value is $\pm$ 20 mL, then:
   - Calibrate the low pressure regulator (Section 4.2).
   - Repeat steps 3 and 4 until readings are within tolerances.

### 4.5.4 Calibration of inspired $O_2$%

To calibrate the $O_2$% of inspiration:

1. Remove the $O_2$ sensor from the breathing circuit and expose it to room air.
2. Adjust the $O_2$ Zero parameter as required, so that the $O_2$ % on the ***Normal*** screen shows 21%. Increasing the calibration setting reduces the displayed value, decreasing the calibration setting increases the displayed value.
3. Put the $O_2$ sensor back into the breathing circuit.
4. Push the $O_2$ flush button.
5. Input 100% $O_2$ with 5L/min flow.
6. Adjust the $O_2$ Gain parameter so the $O_2$% measurement on the top of the display shows 98% (maximum reading is 99). Increasing the calibration setting increases the displayed value; decreasing the calibration setting decreases the displayed value.

# 5 Installation and Maintenance

**In this section**

5.1 ZY9100 Installation checklist . . . . . 5-2
5.2 ZY9100 Planned maintenance . . . . . 5-3

**WARNINGS** Do not perform testing or maintenance on the ZY9100 anesthesia machine while it is being used on a patient. Possible injury can result.

w Items can be contaminated due to infectious patients. Wear sterile rubber gloves. Contamination can spread to you and others.

w Obey infection control and safety procedures. Used equipment may contain blood and body fluids.

# 5.1 ZY9100 Installation checklist

| Serial Number: | Date: (YY/MM/DD) |
|---|---|
| Hospital: | Performed by: |

☐ 1. Unpack and assemble the ZY9100 anesthesia machine.

☐ 2. Complete the System Checkout by performing the following tests:

☐ • Inspect the system (Section 3.2).

☐ • Power failure test (Section 3.3).

☐ • Pipeline and cylinder tests (Section 3.4).

☐ • Safety pressure relief valve test (Section 3.5).

☐ • Flow control tests (Section 3.6).

☐ • $O_2$ supply alarm test (Section 3.7).

☐ • Flush flow test (Section 3.8).

☐ • Vaporizer back pressure test (Section 3.9).

☐ • Low-pressure leak test (Section 3.10).

☐ • Alarm tests (Section 3.11).

☐ • Breathing system tests (Section 3.12).

☐ • Electrical safety tests (Section 3.13).

# 5.2 ZY9100 Planned maintenance

| | |
|---|---|
| Serial Number: | Date: (YY/MM/DD) |
| Hospital: | Performed by: |

This section covers the regular maintenance procedures (minimum requirements) needed to make sure that the ZY9100 anesthesia machine — including the ventilator — operates to specifications.

## Parts Replacement

☐ Replace the vaporizer port o-rings every 12 months.

☐ Replace the batteries every 24 months.

## Checks and Tests

**Refer to the ZY9100 User's Reference Manual.**
Perform the following steps every 12 months after replacing the required parts:

☐ 1. User maintenance listed below. Including disassembly, inspection, cleaning and parts replacement as required.
- Breathing Circuit Maintenance
- Bellows Assembly Maintenance
- Bellows Assembly Tests
- $O_2$ Sensor Calibration
- Calibrate Pressure Sensitivity
- Calibrate Flush Valve

**Refer to this manual for the following Checks and Tests:**

☐ 2. Inspect the system (Section 3.2).

☐ 3. Check that the power failure alarm operates correctly (Section 3.3).

☐ 4. Check that the pipeline gas supplies are connected and cylinders are installed correctly (Section 3.4).

☐ 5. Check the flow control operation (Section 3.6).

☐ 6. Check vaporizer installation.
- Make sure the top of each vaporizer is horizontal (not crooked). Adjust the vaporizer leveling knobs if necessary.
- Make sure each vaporizer is locked and cannot be removed.
- Make sure the alarms and indicators operate correctly (Tec 6 series vaporizer).
- Make sure that more than one vaporizer cannot be turned on at the same time.
- Make sure the vaporizers are adequately filled.

☐ 7. Turn the power switch On. Push the control knob one time to enter ***Normal*** mode.

☐ 8. Check that the flow sensor is positioned properly at the patient Y-connection of the breathing circuit and functioning properly.

☐ 9. Check the vaporizer back pressure (Section 3.9).

☐ 10. Test for negative low-pressure leakage or ISO 5358 or BSI standard positive low-pressure leakage (Section 3.10).

☐ 11. Verify system alarm operation (Section 3.11).
- Test Low $O_2$ alarm
- Test High $O_2$ alarm
- Test Low $V_E$ alarm
- Test High $V_E$ alarm
- Test high airway pressure alarm
- Test sustained airway pressure alarm
- Test $O_2$ sensor disconnect alarm

☐ 12. Check that the ventilator functions correctly:
- Connect the test lung to the patient Y-connection.
- Set the Manual/Mechanical ventilator switch to mechanical and push the bellows key on the display. Set $V_T$ to 400 ml, **FREQ** to 12, **I:E** at 1:2
- Set the gas flow to minimum.
- Fill the bellows using $O_2$ flush.
- Check that mechanical ventilation starts. Check that the bellows inflate and deflate. Check that the display shows the correct ventilator data. Check that there are no inappropriate alarms.

# 6 Troubleshooting

**In this section**


6.1 General troubleshooting . . . . . 6-2
6.2 Breathing system leak test guide . . . . . 6-4
6.2.1 Breathing system leak test . . . . . 6-4
6.3 Ventilator troubleshooting instructions . . . . . 6-6
6.4 Alarm messages . . . . . 6-7
6.5 Mechanical/Electrical troubleshooting guide . . . . . 6-9

# 6.1 General troubleshooting

**WARNING** Objects in the breathing system can stop gas flow to the patient. This can cause injury or death:

- Do not use a test plug that is small enough to fall into the breathing system.
- Make sure that there are no test plugs or other objects caught in the breathing system.

| Problem | Possible Cause | Action |
|---|---|---|
| High Pressure Leak | Pipeline leak | Use a leak detector or Snoop to check for source of leak. Repair or replace defective parts. |
| | $O_2$ flush valve | Use a leak detector or Snoop to check for source of leak.<br>Make sure tubing connections are tight.<br>Replace valve if defective. |
| | Cylinder not installed properly | Make sure cylinder is correctly aligned.<br>Verify that T-handles are tight. |
| | Cylinder gauges | Use a leak detector or Snoop to check for source of leak.<br>Replace gauge if defective. |
| | Cylinder gaskets | Use a leak detector or Snoop to check for source of leak.<br>Replace gasket if defective. |
| | Regulator valves | Use a leak detector or Snoop to check for source of leak.<br>Replace valve if defective. |
| | Ventilator solenoid valve | Check that all tubing is connected correctly.<br>Check for leakage through the valve.<br>Replace the valve. |
| Low Pressure Leak (with vaporizer mounted) | Vaporizer not installed properly | Reseat vaporizer if not installed properly.<br>Have vaporizer serviced at vaporizer center if vaporizer leaks. |
| | Missing or damaged o-ring on vaporizer manifold | Check condition of o-ring.<br>Replace if missing or damaged. |
| | Loose fill port | Check fill port. Tighten if loose. |
| Low Pressure Leak (with or without vaporizer) | Leaking port valve on vaporizer manifold | Use the Vaporizer Manifold Valve Tester to check for leak. If test fails, tighten, repair, or replace as needed. |
| | Leak at flow control assembly | If vaporizer manifold passed previous tests:<br>Remove tubing from input side of head and occlude the ports.<br>Perform leak test. If test fails, replace flow control assembly.<br>Note: An alternate method is to pressurize the system and use a leak detector or Snoop to check for source of leak. |
| | Leaking flush valve | Attach pressure measuring device on fresh gas port.<br>Replace valve if device shows increased pressure. |
| Bellows leak | Pop-off valve diaphragm not sealing properly | Disassemble pop-off valve; inspect and clean seats; reseat; reassemble. |
| | Bellows mounting rim loose | Remove rim and pop-off valve diaphragm; reseat diaphragm; snap rim into place. |
| | Bellows improperly mounted or has a hole or tear | Check that only the last bellows convolution is mounted to the rim and that the ring roll is in the groove under the rim. Inspect the bellows for damage; replace. |

| Problem | Possible Cause | Action |
|---|---|---|
| Breathing System Leak | Absorber canister not installed properly | Install canister properly. |
| | Soda lime dust on canister seals | Clean seals and mating surfaces. |
| $N_2O$ flow does not decrease with $O_2$ flow | Defective flow control assembly | Verify low pressure regulator calibration.<br>Replace flow control assembly. |
| Unable to begin mechanical ventilation | No $O_2$ supply | Check $O_2$ supply. |
| | Defective Manual/Mechanical ventilation switch | Check Manual/Mechanical ventilation switch. |
| | Defective bellows key on the display | Check the bellows key on the display. |

# 6.2 Breathing system leak test guide

**Note** Always perform the low-pressure leak test (Section 3.10) on the machine before proceeding with these breathing system leak tests.

The low-pressure leak test helps to isolate the leak: to manual mode components, to mechanical mode components, or to components that are common to both modes.

- If you have a similar leak in both the manual mode and the mechanical mode, consider the absorber canister area.
- If you have a larger leak in one area than the other (mechanical or manual), the leak is most likely NOT in the absorber canister area.

The procedures in Section 3.12 test specific components of the breathing system for leaks.

## 6.2.1 Breathing system leak test

This test checks for leaks in the mechanical and manual ventilation mode components. It is part of the overall checkout procedure, Section 3.10 “Breathing system tests.” It is repeated here for testing convenience.

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

1. Zero the pressure gauge (Section 4.4.1).

**Check valves**

2. Make sure that the check valves on the breathing circuit module work correctly:
   - The Inspiratory check valve rises during inspiration and falls at the start of exhalation.
   - The Expiratory check valve rises during exhalation and falls at the start of inspiration.

**Ventilator bellows**

3. Ventilator bellows test:
   - Set the power switch to Off.
   - Set the Manual/Mechanical ventilation switch to mechanical.
   - Turn all flow controls fully clockwise (closed).
   - Use the test plug or your hand to close the breathing circuit at the patient connection.
   - Push the $O_2$ flush button to fill the bellows.
   - The pressure must not increase to more than 15 $cmH_2O$ on the pressure gauge.
   - If the bellows falls more than 100 mL/min (top of indicator), it has a leak.

**Bag circuit**

4. Test the manual ventilation circuit for leaks:
   - Set the Manual/Mechanical ventilation switch to manual.
   - Plug the bag port (use your hand or the approved test plug).
   - Close the APL valve.
   - Set the $O_2$ flow to 0.25 L/min.
   - Close the patient connection (using a hand or the approved test plug) and pressurize the bag circuit with the $O_2$ flush button to approximately 30 $cmH_2O$.
   - Release the $O_2$ flush button. The pressure must not decrease. A pressure decrease large enough to see on the gauge indicates an unacceptable leak.

**APL valve**

5. Test the APL valve:
   - Fully close the APL valve.
   - Set the total common gas flow to approximately 3 L/min and make sure that the value on the inspiratory pressure gauge does not exceed 85 $cmH_2O$. Some pressure fluctuation is normal.
   - Fully open the APL valve.
   - Set $O_2$ flow to 3 L/min. Turn any other gases off.
   - Make sure that the value on the inspiratory pressure gauge is less than approximately 5 $cmH_2O$.
   - Push the $O_2$ flush button. Make sure that the value on the inspiratory pressure gauge stays less than 10 $cmH_2O$.
   - Set the $O_2$ flow to minimum and make sure that the value on the inspiratory pressure gauge does not decrease below 0 $cmH_2O$.
6. Remove your hand or the test plug from the patient connection.
7. Turn all flow controls fully clockwise (closed).

**WARNING** Make sure that there are no test plugs or other objects caught in the breathing system.

# 6.3 Ventilator troubleshooting instructions

For ventilator problems that do not generate any error or alarm messages, even though the ventilator may not be functioning correctly:

- Refer to Section 6.5, Mechanical/Electrical troubleshooting guide.

For ventilator problems that result in an alarm or error message:

- Refer to Section 6.4, Alarm messages.

**Important** If the ventilator experiences extreme electrical interference, it may interrupt mechanical ventilation. If this interruption occurs, the ventilator generates an internal reset function and resumes normal operation after two seconds. For situations where continuous electrical interference is experienced by the ventilator, causing a continuous interruption, the ventilator's internal reset repeats until the interference ceases.

If the electrical interference is continuously present and mechanical ventilation is interrupted for approximately 30 seconds, the ventilator produces a continuous beeping audio alarm. Manual ventilation of the patient must be performed while the mechanical ventilation is interrupted. When the electrical interference ceases, the continuous beeping audio alarm can be silenced only by turning the anesthesia machine power switch Off and after five seconds back On.

**WARNING** This system operates correctly at the electrical interference levels of IEC 601-1-2. Higher levels can cause nuisance alarms that may stop mechanical ventilation.

w Manual ventilation must be performed when electrical interference causes interruption of ventilator delivered mechanical ventilation. Manual ventilation must be continued until the ventilator resumes normal operation or an alternate ventilator/anesthesia system can be used.

# 6.4 Alarm messages

| Message | Cause | Action |
|---|---|---|
| Connect $O_2$ Sensor | $O_2$ sensor not installed in the breathing system.<br>Sensor not measuring gas in breathing circuit. | Make sure the breathing circuit and an $O_2$ sensor is installed correctly. |
| Disconnect! | Low Paw, patient disconnected from breathing tubes. | • Reconnect patient to breathing circuit tubes.<br>• If problem persists, check or replace the interface board to main board cable.<br>• If problem persists, replace the interface board.<br>• If problem persists, replace the main board. |
| High $O_2$ | $O_2$% is > alarm high limit setting. | • Check if the $O_2$ limit is set correctly. Check if the sensor measures 21% $O_2$ in room air; if not, calibrate $O_2$ sensor.<br>• If calibration does not pass, replace the $O_2$ sensor.<br>• If calibration does not pass, replace the interface board. |
| High Paw | Paw is > high pressure airway limit (PawH). | • Check if PawH is set too low for ventilator settings and breathing circuit.<br>• Look for blockages.<br>• Check the interface board to main board cable.<br>• If problem persists, replace the interface board.<br>• If problem persists, replace the main board. |
| High $V_E$ | The minute volume is > the set high limit. | • Check ventilator settings and volume output.<br>• Check the breathing circuit and flow sensor connections.<br>• If problem persists, replace the flow sensor.<br>• If problem persists, check or replace the interface board to main board cable.<br>• If problem persists, replace the interface board.<br>• If problem persists, replace the main board. |
| High $V_{TE}$ | The tidal volume is > the set limit. | • Check ventilator settings and volume output.<br>• Check the breathing circuit and flow sensor connections.<br>• If problem persists, replace the flow sensor.<br>• If problem persists, check or replace the interface board to main board cable.<br>• If problem persists, replace the interface board.<br>• If problem persists, replace the main board. |
| Low Battery Voltage | Battery voltage is < 22 V while using backup battery. | • Manually ventilate the patient to save power.<br>• Make sure power is connected and fuses are operational.<br>• Check charge voltage.<br>• Replace charge board. |
| Low $O_2$ | $O_2$% is < alarm low limit setting. | • Check if the $O_2$ limit is set correctly.<br>• Check that the $O_2$ flow is sufficient.<br>• Does the sensor measure 21% $O_2$ in room air? If not, calibrate $O_2$ sensor.<br>• If calibration does not pass, replace the $O_2$ sensor. |
| Low Paw | Peak Paw is < low Paw alarm limit setting. | • Check breathing circuit connections for leaks.<br>• If problem persists, check or replace the interface board to main board cable.<br>• If problem persists, replace the interface board.<br>• If problem persists, replace the main board. |

| Message | Cause | Action |
|---|---|---|
| Low $V_E$ | Exhaled minute volume is < low limit alarm setting. | • Check ventilator settings and volume output.<br>• Check the breathing circuit and flow sensor connections.<br>• If problem persists, replace the flow sensor.<br>• If problem persists, check or replace the interface board to main board cable.<br>• If problem persists, replace the interface board.<br>• If problem persists, replace the main board. |
| Low $V_{TE}$ | Exhaled tidal volume is < low limit alarm setting. | • Check ventilator settings and volume output.<br>• Check the breathing circuit and flow sensor connections.<br>• If problem persists, replace the flow sensor.<br>• If problem persists, check or replace the interface board to main board cable.<br>• If problem persists, replace the interface board.<br>• If problem persists, replace the main board. |
| No $O_2$ pressure | The $O_2$ supply has failed. | • Ventilate manually if necessary.<br>• Check $O_2$ supply pressure.<br>• Connect a pipeline supply or install an $O_2$ cylinder. |
| On Battery, Power OK? | The mains supply is not connected or has failed and the system is using battery power. | • Ventilate manually to save power.<br>• At full charge the battery permits approximately 6 hours of mechanical ventilation. Make sure power is connected and fuses are operational. |
| Sustained Paw | Paw is > sustained pressure limit for 15 seconds. | • Check pressure gauge to see if the indicated sustained Paw is present.<br>• Check the breathing circuit and flow sensor connections.<br>• If problem persists, replace the flow sensor.<br>• If problem persists, check or replace the interface board to main board cable.<br>• If problem persists, replace the interface board.<br>• If problem persists, replace the main board. |

# 6.5 Mechanical/Electrical troubleshooting guide

The power supply circuits are located on two modules: the AC to DC converters are on a universal power supply (PS), the regulated power circuits are integrated into the CPU board (IntCPU).

| Symptom | Probable cause | Action |
|---|---|---|
| System on, Power indicator on, no display | 1. Power cable to display board.<br>2. display board. | 1. Check power to the display board. Replace cable if necessary.<br>2. Check display board for operation. |
| Power indicator not on and no battery in the circuit | 1. Power cord<br>2. AC power<br>3. Cable from front panel to main board<br>4. Power supply board<br>5. Membrane switch LED | 1. Is the cord plugged in?<br>2. Is the power outlet OK?<br>3. Check cable connection.<br>4. Verify output voltages of power supply. Replace power supply.<br>5. Replace main board.<br>6. Replace membrane keyboard. |
| No battery | 1. Battery cable disconnected<br>2. Battery power less than 22 V while running on battery power<br>3. Battery charge circuit defective<br>4. Defective battery | 1. Connect cable.<br>2. Charge battery.<br>3. Replace charge board.<br>4. Replace battery. |
| Alarms display, but not audible | 1. Speaker cable<br>2. Speaker<br>3. Main board | 1. Make sure cable is plugged in.<br>2. Replace speaker.<br>3. Replace main board. |
| Bellows does not expand or tends to collapse during ventilation | 1. Leak in the breathing circuit<br>2. Bellows not installed properly<br>3. Tear or leak in bellows<br>4. Insufficient common gas flow<br>5. Improperly functioning pressure relief valve in bellows assembly | 1. Check breathing circuit and absorber for leaks.<br>2. Check the bellows to rim attachment. Make sure bellows ring roll is into groove under rim.<br>3. Check the entire surface of the bellows. Pay close attention to the angles in the convolutions.<br>4. Check that settings on flowmeters are adequate.<br>5. Check the pressure relief valve and seal for damage. Reseat. |
| Bellows distended and/or slips off base | 1. Bellows retention problem<br>2. Bellows assembly exhaust restricted<br>3. Bellows assembly pressure relief valve problem | 1. Check/replace bellows.<br>2. Check the waste gas scavenging system for high vacuum or blockage.<br>3. Control port plugged or drive gas inlet hose blocked. |
| Bellows does not descend during inspiration | 1. Normal<br>2. Leak in breathing system | 1. If the common gas flow is greater than tidal volume, the bellows may not descend.<br>2. Check for leaks in drive gas circuit. |
| Ventilator will not turn on when the bellows key is pressed and Power indicator is on | 1. Display keypad<br>2. Display board<br>3. Solenoid valve<br>4. Main board | 1. Ensure that all cables are plugged in properly on the display board and the main board.<br>2. Replace the keypad.<br>3. Replace the display board.<br>4. Replace solenoid valve.<br>5. Replace main board. |
| Erratic pressure waveform<br><br>Slow exhalation pressure release | 1. Slight to moderate drive gas leakage<br>2. Solenoid valve<br>3. Exhalation valve assembly | 1. Check for leaks at tubing connections and bellows housing.<br>2. Replace solenoid valve.<br>3. Replace the exhalation valve. |
| Flow waveform is inverted | Sensing tubes incorrectly connected. | Check that the tube closest to the patient is connected to the “+” port on the rear of the machine. |
| No $V_E$ or $V_{TE}$ readings displayed | Sensing tubes incorrectly connected. | Check that the tube closest to the patient is connected to the “+” port on the rear of the machine. |

# 7 Software Installation

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**CAUTION** The circuit boards are electrostatic sensitive. Use an anti-static workstation and wear a wrist grounding strap when handling a circuit board.

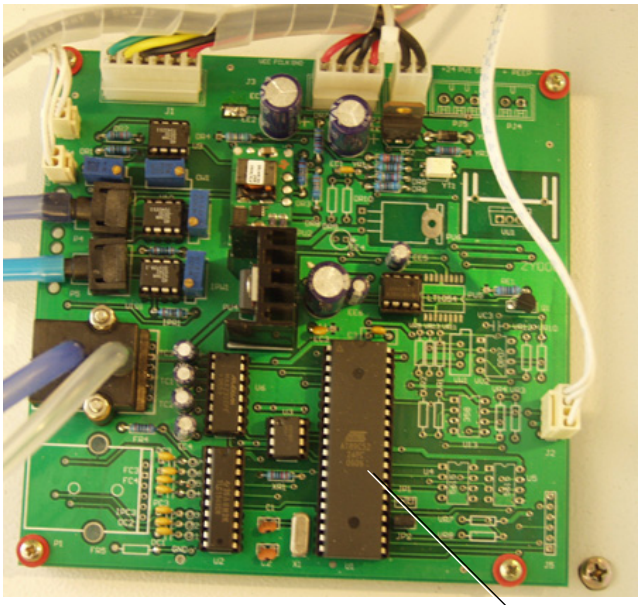
**WARNING** After repairs are completed, always perform thecorresponding service tests and calibrations followed by the checkout procedure. Refer to Sections 3 and 4 of this manual.

# 7.1 Firmware replacement procedure

**Main board**

When there is a software revision:

On the main board, replace the 89C52 integrated circuit as shown in the illustration.

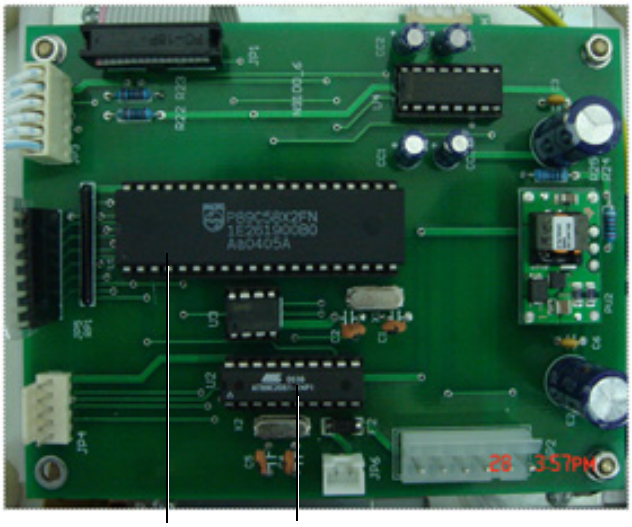


Replace this IC

**Display board**

When there is a software revision:

On the display board, replace the 89C2051 and the 89C58 integrated circuits as shown in the illustration.



Replace these two ICs

# 8 Repair Procedures

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**WARNING** To prevent fires:

- Use lubricants approved for anesthesia or $O_2$ equipment, such as Krytox.
- Do not use lubricants that contain oil or grease; they burn or explode in high $O_2$ concentrations.
- All covers used on the system must be made from antistatic (conductive) materials. Static electricity can cause fires.

w Obey infection control and safety procedures. Used equipment may contain blood and body fluids.

w A movable part or a removable component may present a pinch or a crush hazard. Use care when moving or replacing system parts and components.

w Some internal parts have sharp edges and can cause cuts or abrasions. Use care when servicing internal components.

w When servicing the ventilator, extreme care must be taken to avoid introducing foreign debris, particularly metal chips generated by screw threads, into the pneumatic flow passages of the ventilator. Failure to do so can result in damage to the flow valve and possible injury to the patient.

w After repairs are completed, always perform the correponding service tests and calibrations followed by the checkout procedure. Refer to Sections 3 and 4 of this manual.

**CAUTION** Electrostatic discharge through circuit boards may damage the components on them. Wear a static control wrist strap before touching the circuit boards. Handle all circuit boards by their non-conductive edges. Use anti-static containers when transporting them.

# 8.1 How to bleed gas pressure from the machine

Before disconnecting pneumatic fittings, bleed all gas pressure from the machine.

1. Close all cylinder valves and disconnect all pipeline supplies from the source.
   Note: If the machine includes $N_2O$, do not disconnect the $O_2$ pipeline.
   If pipeline $O_2$ is not available, open the $O_2$ cylinder valve.
2. Turn the flow controls for all gases (except $O_2$) at least one turn counterclockwise.
3. Make sure that all cylinder and pipeline gauges read zero before proceeding.
   - For machines with $N_2O$, disconnect the $O_2$ pipeline supply from the source (or close the $O_2$ cylinder valve).
   - Push the $O_2$ flush button to bleed $O_2$ from the system.

# 8.2 How to remove the back panels

You must remove the back panels to repair or replace many of the machine's components.

## 8.2.1 Upper back panel

1. Bleed all gas pressure from the machine.
2. Make sure that the pressure reading in all pipelines is 0.
3. Unplug the power plug.
4. Unscrew the eight screws attaching the panel to the frame. Remove the panel.

## 8.2.2 Lower back panel

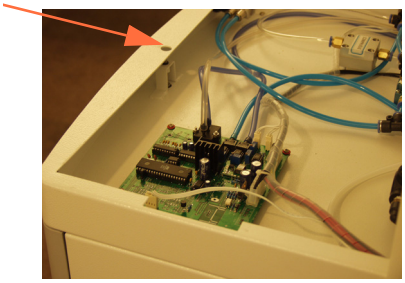
1. Bleed all gas pressure from the machine.
2. Make sure that the pressure reading in all pipelines is 0.
3. Unplug the power plug.
4. Unscrew the six screws attaching the panel to the frame. Remove the panel.

# 8.3 How to remove the table top panel

The table top assembly is attached with hooks located under the panel and one steel bolt.

To remove the table top panel:

1. Use a 4 mm hex wrench to unscrew the bolt. This is accessed from under the table top by opening the top drawer.



2. Slide the table forward and lift.

## 8.4 Replace pipeline inlet filter and check valve

1. Use a 24 mm or 5/16” wrench to remove the pipeline inlet fitting.
2. Pull the pipeline inlet filter out of the fitting. The o-ring should come out with the filter.
3. The $O_2$ pipeline manifold includes a drive gas connection at the back of the manifold. Remove the drive gas tube or plug to access the check valve.
4. From the back of the pipeline manifold, use a thin tool to push out the check valve.
5. Push the new check valve into the opening, using the same thin tool. The new check valve includes an o-ring — orient it toward the pipeline inlet.
   Note: Make sure to push the new check valve all the way back into the opening until it bottoms out on the shoulder.
6. Install the pipeline inlet fitting.
7. Perform the checkout procedure (Section 3).

# 8.5 Service the cylinder supply modules

**WARNING** Be careful not to expose internal components to grease or oil (except Krytox or equivalent).

## 8.5.1 Tightening procedure for high-pressure tube fittings

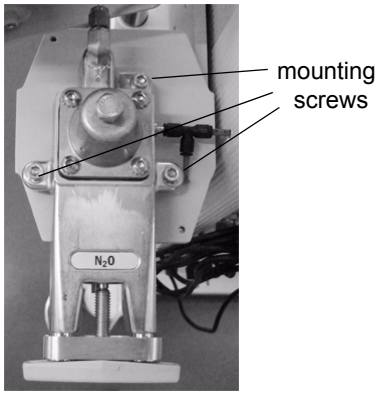
The cylinder pressure gauge is connected to the cylinder supply through a copper tube with fittings at both ends. Use the following tightening procedure whenever replacing a cylinder supply or a cylinder pressure gauge.

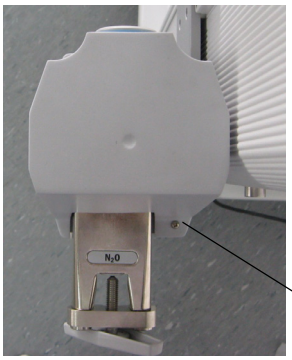
1. Insert the tubing into the fitting until the ferrule seats in the fitting.
2. Tighten the nut by hand.
3. Continue tightening the nut with a wrench until it reaches the original position (about 1/4 turn). An increase in resistance can be felt at the original position.
4. After reaching the original position, tighten the nut just slightly.

**Note** When installing a new tube that has not been tightened before, tighten the nut with a wrench an additional 3/4 of a turn after the nut is finger tight.

## 8.5.2 Replace high-pressure regulator module (complete replacement)

1. Bleed all gas pressure from the machine (Section 8.1).
2. Make sure that all cylinder and pipeline gauges read zero before proceeding.
3. Remove the cylinder cover.
4. Disconnect the high-pressure cylinder gauge fitting.
5. Disconnect the output tube fitting.
6. Remove the three mounting screws and lock washers.
7. To reassemble, perform the previous steps in reverse order.
   - Tighten the high-pressure fitting as detailed in Section 8.5.1.
   - Pull on the cylinder output fittings to ensure they are locked in place.
8. Reinstall the cylinder cover.




9. Perform the cylinder regulator test (Figure 4.1).
10. Perform the checkout procedure (Section 3).

### 8.5.3 Replace cylinder inlet filter

1. Open the cylinder yokes.
2. Remove the inlet adapter from the cylinder yoke, using a 4 mm hex wrench.

**Note** A brass retaining ring keeps the filter inside the inlet adapter.

3. Thread a 6-mm screw (two turns only) into the brass retaining ring and pull it out.

**CAUTION** Be careful not to crush the filter. Do not thread in the screw more than two full turns.

4. Remove the filter.
5. Install the new filter and brass retaining ring.
6. Install the inlet adapter in the cylinder yoke.
7. Perform the checkout procedure (Section 3).

### 8.5.4 Replace cylinder check valve

The cylinder check valve is not a replaceable item. If the check valve is defective, you must replace the complete cylinder supply module.

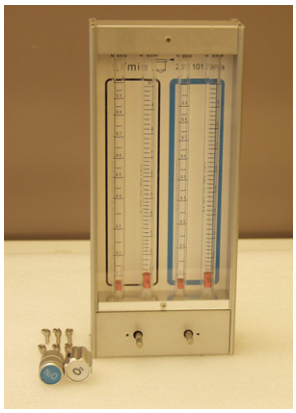
# 8.6 Replace system switch assembly

1. Make sure the power switch is in the Off position.
2. Disconnect the power cord from the back of the machine.
3. Remove the lower back panel (Section 8.2.2).
4. Disconnect the battery.
5. Disconnect the wires attached to the back of the switch. Be sure to label or take note of where each connector plugs into the switch.
6. Compress the plastic tabs on the switch.
7. Push the switch assembly out of the hole in the panel. Some tabs may break off.
8. Replace with a new system switch and reassemble in reverse of the steps listed.

# 8.7 Service flowmeter module

The flowmeter is an internal assembly and is not serviceable. If it is malfunctioning, the entire module must be replaced.

1. Use 2 mm hex wrench to loosen the setscrews for the $N_2O$ and $O_2$ knobs. Remove the knobs.
2. Remove the machine upper back panel (Section 8.2.1).
3. Remove the complete flowmeter head. Do this by removing the six screws that fasten the module to the machine frame. Use a 3mm hex wrench.



4. Remove the tubing from the back of the flow sensor module.


5. Keep all the parts for reassembly.
6. Insert a new flowmeter module. To reassemble, perform the previous steps in reverse order.
7. Perform the checkout procedure (Section 3).

# 8.8 Service vaporizer manifold parts

## 8.8.1 Repair manifold port valve

1. Close all flow control valves.
2. Remove the vaporizers from the vaporizer manifold.
3. Using a 3 mm hex wrench, remove the retaining screw from the bottom side of the vaporizer manifold.
4. Disassemble as necessary to replace parts.
5. When installing a new valve cartridge assembly into the vaporizer manifold, put a light coat of Krytox on the bottom portion of the cartridge.
6. Verify that the parts are free of dust and dirt.
7. To reassemble, perform the previous steps in reverse order.
8. Complete the port valve checkout procedure described in section (Section 8.8.2).

## 8.8.2 Checkout procedure for manifold port valve

Use the Vaporizer Manifold Valve Test Tool to perform the checkout procedure for the manifold port valve. This tool and test procedure are intended for use only when the valve cartridge assembly is replaced.

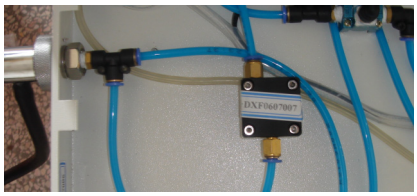
**Note** This replacement and test procedure is a service action and is not part of the maintenance program.

1. Close all flow control valves.
2. Set the system switch to Off.
3. After replacing or repairing vaporizer manifold port valve, remove the vaporizer port o-ring.
4. Attach the valve tester to the top of the valve by sliding the bottom of the tester onto the o-ring groove.
5. Test the negative low-pressure leak-test device:
   - Put your hand on the inlet of the leak-test device. Push hard for a good seal.
   - Remove all air from the bulb.
   - The bulb should not inflate in less than 60 seconds.
6. Attach the negative low-pressure leak-test device to the common gas outlet.
7. Remove all air from the bulb. The bulb should not inflate in less than 45 seconds.
8. Remove the valve tester.
9. Reassemble the inlet tube, vaporizer port o-ring, and the upper rear panel.
10. Conduct a negative low-pressure leak test on the system (Section 3).

**WARNING** If the valve test tool is not removed before flowing gas through the system, flowmeter module damage could result.

## 8.8.3 Replace common gas check valve

1. Close all flow control valves.
2. Set the power switch Off.
3. Remove the table top panel.
4. Remove the two tubes connected to the check valve.
5. Use a 3 mm hex wrench to unscrew the two mounting screws.

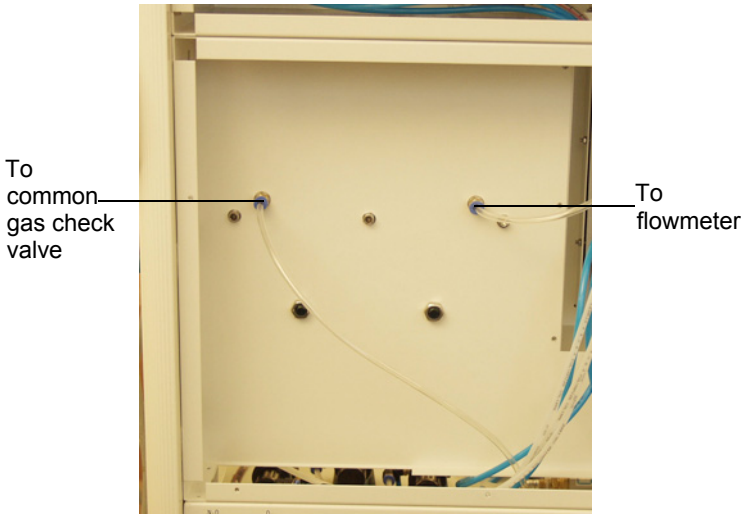


6. Install a new check valve in the reverse order.

**Note** The arrow on the check valve must point to the common gas outlet.

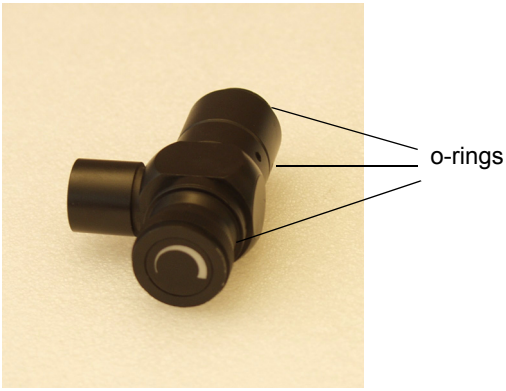
## 8.8.4 Replace vaporizer manifold

1. Set the power switch Off.
2. Remove the upper back panel.
3. Remove the tubes attached to the back of the vaporizer manifold.
4. Remove the three mounting screws.
5. Install a new manifold in reverse order.



# 8.9 Replace APL valve

1. Bleed all gas pressure from the system.

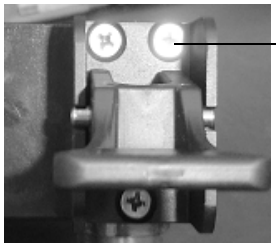



2. Unscrew the APL valve assembly from the breathing system platform.
3. If having leakage problems, replace the o-rings in the valve.
4. If there is a mechanical malfunction, replace the entire valve.
5. Reassemble and check operability in the fully open (minimum) and fully closed (maximum) positions.

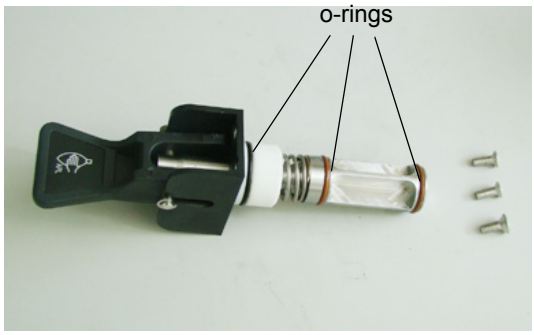
# 8.10 Replace Manual/Mechanical ventilation switch

## 8.10.1 Replace Manual/Mechanical ventilation switch

1. Set the Manual/mechanical ventilation switch to manual position for replacement.
2. Remove the three screws that fasten the switch to the breathing system platform.



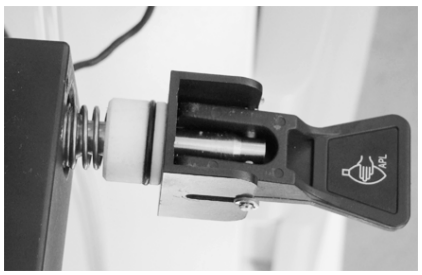

3. Pull the switch assembly out.
4. If having leakage problems, replace the o-rings.



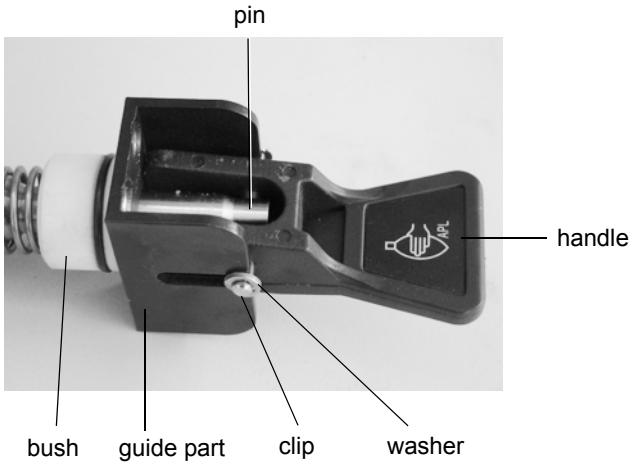

5. If having mechanical problems, replace the entire switch assembly.
6. Reassemble and check operability.

## 8.10.2 Replace switch shaft

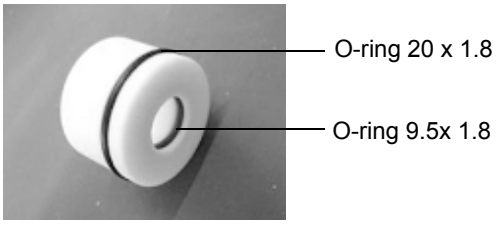
1. Remove the three screws that are used to fix the manual/ mechanical ventilation switch on the breathing circuit.
2. Remove the manual/mechanical ventilation switch from the breathing circuit.



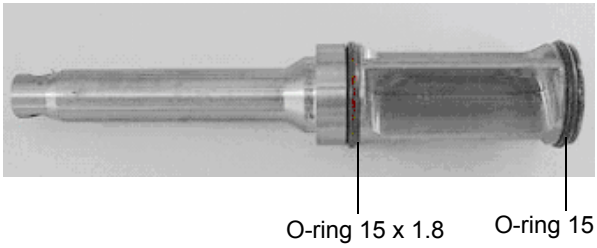
3. In sequence to remove the clip, washer and pin from the switch, and then remove the guide part, handle, bush, and spring.




4. Remove the O-ring 9.5 ×1.8 and O-ring 20×1.8 from the bush, then install new O-rings with same type and a little lubricant on the bush. Please place a litter lubricant on the O-rings.

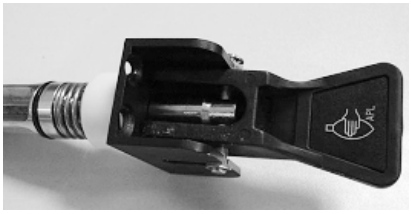



5. Install two new O-rings 15 ×1.8 with a little lubricant to the new switch shaft.




6. In sequence to assemble spring, bush, guide part, handle and pin *(*please note the assemble orientation of guide part and handle*)*, then install the washer and new clip.



7. Mount the manual/mechanical ventilation switch on the breathing circuit with three M4×10 screws.

## 8.10.3 Test in manual ventilation mode

1. Set the APL valve to maximum pressure.
2. Connect the inspiratory port, expiratory port, and bag port on the breathing circuit with tubes.
3. Deliver gas to the breathing circuit by adjusting the $O_2$ flowhead, and stop gas supply until the airway pressure gauge displays 30 $cmH_2O$.
4. Fold the fresh gas tube to avoid the gas in breathing circuit leak through the internal pneumatic paths.

5. Observe the airway pressure gauge to make sure the reading change is less than less than 6 $cmH_2O$ within 1 minute.

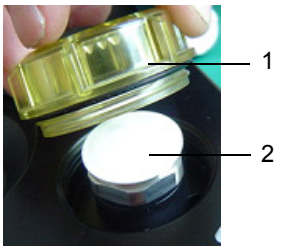
## 8.10.4 Test in mechanical ventilation mode

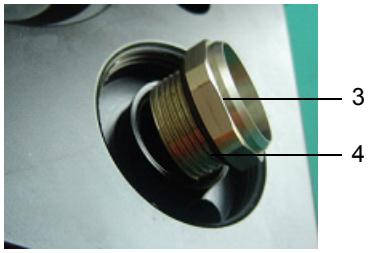
1. Connect the inspiratory port, expiratory port, and bellows port on the breathing circuit with tubes.
2. Deliver gas to the breathing circuit by adjusting the $O_2$ flowhead, and stop gas supply until the airway pressure gauge displays 30 $cmH_2O$.
3. Fold the fresh gas tube to avoid the gas in breathing circuit leak through the internal pneumatic paths.
4. Observe the airway pressure gauge to make sure the reading change is less than less than 6 $cmH_2O$ within 1 minute.

# 8.11 Replace the disc seat of inspiratory/expiratory check valves

## 8.11.1 Replace the disc seat of inspiratory/expiratory check valves

1. Remove the transparent cover from the inspiratory and expiratory check valves on the breathing circuit, and take off the ceramic disc.
2. Discharge the disc seat by using a wrench.
3. Install an O-ring 20×1.8 on the new disc seat.
4. Wrench the new disc seat back to the breathing circuit.
5. Install a new ceramic disc, and mount the transparent cover.




1. Transparent cover
2. Ceramic disc
3. Disc seat
4. O-ring 20x18

## 8.11.2 Check Valve Test

In normal operation, observe the check valve whether it can rise and fall normally within transparent cover.

- The expiratory check valve rises during the expiration and falls at the start of inspiration.
- The inspiratory check valve rises during inspiration and falls at the start of expiration.

## 8.12 Replace casters

**WARNING** Replacing a caster requires at least two people to maneuver and tip the machine. Personal injury and/or machine damage is possible if one person attempts this procedure alone.

1. Set the power switch to Off. Disconnect all pipeline hoses, close all gas cylinders, and unplug the power cord.

**CAUTION** Remove the vaporizers before tipping the machine. If a vaporizer is inverted, it must be set to 5% and purged for 30 minutes with a 5 L/min flow. The interlock system prevents purging more than one vaporizer at a time.

2. Remove the vaporizers, gas cylinders, drawers and all auxiliary equipment. Remove the breathing system by loosening the slotted head set screw on the mounting post and lifting upward.

**CAUTION** To prevent damage, do not tip the machine more than 10 degrees from vertical.

3. Block the opposite wheels; then, block up the machine until there is enough room to remove the defective caster.
4. To block up the machine, tip and slide blocks under the caster base. Raise both sides evenly until the unit is high enough to remove the caster.
5. The casters are threaded into the base and held with a Loctite compound. Remove the caster with an appropriately sized open-end wrench.
6. If required, clean the threads of the new caster with denatured alcohol.
7. Apply Loctite 242 to the threads of the new caster. Install the caster securely into place.
8. Make sure the caster turns freely.
9. Carefully lower the machine to the floor.
10. Perform the checkout procedure (Section 3).

# 8.13 Replace task light and switch

**WARNING** Disconnect the power cord from the outlet receptacle before removing any access panels to avoid shock hazard.

1. Set power switch to the Off position.
2. Remove the top panel of the machine by first unscrewing the fastening screws. These screw in from the top of the panel.
3. Carefully lift the top panel off the machine.

**Replace task light**

1. Remove the screws used to hold the light brackets in place (three).
2. Unplug the wires connected from the switch to the light.
3. Remove and replace the light.
4. Reassemble and check operability.

**Replace the task light switch**

1. Unplug the wires connected from the power and the light to the task light switch.
2. Compress the plastic tabs on the sides of the switch and push the switch assembly down through the machine panel.
3. Replace the switch assembly.
4. Reassemble and check operability.

## 8.14 Electrical enclosure components

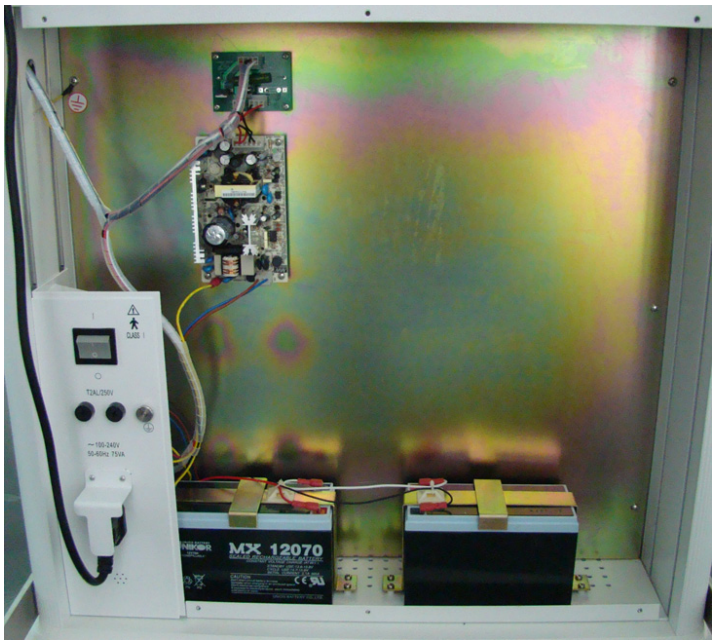
**WARNING** Disconnect the power cord from the outlet receptacle before removing any access panels to avoid shock hazard.

**CAUTION** Disconnect the internal battery before attempting to remove or repair any circuit board. Failure to do so may damage the internal electronics.

w The circuit boards and CPUs are electrostatic sensitive. Use an anti-static workstation and wear a wrist grounding strap when handling a circuit board.

To access the electrical enclosure components:

1. Disconnect the power cord.
2. Remove the lower electronic access panel (Section 8.2.2).
3. Disconnect the battery cable from the charge board by gently grasping the sides of the connector and pulling.



### 8.14.1 Charge board

**CAUTION** The circuit boards are electrostatic sensitive. Use an anti-static workstation and wear a wrist grounding strap when handling a circuit board.

1. Disconnect the connectors going to the charge board by gently grasping the sides of the connector and pulling.
2. Unscrew the four screws that secure the board to the machine.
3. Replace the charge circuit board and reconnect the connectors.

**WARNING** After repairs are completed, always perform the corresponding service tests and calibrations followed by the checkout procedure. Refer to Sections 3 and 4 of this manual.

### 8.14.2 Power supply

**WARNING** Disconnect the power cord from the outlet receptacle before removing any access panels to avoid shock hazard.

1. Disconnect the wires connected to the power supply from the screw terminals. Be sure to label or note which color wire goes to which screw terminal.
2. Remove the four screws that hold the power supply assembly to the electrical enclosure.
3. Install a new power supply and reconnect the spade connectors.
4. Perform the Checkout Procedure found in Section 3.

### 8.14.3 Battery

**CAUTION** Disconnect the internal battery before attempting to remove or repair any circuit board. Failure to do so may damage the internal electronics.

**WARNING** Disconnect the power cord from the outlet receptacle before attempting to remove or replace the battery to avoid shock hazard.

The batteries are mounted on the floor of the lower electrical enclosure.

1. Disconnect the spade connectors at the batteries by gently pulling the connectors.
2. Remove the batteries:

- The batteries are held in place with a formed bracket. To replace the batteries, remove the two screws that retain the bracket.

3. Install new batteries by following these instructions in reverse order.
4. Perform the Checkout Procedure found in Section 3.
5. Allow the batteries to charge. Perform the Checkout Procedure found in Section 3.

## 8.15 Replace the membrane of exhalation valve

The vioce sounds too harsh during the anesthetic machine normal operation, you have to replace the membrane of exhalation valve.

1. Bleed all pressure gas from the machine.
2. Set the power switch to Off.
3. Turn all flow control valves to minimum position, and close all cylinder valves.
4. Pull out the first drawer to remove the work surface.
5. Remove the work surface from the work table, disassemble the exhalation valve, pull out the tubing.
6. Open the top cover of exhalation valve, take out the membrane from the valve.
7. Install a new membrane in the valve, close the cover, ang tighten the screws.
8. Mount the exhalation valve back, and connect the tubing.

# 9 Illustrated Parts

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# 9.1 Service tools

## 9.1.1 Test devices

| Item | Description | Stock number |
|---|---|---|
| | Low-pressure Leak Test Device (negative pressure) | 0309-1319-800 |
| | Low-pressure Leak Test Device (positive pressure ISO) | 1001-8976-000 |
| | Low-pressure Leak Test Device (positive pressure BSI) | 1001-8975-000 |
| | Leakage current test device | Refer to Section 3.13 |
| | Test device capable of measuring 689 kPa (100 psi) | Refer to Section 4.1 and Section 4.2 |
| | Low-pressure test device (digital manometer or test gauge) with accuracy of ± 2% of reading | Refer to Section 4.4.2 |
| | Flow test device capable of measuring 0 -15 L/min with an accuracy of ± 5% of reading | Refer to Section 4.5.3 |
| | Vaporizer manifold valve test tool | 1006-3967-000 |

## 9.1.2 Lubricants and adhesives

| Item | Description | Stock number |
|---|---|---|
| | Lubricant, Krytox GPL 205, 2 oz. | 1001-3845-000 |
| | Thread lock, Loctite No. 24221, 10 ml | 0220-5017-300 |

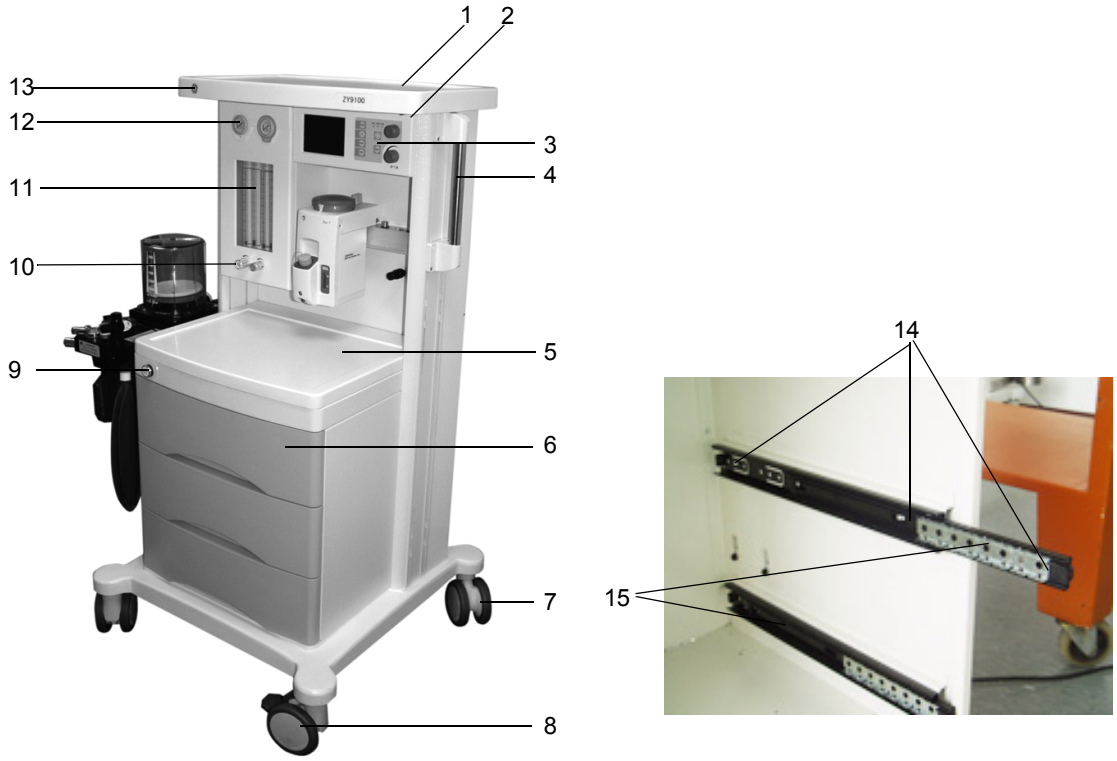
## 9.1.3 Test tools

1

2

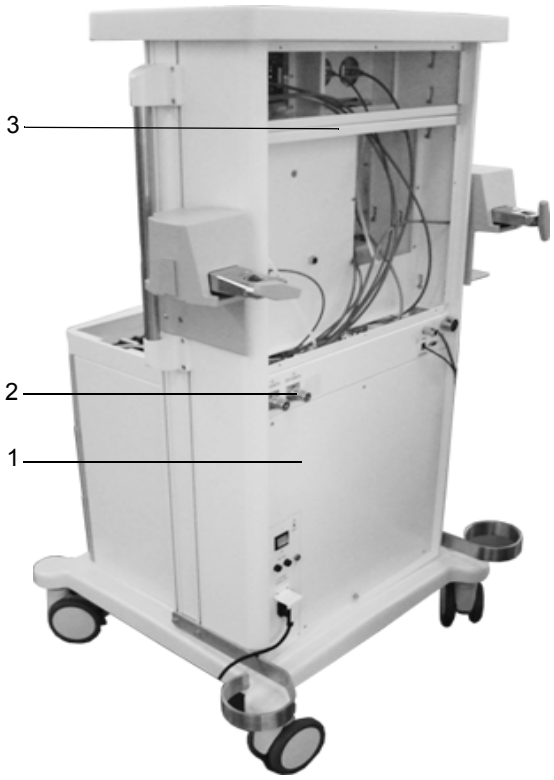
| Item | Description | Stock number |
|---|---|---|
| 1 | Vaporizer manifold valve test tool | 1006-3967-000 |
| 2 | Plug stopper | 2900-0001-000 |

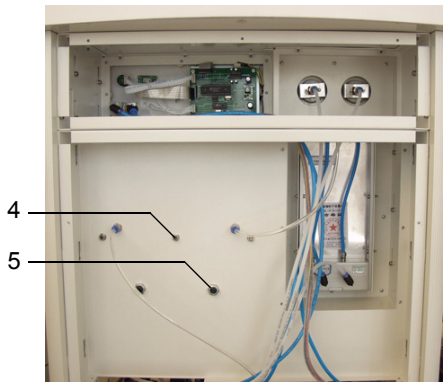
# 9.2 External components - front view

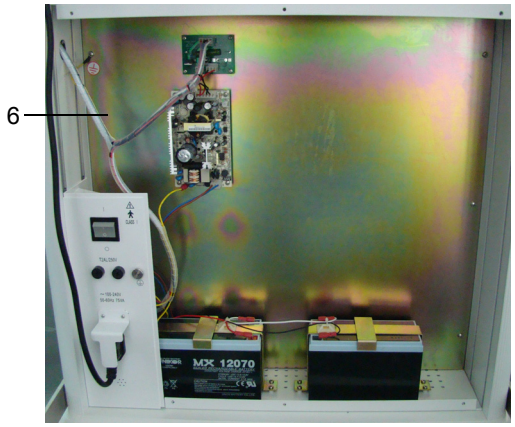



| Item | Description | Stock number |
|---|---|---|
| 1 | Machine top panel | M1167394 |
| 2 | Task light | M1174423 |
| | Task light switch | M1169266 |
| 3 | Display keypad | Refer to Section 9.6 |
| 4 | Side handle | M1174440 |
| 5 | Table top | M1164444 |
| 6 | Drawer assembly | M1164289 |
| | Drawer body | M1164290 |
| | Drawer front | M1167429 |
| | Screws for drawer side rail - drawer side M3 x 5 (3 per side) | M1168632 |
| 14 | Screws for drawer side rail - frame side M4 x 8 (3 per side) | M1168652 |
| 15 | Drawer side rail | M1169611 |
| 7 | Caster | M1169599 |
| 8 | Caster with brake | M1169598 |
| 9 | $O_2$ flush button | M1174434 |
| 10 | Flow control knob | Refer to Section 9.4 |
| 11 | Flow control assembly (ISO) | M1164286 |
| | Flow control assembly (ANSI) | M1164287 |
| 12 | Pressure gauge | Refer to Section 9.4 |
| 13 | GE logo | M1163818 |

# 9.3 External components - rear view

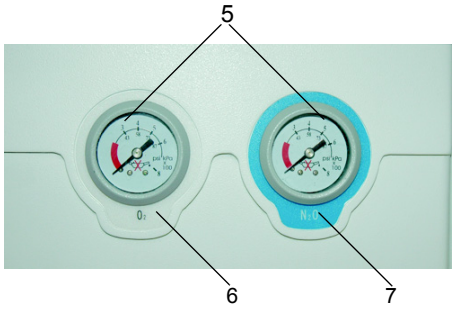


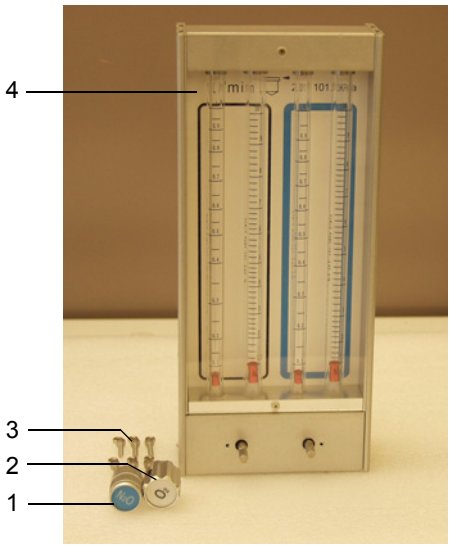




| Item | Description | Stock number |
|---|---|---|
| 1 | Lower back panel | M1164291 |
| 3 | Upper back panel | M1164293 |
| 2 | Gas pipeline inlet | Refer to Section 9.9 |
| 4 | Vaporizer manifold mounting screws | Refer to Section 9.11 |
| 5 | Vaporizer leveling knob hex bolts | Refer to Section 9.11 |
| 6 | Rear panel power components | Refer to Section 9.5 |

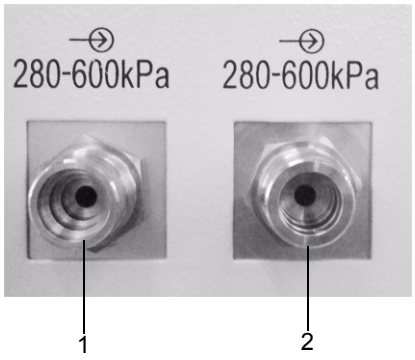
# 9.4 Flow meter and gauges

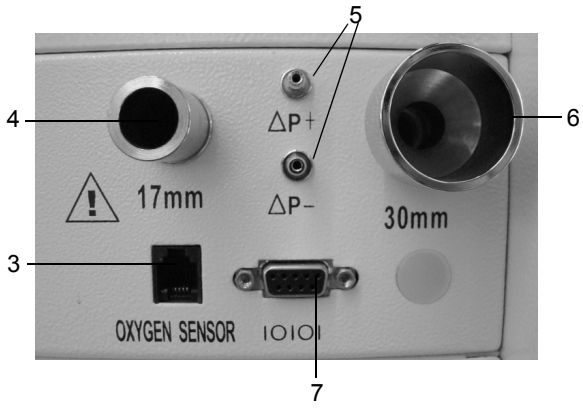


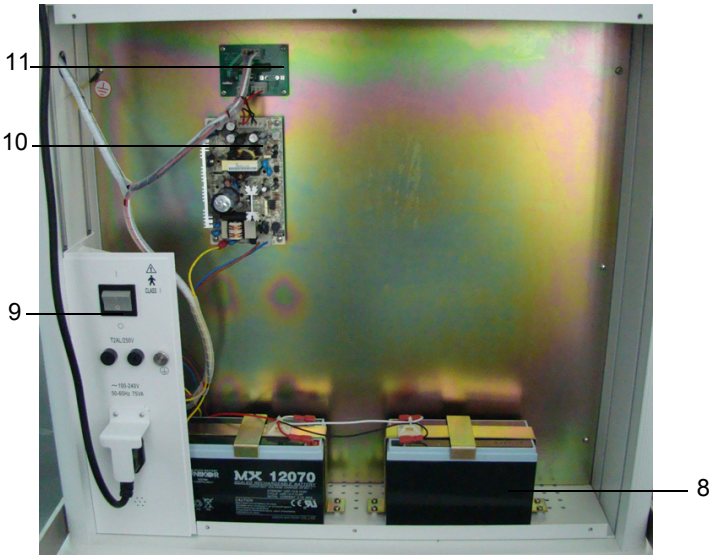




| Item | Description | Stock number |
|---|---|---|
| 1 | $N_2O$ knob | M1167370 |
| 2 | $O_2$ knob | M1167368 |
| 3 | Flow control assembly fastening screws M4 x 16 (6)<br>Flow control assembly fastening nuts M4 (6) | M1168467<br>M1170206 |
| 4 | Flow control assembly (ISO)<br>Flow control assembly (ANSI) | M1164286<br>M1164287 |
| 5 | $O_2$, $N_2O$ Pressure gauge | M1164288 |
| 6 | $O_2$ label (ISO)<br>$O_2$ label (ANSI) | M1164987<br>M1165004 |
| 7 | $N_2O$ label (ISO/Natural)<br>$N_2O$ label (ANSI) | M1169797<br>M1164989 |

# 9.5 Rear panel components

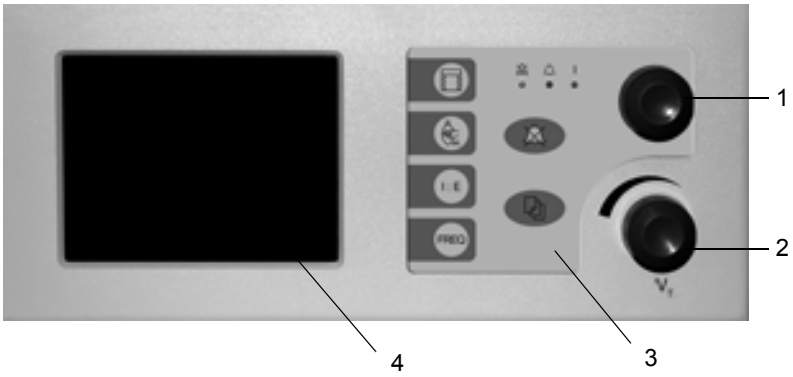


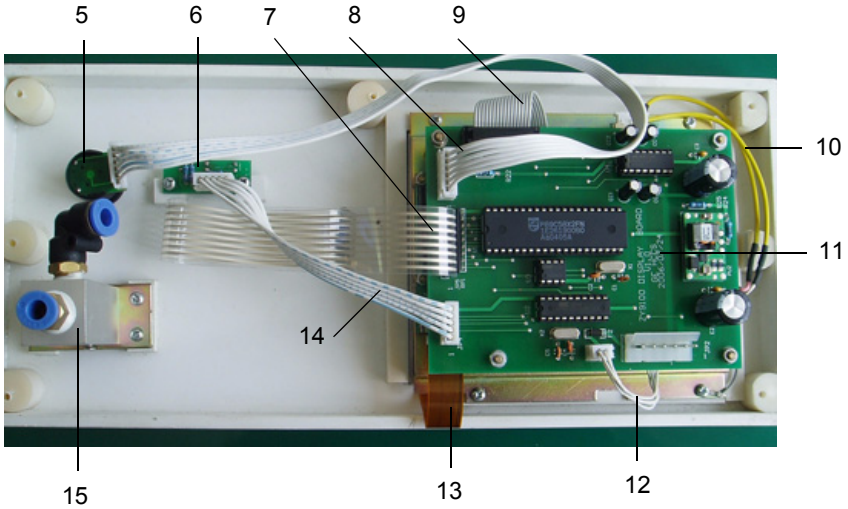



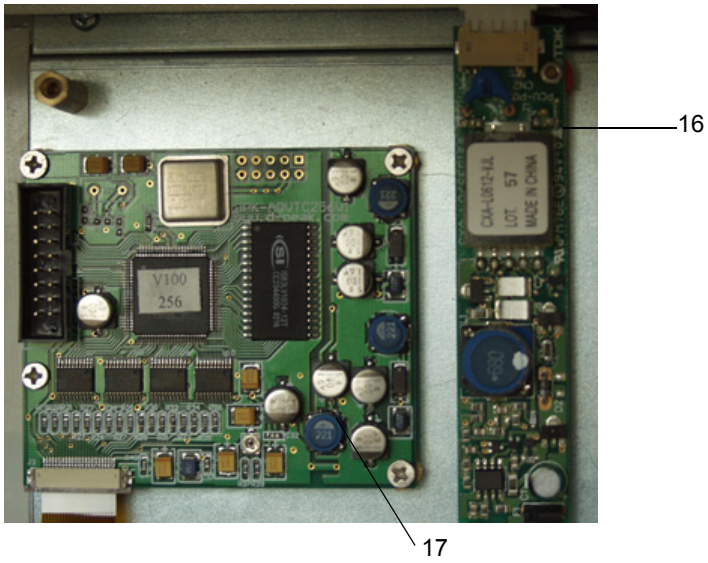




| Item | Description | Stock number |
|---|---|---|
| 1 | $N_2O$ pipeline inlet, NIST | M1169171 |
| 2 | $O_2$ pipeline inlet, NIST | 7-03-000102-S |
| 3 | $O_2$ sensor connector | Comes with interface board |
| 4 | Drive gas connector | M1166574 |
| 5 | Flow sensor connectors (2) | M1165410 |
| 6 | Exhaust gas outlet | M1166589 |
| 7 | RS-232 Connector | Comes with interface board |
| 8 | Battery, 12V (2) | M1169602 |
| 9 | AC Power panel components | Refer to Section 9.7 |
| 10 | Power supply | M1169274 |
| 11 | Charge board | M1158776 |

# 9.6 Display cables, board, assemblies

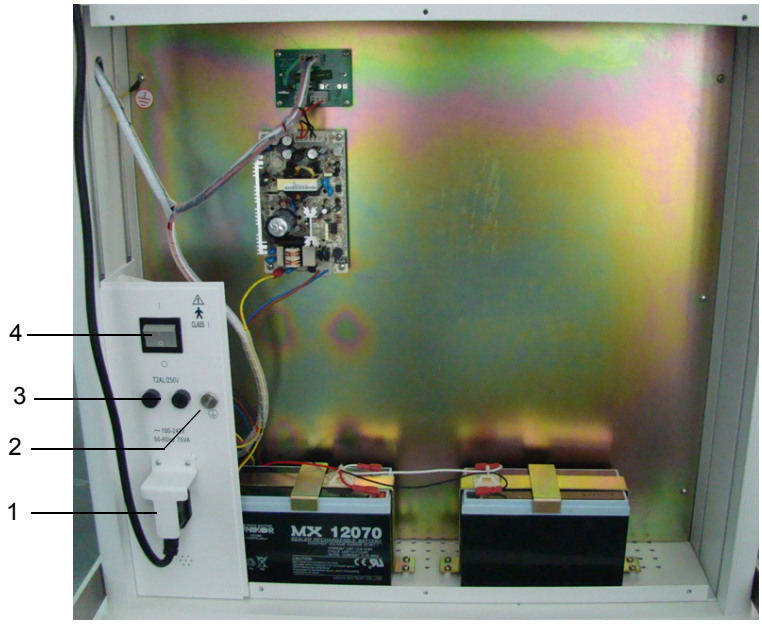


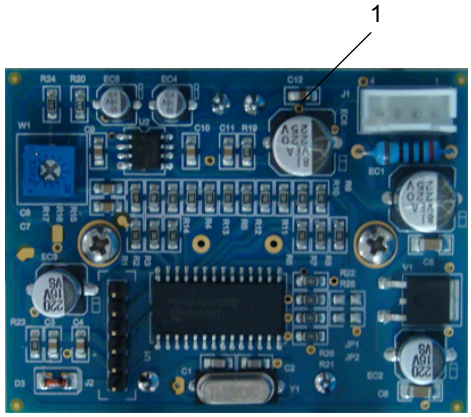
| Item | Description | Stock number |
|---|---|---|
| 1 | Control Knob | M1081590 |
| 2 | $V_T$ control knob | M1170234 |
| 3 | Display keypad, English | M1166011 |
| 4 | LCD display | M1169641 |
| 5 | Encoder | M1169287 |
| 6 | LED board | M1158778 |
| 7 | Cable from display keypad to display board | Comes with display keypad |
| 11 | Display board assembly | M1164663 |
| 15 | Tidal volume needle valve assembly | M1169160 |
| 16 | Inverter board | Comes with LCD display |
| 17 | Display drive board | Comes with LCD display |
| 8 - 10, 12 - 14 | Cables | Refer to Section 9.17 |

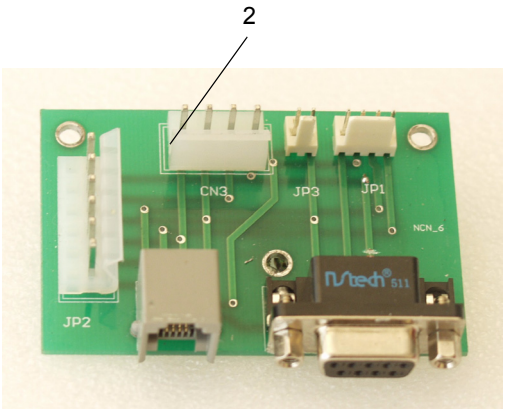
# 9.7 AC power components

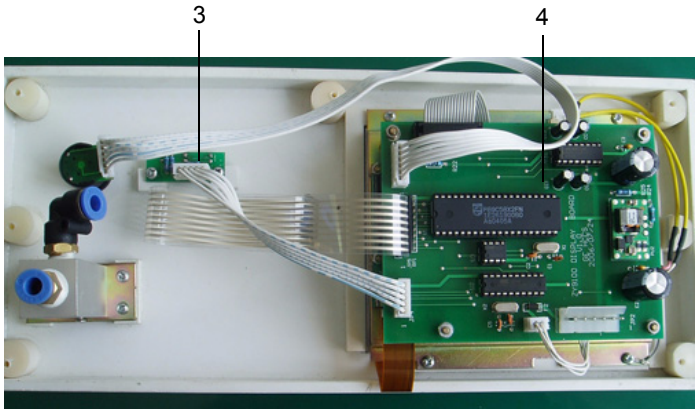


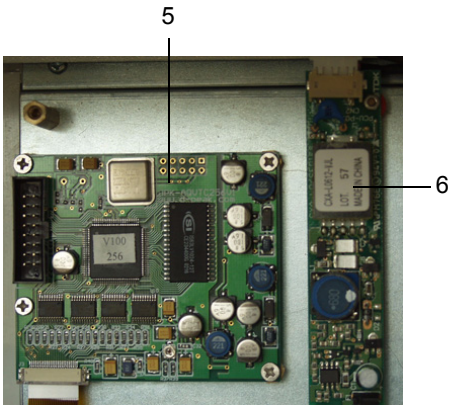

| Item | Description | Stock number |
|---|---|---|
| 1 | Power cord socket | M1162294 |
| | Power cord China | M1053942 |
| | Power cord India | M1162195 |
| | Power cord Euro/France | M1161439 |
| | Power cord Brazil | M1162194 |
| 2 | Grounding connector - post and fastener | M1166546 |
| | | M1165382 |
| 3 | Fuse holder | M1169279 |
| | Fuse T2AL 2 Amp (2) | M1169276 |
| 4 | Power switch | M1169270 |

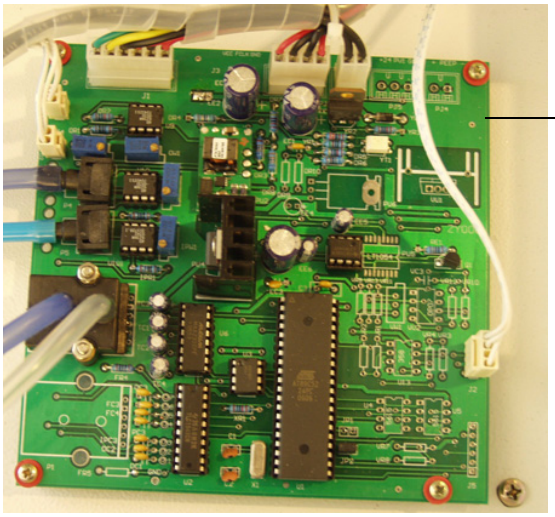
# 9.8 Circuit board assemblies

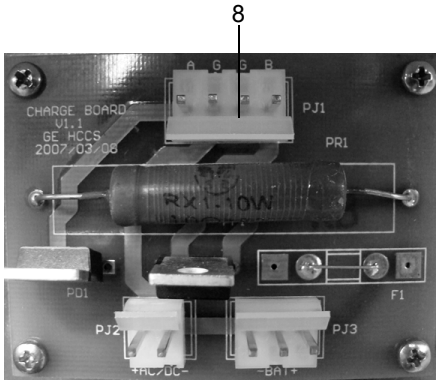


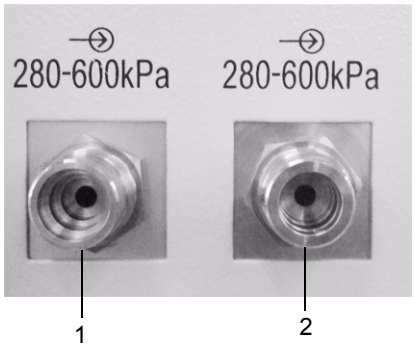



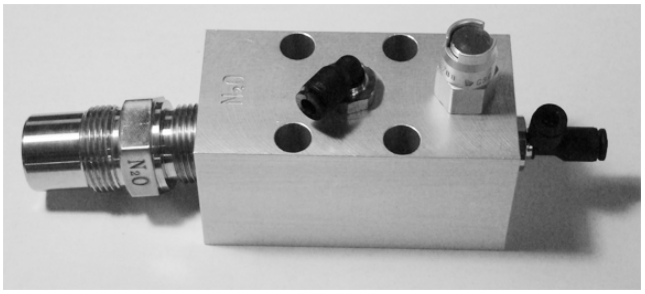
| Item | Description | Stock number |
|---|---|---|
| 1 | Alarm board | M1158780 |
| 2 | Interface board | M1158773 |
| 3 | LED board | M1158778 |
| 4 | Display board<br>Note: The Software not included. See section 9.8.1. | M1164663 |
| 5 | Display driver board | M1169282 |
| 6 | Inverter board | |
| 7 | Main board<br>Note: The Software not included. See section 9.8.1. | M1164954 |
| 8 | Power charge board | M1158776 |

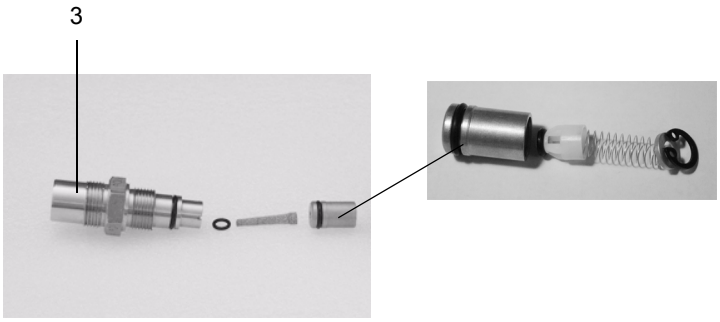
## 9.8.1 Software version

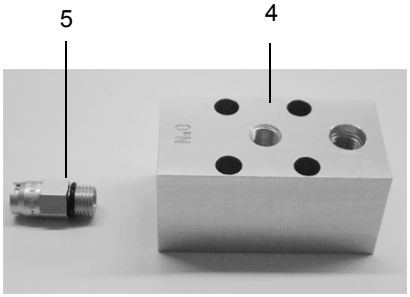
| Item | Description | Stock number |
|---|---|---|
| 1 | ZY9100 Software, English version: | |
| | Mainboard Software | 5.10.1E31E1 |
| | Display Board Software | 5.10.1E31E2 |
| | Control Knob Software | 5.10.1E31E4 |
| 2 | ZY9100 Software, Spanish version: | |
| | Mainboard Software | 5.10.1E31S1 |
| | Display Board Software | 5.10.1E31S2 |
| | Control Knob Software | 5.10.1E31S4 |
| 3 | ZY9100 Software, Portuguese version: | |
| | Mainboard Software | 5.10.1E31P1 |
| | Display Board Software | 5.10.1E31P2 |
| | Control Knob Software | 5.10.1E31P4 |

# 9.9 Pipeline inlet fittings



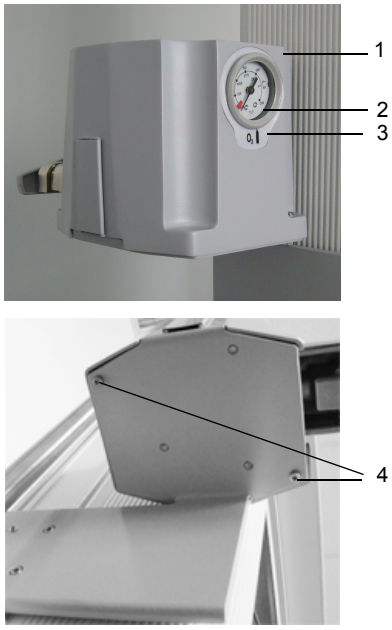



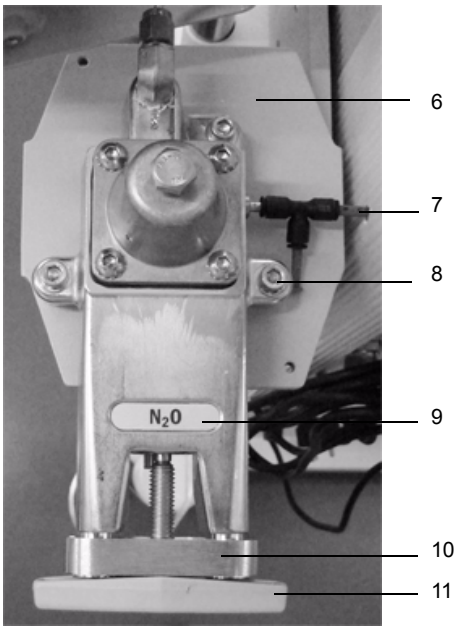



| Item | Description | Stock number |
|---|---|---|
| 1 | $N_2O$ pipeline inlet (NIST) | M1169171 |
| | $N_2O$ pipeline inlet (DISS) | M1169177 |
| 2 | $O_2$ pipeline inlet (NIST) | 7-03-000102-S |
| | $O_2$ pipeline inlet (DISS) | 7-03-000130-S |
| 3 | Pipeline inlet $O_2$ fitting (NIST) | M1166464 |
| | Pipeline inlet $O_2$ fitting (DISS) | M1164436 |
| | Pipeline inlet $N_2O$ fitting (NIST) | M1166459 |
| | Pipeline inlet $N_2O$ fitting (DISS) | M1164438 |
| 4 | Pipeline manifold $N_2O$ (NIST/DISS) | M1164426 |
| | Pipeline manifold $O_2$ (NIST/DISS) | M1164430 |
| 5 | Pressure relief valve | 1006-3161-000 |

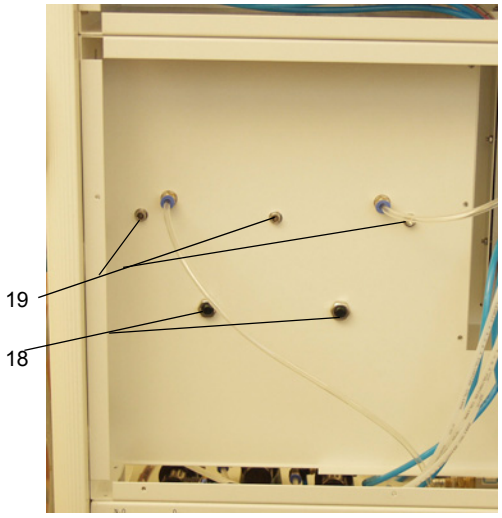
# 9.10 Cylinder gas supplies

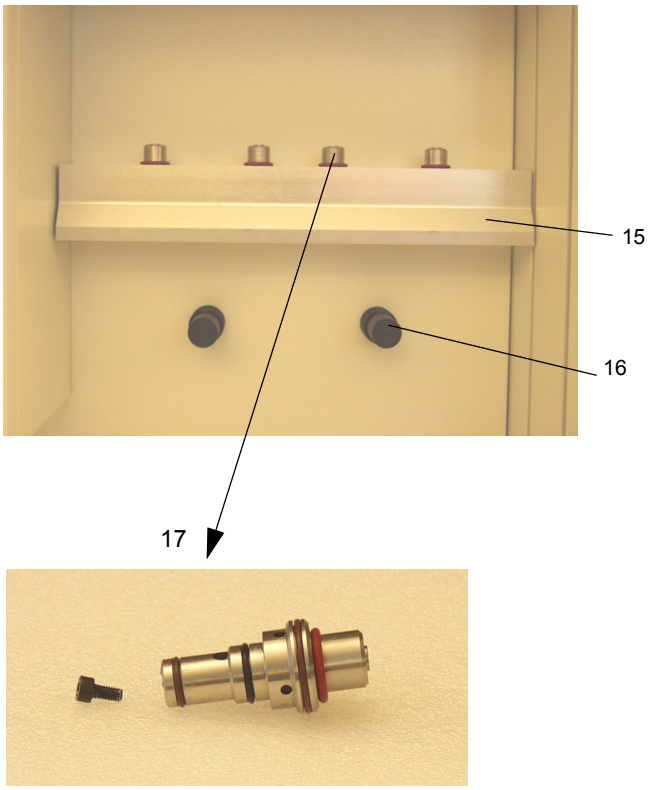



| Item | Description | Stock number |
|---|---|---|
| 1 | Gas supply cover | M1164483 |
| 2 | Cover pressure gauge | 1009-3080-000 |
| 3 | Cover label - $O_2$ ISO<br>Cover label - $O_2$ ANSI<br>Cover label - $N_2O$ ISO/ANSI | M1166428<br>M1164498<br>M1164495 |
| 4 | Cover screw M4 x 12 | M1168460 |
| 5 | Screw M6 x 20, 3 per supply<br>Standoff 6mm, 3 per supply<br>Washer M6 | M1168489<br>M1168772<br>M1168772 |
| 6 | $N_2O$ TEE connector, 4mm<br>$O_2$ TEE connector, 6mm | M1169349<br>M1169350 |
| 7 | Legris quick fitting plug 6 mm<br>Legris quick fitting plug 4 mm | M1169143<br>M1169134 |
| 8 | Label set, cylinder supply, $O_2$<br>Label set, cylinder supply, $N_2O$ | 1006-3854-000<br>1006-3855-000 |
| 9 | Clamp, yoke | 1001-4076-000 |
| 10 | T-handle | 0219-3372-600 |

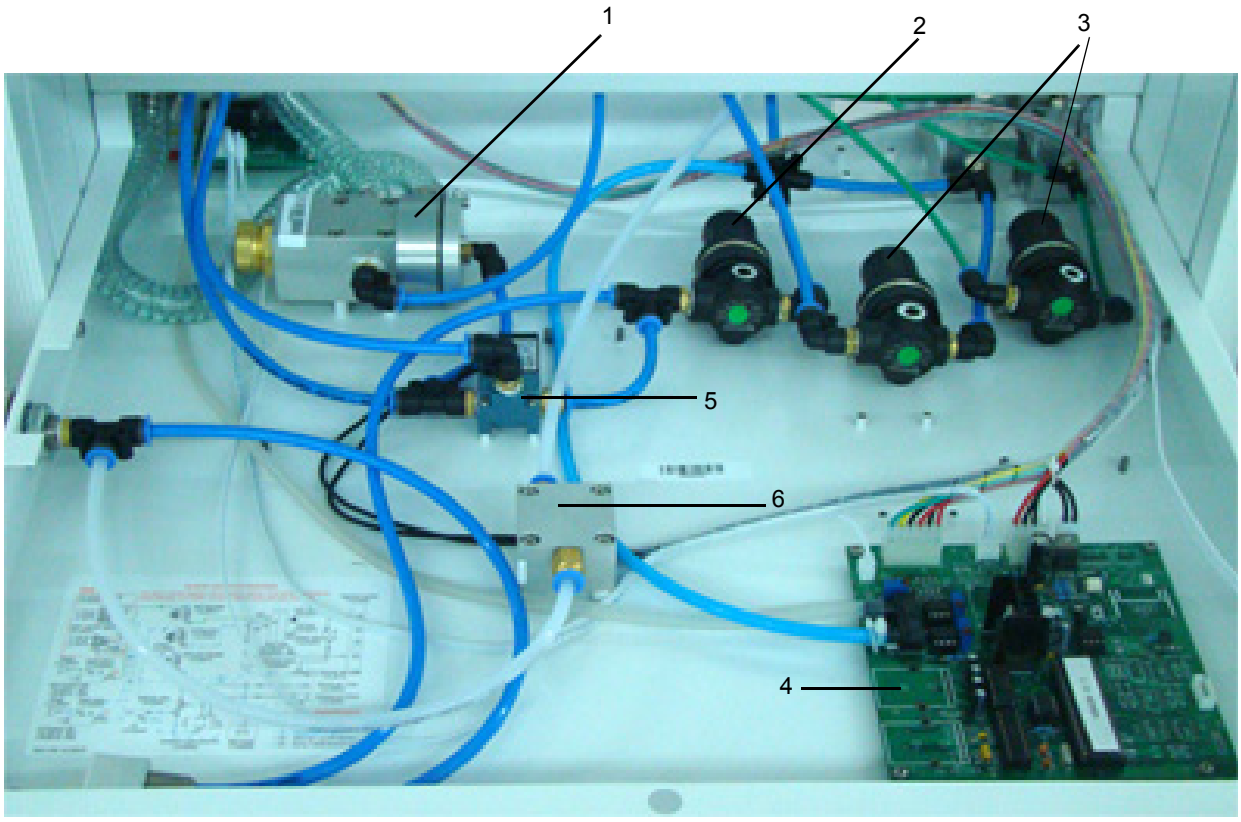
# 9.11 Vaporizer and vaporizer manifold



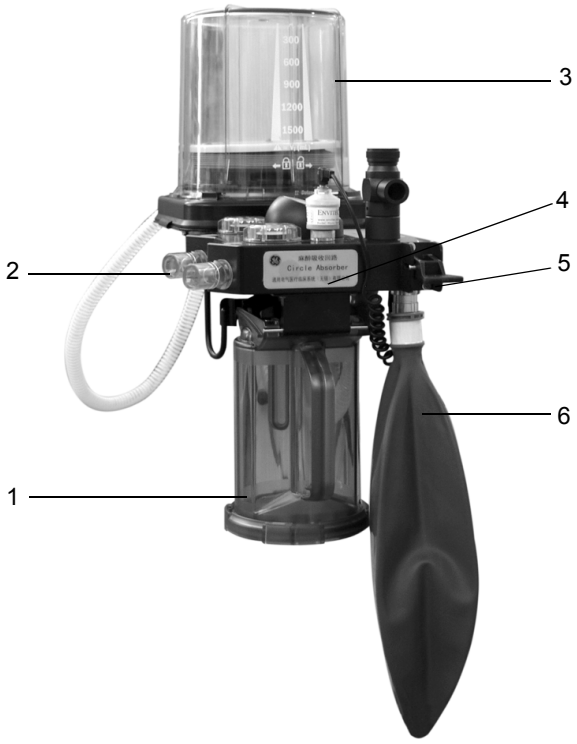

| Item | Description | Stock number |
|---|---|---|
| 15 | Manifold back bar | M1166901 |
| 16 | Vaporizer leveling knob assembly | M1175575 |
| 17 | Vaporizer port valve assembly | M1166909 |
| | O-ring 10 x 1.8 | M1168782 |
| | O-ring 12.5 x 1.8 | M1168806 |
| | O-ring 14 x 2.65 | M1168784 |
| | O-ring 21.2 x 1.8 | M1168809 |
| 18 | Vaporizer leveling knob hex nuts (2) | M1168458 |
| 19 | Vaporizer manifold mounting screws (3) | M1168488 |
| | Washer | M1168772 |
| | Spring washer | M1168762 |

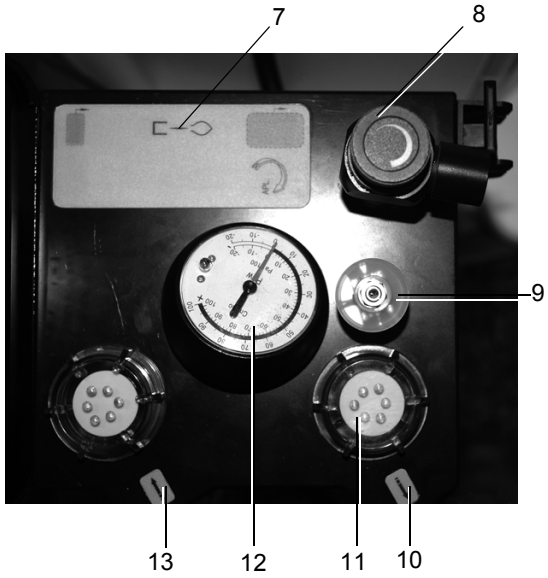
# 9.12 Components under table

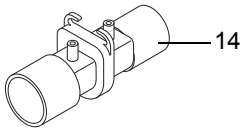



| Item | Description | Stock number |
|---|---|---|
| 1 | Exhalation valve assembly | M1169164 |
| | Screws M4 x 40 (4) | M1168471 |
| 2 | $O_2$ flush and drive gas regulator | M1169165 |
| 3 | $N_2O$ regulator | M1169168 |
| | $O_2$ regulator | M1169166 |
| 4 | Main board | M1164954 |
| 5 | Solenoid valve | M1169161 |
| | Screws M3 x 20 (2) | M1168634 |
| 6 | Fresh gas check valve | M1169169 |

# 9.13 Breathing circuit and interface

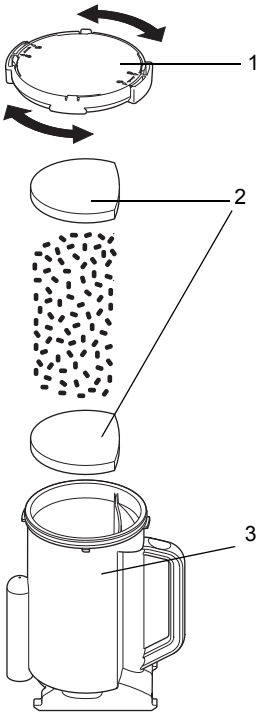


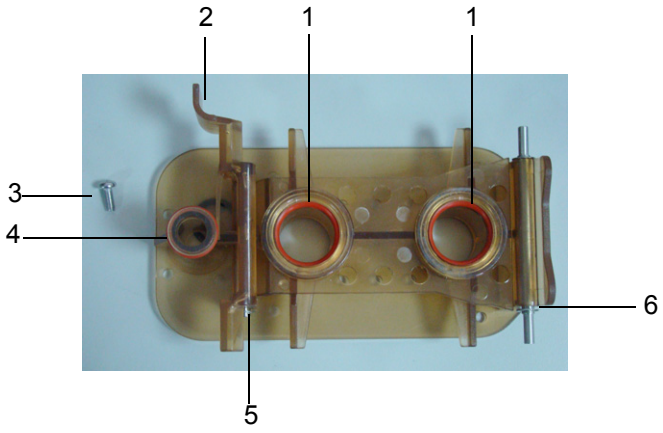

| Item | Description | Stock number |
|---|---|---|
| 1 | Absorber canister | Refer to Section 9.13.1 |
| 2 | Patient circuit ports (inspire/expire) | M1167437 |
| 3 | Bellows assembly | Refer to Section 9.13.4 |
| 4 | Front label | M1164997 |
| 5 | Manual/Mechanical switch<br>O-ring 20 x 1.8<br>O-ring 9.5 x 1.8 | M1167432<br>M1168789<br>M1168800 |
| 6 | Bag | M1169600 |
| 7 | Symbol label | M1164500 |
| 8 | APL valve<br>O-ring 10 x 1.8<br>O-ring 20 x 1.8<br>O-ring 21.2 x 1.8<br>O-ring 22.4 x 1.8<br>O-ring 23.6 x 1.8 | M1173819<br>M1168782<br>M1168789<br>M1168809<br>M1168810<br>M1168812 |
| 9 | $O_2$ sensor<br>$O_2$ sensor port | M1169610<br>M1166923 |
| 10, 13 | Inspire/expire port labels | M1167629 |
| 11 | Transparent cover<br>Ceramic disc<br>Disc seat<br>O-ring, 40 x 1.8<br>O-ring, 20 x 1.8 | M1167435<br>M1167404<br>M1165447<br>M1168795<br>M1168789 |
| 12 | Pressure gauge assembly | M1176166 |
| 14 | Flow sensor adapter | M1174442 |

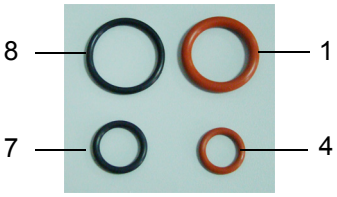
## 9.13.1 Absorber canister

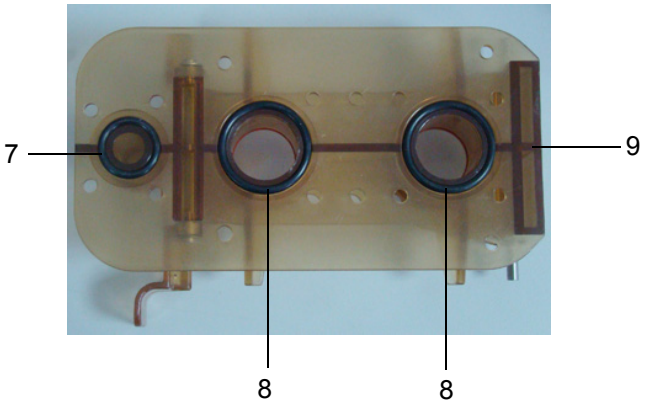



| Item | Description | Stock number |
|---|---|---|
| | Absorber Canister Assembly, reusable | 1407-7004-000 |
| 1 | Cover, $CO_2$ Canister with Locking ring | 1407-3203-000 |
| | Screen, $CO_2$ Canister cover | 1407-3205-000 |
| 2 | Foam, $CO_2$ Canister (40 per pkg) | 1407-3201-000 |
| 3 | Canister, $CO_2$ | 1407-3200-000 |
| | O-ring 110.72 x117.78 | 1407-3204-000 |
| | Screw, M3 x 8 | 9211-0530-083 |

## 9.13.2 Absorber Canister Interface Module

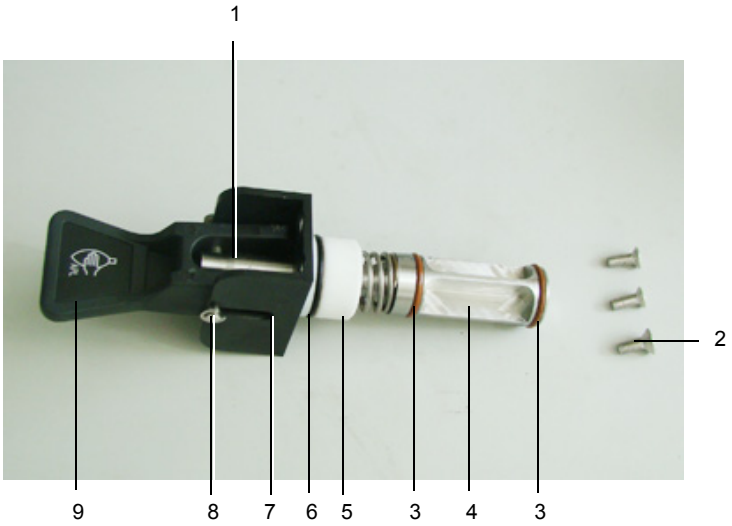


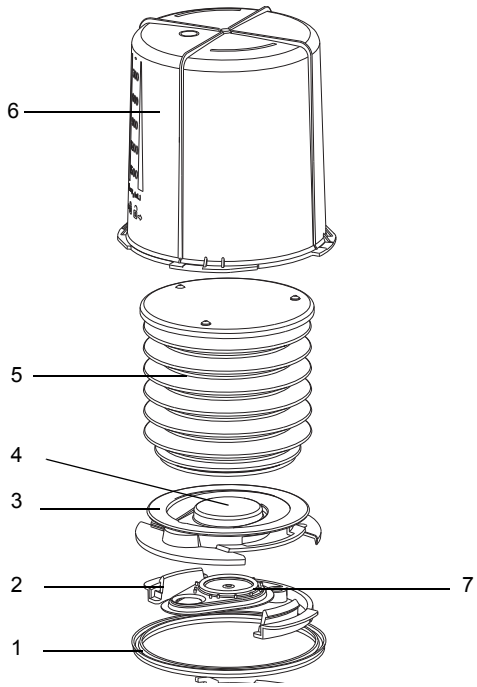

| Item | Description | Stock Number |
|---|---|---|
| | Shelf absorber canister assembly | M1172138 |
| 1 | O-ring (2), 22x4 | M1169929 |
| 2 | Latch, release pin | M1159525 |
| 3 | Screw(10), M8x16 | M1168576 |
| 4 | O-ring, 12.37x2.62 | M1169930 |
| 5 | Shaft hook, 61mm | M1164452 |
| 6 | Shaft hook, 85mm | M1165449 |
| 7 | O-ring, 15x2.65 | M1169931 |
| 8 | O-ring (2), 25x2.65 | M1169932 |
| 9 | Shelf canister | M1170491 |

## 9.13.3 Manual/ Mechanical ventilation switch




| Item | Description | Stock number |
|---|---|---|
| | Manual/Mechanical ventilation switch assembly | M1174832 |
| 1 | Pin | M1167366 |
| 2 | Screws (3), M4x10 | M1168642 |
| 3 | O-ring (2), 15x1.8 | M1168784 |
| 4 | shaft | M1165443 |
| 5 | shaft bush | M1166915 |
| 6 | O-ring, 20x1.8<br>O-ring, 9.5x1.8 | M1168789<br>M1168800 |
| 7 | Guide part | M1166913 |
| 8 | Washer | M1167655 |
| 9 | Switch handle | M1167432 |

## 9.13.4 Bellows assembly



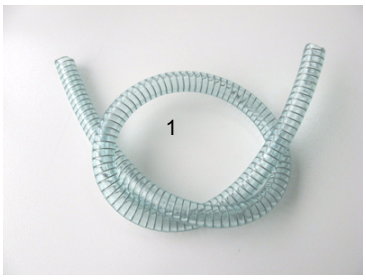

| Item | Description | Stock number |
|---|---|---|
| 1 | Seal, base | 1500-3359-000 |
| 2 | Latch, base | 1500-3352-000 |
| 3 | Pressure relief valve assembly | 1500-3377-000 |
| 4 | Rim | 1500-3351-000 |
| 5 | Bellows | 1500-3378-000 |
| 6 | Bellows housing | 1500-3117-000 |
| 7 | Pop-off valve | 1500-3377-000 |

# 9.14 Legris quick-release fittings

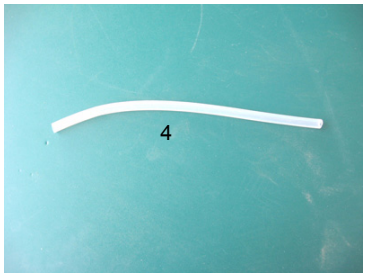

| Item | Description | Stock number |
|---|---|---|
| **Tees — (tube/tube/thread)** | | |
| 1 | 4 mm Tee connector | M1169133 |
| 2 | 6 mm Tee connector | M1169128 |
| **Elbow connector** | | |
| 3 | 4 mm Elbow connector | M1169131 |
| 4 | 6mm Elbow connector | M1169127 |
| **Plug** | | |
| 5 | 4 mm plug | M1169134 |
| 6 | 6 mm plug | M1169143 |
| **TEE EQUAL connector** | | |
| 7 | 6 mm TEE EQUAL connector | M1169350 |
| 8 | 4 mm TEE EQUAL connector | M1169349 |

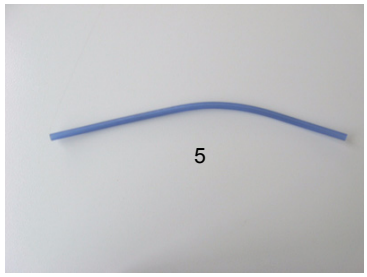
**Note** Not every fitting is used in all machines.

# 9.15 Vent drive and low-pressure tubing



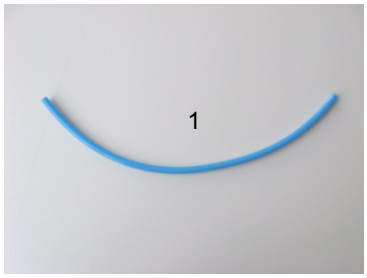


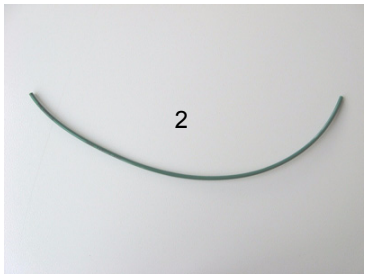




| Item | Description | Stock number |
|---|---|---|
| 1 | Exhaust tubing | M1167408 |
| 2 | Rubber tubing | M1167615 |
| 3 | Flow sensor tubing (outside) | M1167609 |
| 4 | Flow sensor tubing (inside clear) | M1167611 |
| 5 | Flow sensor tubing (inside blue) | M1167613 |

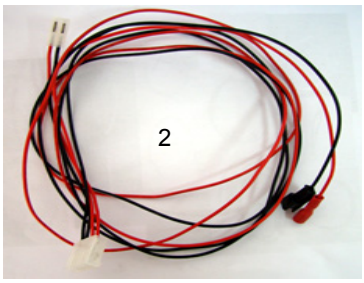
# 9.16 Tubing for use with Legris fittings

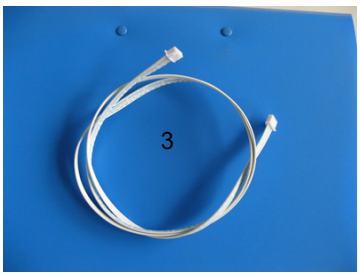


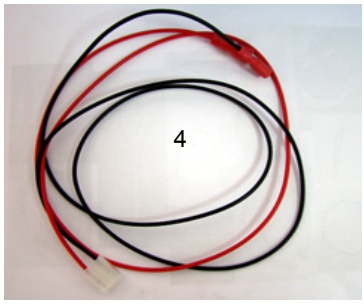



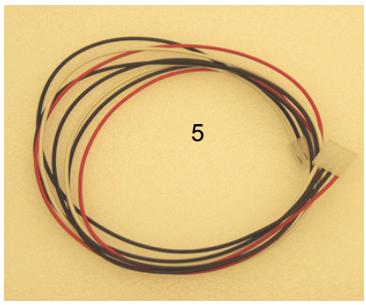

| Item | Description | Stock number |
|---|---|---|
| 1 | Nylon tubing - 11 pressure pipe 6 mm OD (blue) - 2 m | M1167496 |
| | Nylon tubing - 11 pressure pipe 6 mm OD (clear) - 1 m | M1167494 |
| 2 | Nylon tubing - 11 pressure pipe 4 mm OD (green) | M1167498 |

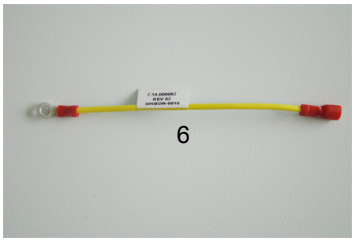
# 9.17 Cables and harnesses

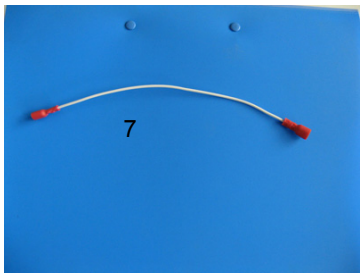



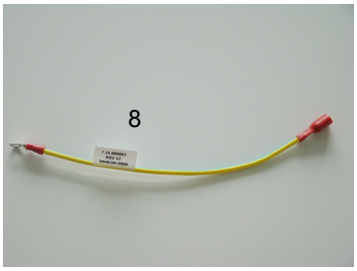



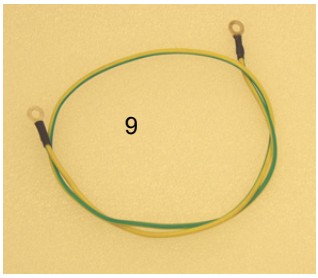



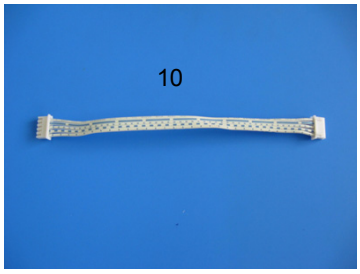



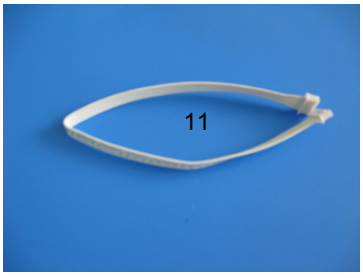



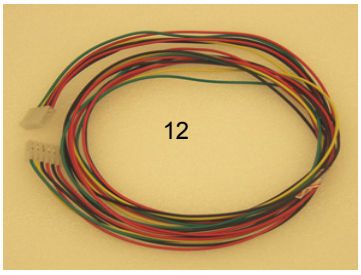



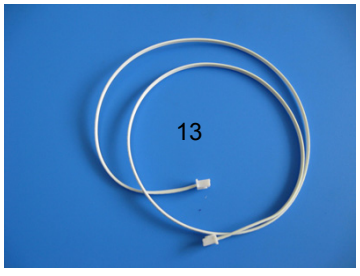



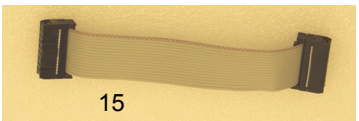



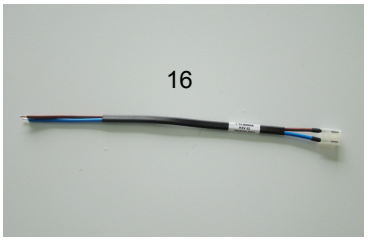



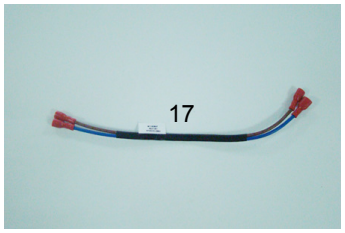



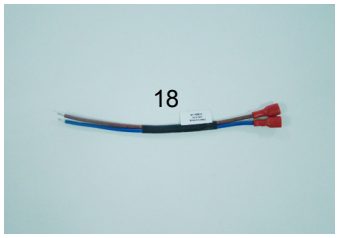



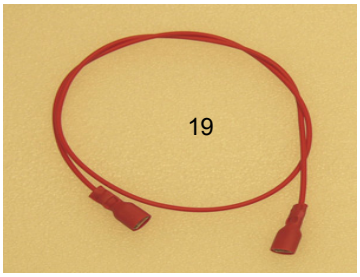






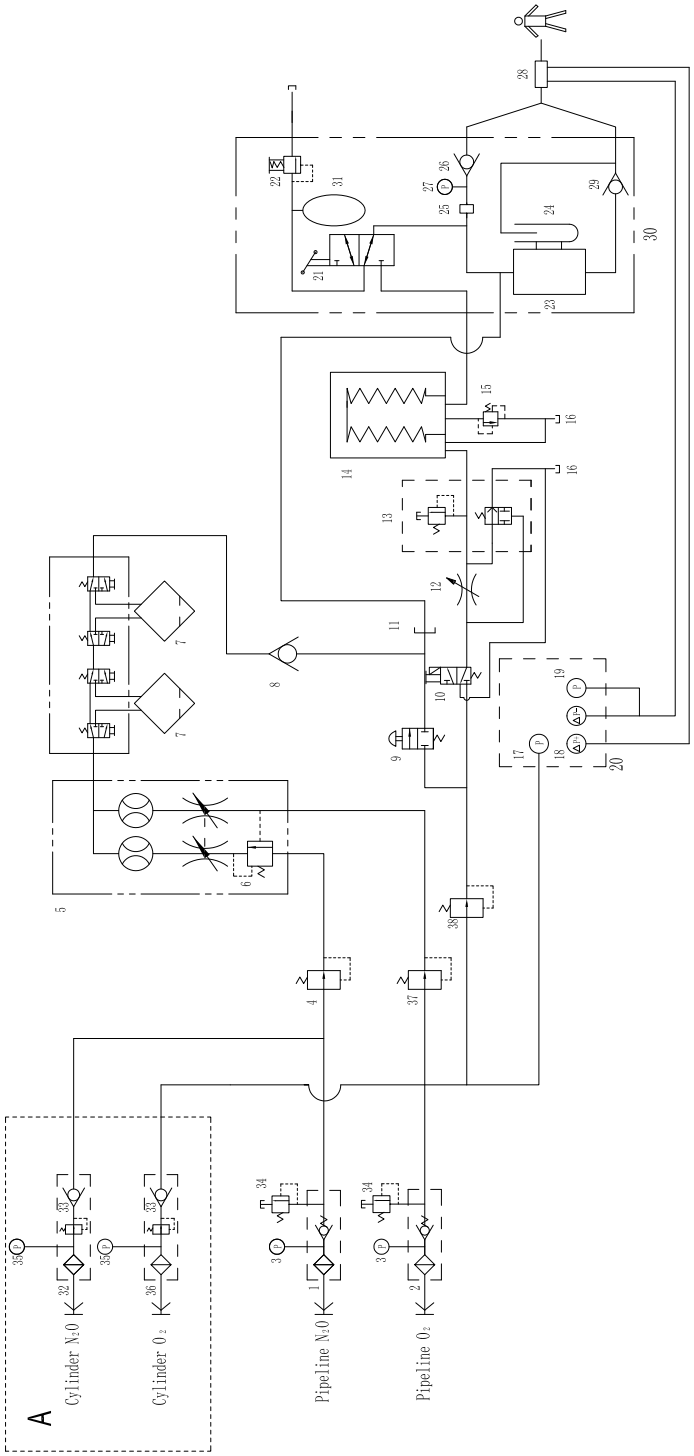

| Item | Description | Stock number |
|---|---|---|
| 1 | Main board to Interface board | M1163995 |
| 2 | Switch power to Charge board | M1163982 |
| 3 | Main board to Alarm board | M1163341 |
| 4 | Switch and Battery to Charge board | M1163622 |
| 5 | Main board to Charge board | M1163393 |
| 6 | Power socket to Common ground | M1163603 |
| 7 | Battery 1+ to Battery 2- | M1164012 |
| 8 | Switch Power to Common ground | M1163605 |
| 9 | Machine ground to Common ground | M1163601 |
| 10 | Indicator board to Display board | M1163966 |
| 11 | Encoder to Display board | M1163878 |
| 12 | Main board to Display board | M1163599 |
| 13 | Main board to Interface board | M1163985 |
| 14 | $O_2$ sensor cable | M1163988 |
| 15 | Cable from Display board to Display driver board | M1163980 |
| 16 | Fuse to AC/DC | M1163617 |
| 17 | Cable socket to switch (L)<br>Cable socket to switch (N) | M1163607 |
| 18 | Fuse holder to switch (L)<br>Fuse holder to switch (N) | M1163615 |
| 19 | Battery+ to power switch | M1163325 |

# 10 Schematics and Diagrams

**In this section**

10.1 Pneumatic circuit diagram . . . . . 10-2
10.2 Electrical cabling block diagram . . . . . 10-4
10.3 Tubing diagram . . . . . 10-5

# 10.1 Pneumatic circuit diagram



1. $N_2O$ pipeline inlet
2. $O_2$ pipeline inlet
3. Pipeline airway pressure gauge
4. $N_2O$ pressure regulator
5. Flow control and mixer
6. $O_2$ proportional control (balance regulator)
7. Vaporizers
8. Fresh gas Check valve
9. $O_2$ flush valve
10. Solenoid valve
11. Fresh gas outlet
12. $V_T$ control valve
13. Exhalation valve
14. Bellows assembly
15. Pop-off valve
16. Drive gas exhaust
17. Gas inlet pressure transducer
18. Flow sensor
19. Paw transducer
20. Control board
21. Manual/mechanical ventilation switch
22. APL valve
23. Absorber canister
24. Reservior
25. $O_2$ sensor
26. Inspiratory check valve
27. Pressure guage
28. Flow sensor adapter
29. Expiratory check valve
30. Breathing circuit
31. Manual ventilation bag
32. $N_2O$ cylinder gas inlet valve
33. Check valve
34. Safety pressure relief valve
35. Cylinder gas pressure guage
36. $O_2$ cylinder gas inlet valve
37. Cylinder pressure regulator
38. Drive gas pressure regulator

*Figure 10-1 • Pneumatic circuit diagram*

# 10.2 Electrical cabling block diagram

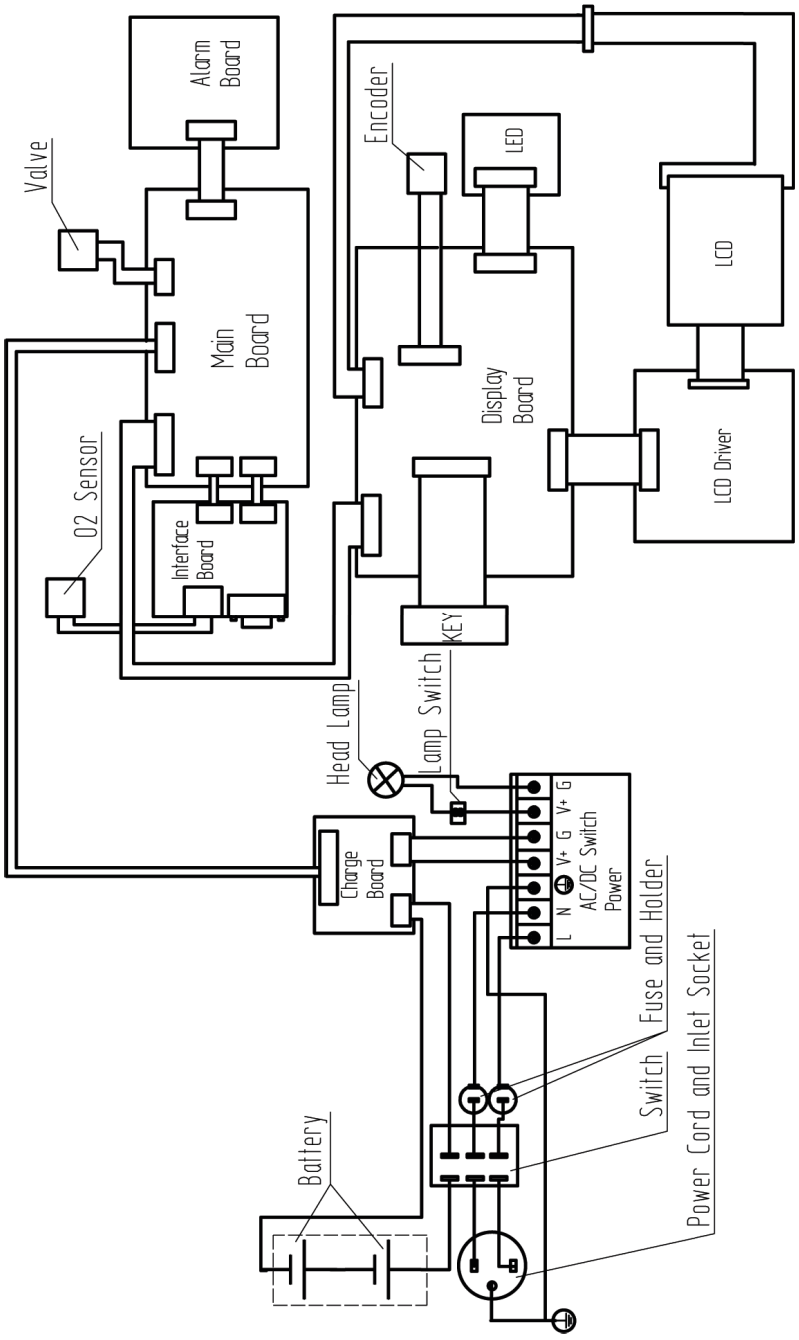



*Figure 10-2 • Functional electrical block diagram*

# 10.3 Tubing diagram

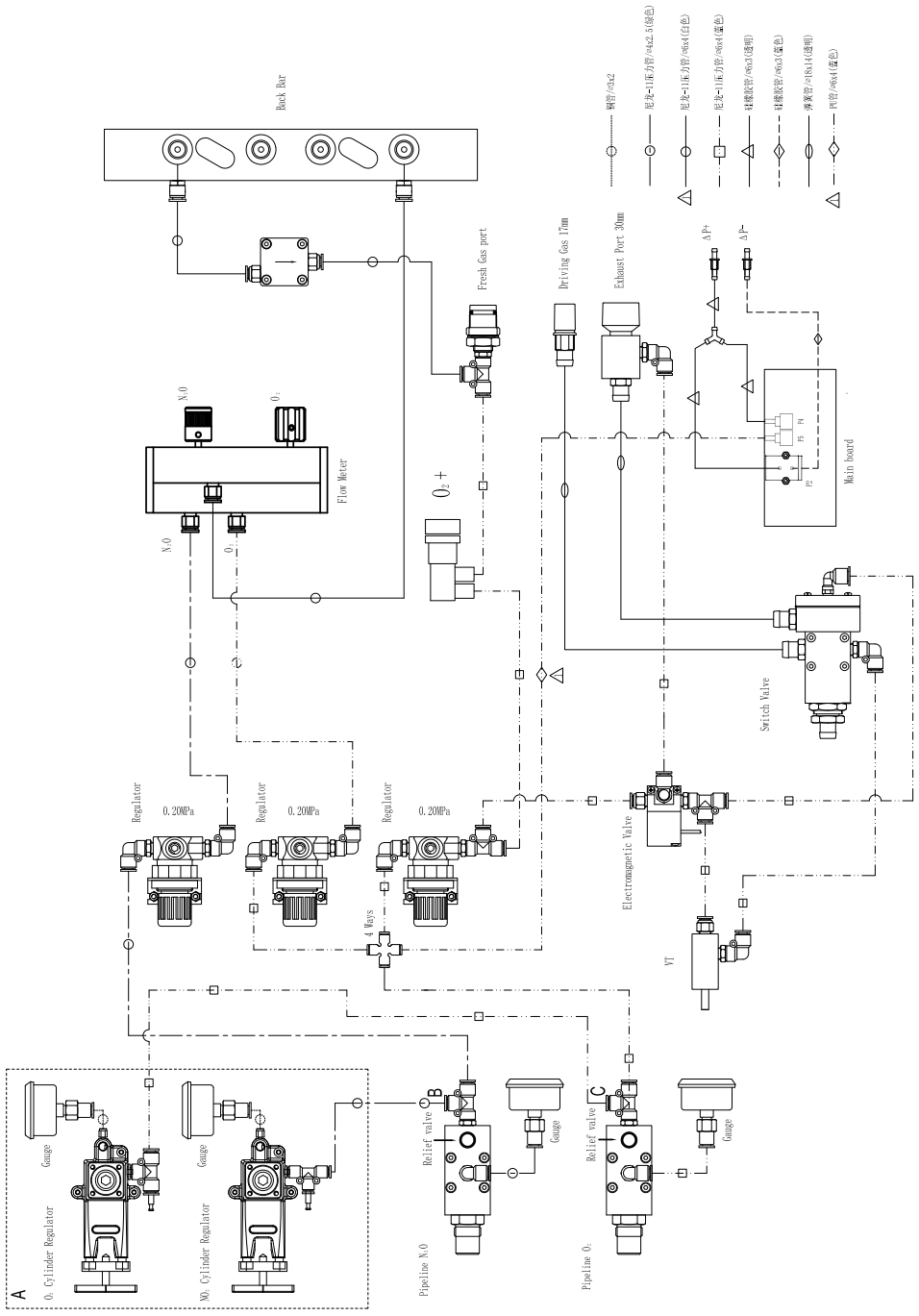



*Figure 10-3 • ZY9100 Tubing diagram*

# 11 System Specifications

## In this section


11.1 Pneumatic specifications . . . . . 11-2
11.1.1 Gas supplies . . . . . 11-2
11.1.2 Flow . . . . . 11-2
11.2 Electrical power specifications . . . . . 11-3
11.3 Breathing system specifications . . . . . 11-4
11.4 Gas scavenging specifications . . . . . 11-5
11.5 Physical specifications . . . . . 11-5
11.6 Environmental specifications . . . . . 11-6
11.7 Ventilator operating specifications . . . . . 11-7
11.7.1 Oxygen . . . . . 11-7
11.8 Ventilator accuracy data . . . . . 11-8


**Note** All displayed values are at ambient temperature and pressure dry.

# 11.1 Pneumatic specifications

## 11.1.1 Gas supplies

| | |
|---|---|
| **Pipeline gases** | $O_2$, $N_2O$ |
| **Cylinder gases** | $O_2$, $N_2O$; up to 2 cylinders total |
| **Cylinder connections** | Pin indexed (all gases) |
| **Primary regulator output pressure** | Pin indexed: The primary regulator is set to pressure less than 345 kPa (50 psi) |
| **Pressure relief valve** | Approximately 758 kPa (110 psi) |
| **Pipeline connections (filtered)** | DISS-Male; DISS-Female; AS 4059 (Australian); S90-116 (French Air Liquide); BSPP 3/8 (Scandinavian) or NIST (ISO 5359). All fittings available for $O_2$, and $N_2O$ |
| **Pressure displays** | Color coded gauges |
| **Pipeline inlet pressure** | 280-600 kPa (41-87 psi) |

**WARNING** All gases supplied to the system must be medical grade.

## 11.1.2 Flow

Flow rates: Minimum $O_2$ flow: 35 to 75 mL/min.

| Gas | Scale (one flow tube) | Scale (two flow tubes) | |
|---|---|---|---|
| $O_2$ | 0.10 - 10 L/min. | 0.1 -1.0 L/min<br>1-10 L/min | |
| $N_2O$ | 0.10 - 10 L/min. | 0.1 -1.0 L/min<br>1-10 L/min | Note: The hypoxic guard sets the nominal $O_2$ flow 25% of the total $O_2$ and $N_2O$ flow. |

Accuracy: At 20 °C with gas supply pressures at 345 kPa (50 psi) and an outlet pressure of 101.3 kPa (absolute) (14.7 psi) flowmeter accuracy agrees with VDE 3513 Part 3, Accuracy Class 2.5 or better.

Different breathing circuit pressures, barometric pressures or temperatures change the accuracy. With some conditions, these changes can be larger than the tolerances.

Flush flow: 35-75 L/min.

$O_2$ supply failure alarm and shutoff:

| | **$O_2$ Pressure:** |
|---|---|
| **$O_2$ supply failure alarm:** | 180 to 220 kPa |
| **$N_2O$ shutoff:** | 120 to 180 kPa |

# 11.2 Electrical power specifications

| | |
|---|---|
| **Voltage:** | 100-120 VAC<br>200-240 VAC |
| **Frequency:** | 50-60 Hz |
| **Input Power:** | 75 VA |
| **Fuse Specifications:** | T2AL |
| **System leakage current limit - do not exceed:** | The earth leakage current<br>Limit: NC 500uA, SFC: 1000 uA<br>The enclosure leakage current<br>Limit: NC 100 uA, SFC: 500uA<br>The patient leakage current under single fault condition with mains voltage on the applied part<br>Limit for AC: 0.5 mA; for DC 50 uA |
| **Resistance to ground:** | less than 0.1 ohm |

# 11.3 Breathing system specifications

| | |
|---|---|
| **Volume** | Ventilator side 2550 ml; bag side 1215 ml |
| **Absorbent** | 950 ml canister |
| **System leakage** | The following values are for continuous pressure and are higher than those expected during mechanical ventilation:<br>Less than or equal to 300 ml/min total at 3 kPa (0.4 psi)<br>Less than or equal to 75 ml/min for all connectors and two part tubes<br>Less than or equal to 225 ml/min for all other breathing system assemblies |
| **System compliance** | Volume of gas lost due to internal compliance (bag mode only)<br>120 ml/3kPa (30 $cmH_2O$) |
| **Pressure required to open inpsiratory or expiratory valves** | Dry: 0.65 $cmH_2O$<br>Wet: 1.2 $cmH_2O$ |
| **Pressure generated by a wet unidirectional valve** | 1.1 $cmH_2O$ |
| **Breathing system pressure range** | 0 to 60 $cmH_2O$ |
| **Pressure relief valve** | Not more than 60 $cmH_2O$ |
| **APL valve** | Approximately 0 to 55 $cmH_2O$ |

| **Breathing system resistance in bag mode *** | | | |
|---|---|---|---|
| | L/min | kPa | $cmH_2O$ |
| | 5 | 0.09 | 0.9 |
| | 30 | 0.28 | 2.8 |
| | 60 | 0.55 | 5.5 |
| * Values include patient circuit tubing and Y-piece 0.15 kPa expiratory resistance at 1l/s. | | | |
| Patient circuit tubing and breathing system configurations may affect resistance. | | | |

| **Pressure flow data (APL valve completely open)** | | |
|---|---|---|
| Flow (l/min) | Flow (l/s) | APL pressure $cmH_2O$ |
| 3 | 0.05 | 1.0 |
| 10 | 0.17 | 1.5 |
| 20 | 0.34 | 2.5 |
| 30 | 0.51 | 3.0 |
| 60 | 1.17 | 5.9 |

## 11.4 Gas scavenging specifications

| | |
|---|---|
| Passive scavenging | |
| Negative pressure relief | 0.3 $cmH_2O$ |
| Outlet connector | 30mm male taper ISO |

## 11.5 Physical specifications

**CAUTION** Do not subject the machine to excessive shock and vibration.

w Do not place excessive weight on flat surfaces or drawers.

**System**

| | |
|---|---|
| **Height:** | 1395 mm |
| **Width:** | 808 mm |
| **Depth:** | 729 mm |
| **Weight:** | 120 kg |
| **Top shelf weight limit:** | 20 kg (45 lb) |

**Casters** 12 cm (5 in) with brakes on the front casters

**Drawers** 12 cm H x 48 cm W x 39 cm D

**Ventilator display** 5.6” TFT LCD

# 11.6 Environmental specifications

## Temperature

| | |
|---|---|
| **Operation:** | 10 to 40 °C<br>Oxygen cell operates to specifications at 10 to 40 °C |
| **Storage:** | -5 to 50 °C<br>Oxygen cell storage is -5 to 50 °C, 10 to 95% Rh, 500 to 800 mm Hg |

## Humidity

| | |
|---|---|
| **Operation:** | less than 80%Rh, non-condensing |
| **Storage:** | less than 93%Rh, non-condensing |

## Altitude

| | |
|---|---|
| **Operation:** | 86 - 106 kPa |
| **Storage:** | 50 - 106 kPa |

# 11.7 Ventilator operating specifications

| | |
|---|---|
| **Ventilation methods:** | Manually and mechanically controlled. |
| **Respiration frequency:** | 4 - 65 times/min; rate of error is ± 15%. |
| **Inspiration to expiration ratio:** | 1:0.5 to 1:8; rate of error is ± 15%. |
| **Tidal volume:** | 50 mL - 1200 mL<br>At 100 - 1200 mL rate of error is ± 20%; when less than 100 mL rate of error is ± 30 mL. |
| **System compliance:** | Less than 4 mL/100 Pa. |
| **$V_E$:** | Greater than 18 L/min. |
| **Maximum safety pressure:** | Less than 6 kPa. |

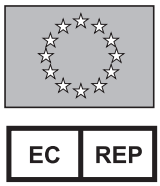
## 11.7.1 Oxygen

| | |
|---|---|
| **Display range:** | 18 to 99% $O_2$ |
| **Display resolution:** | 1% increments |
| **Sensor type;** | Galvanic fuel cell |
| **Measurement range:** | 0 to 100% $O_2$ |
| **Linearity error:** | 2% at 100% $O_2$ applied for 5 minutes |
| **Drift:** | Less than 1% volume $O_2$ /month at air |
| **Cell response time:** | Less than 12 seconds, 10 to 99%<br>response time to cell and adapters is measured using the test method in ISO 7767 |
| **Low $O_2$ alarm range:** | 20% to 70% |
| **High $O_2$ alarm setting:** | 40% to 100%<br>Low $O_2$ limit may not be set above High $O_2$ limit. High $O_2$ limit may not be set below the Low $O_2$ limit. |
| **Expected cell life:** | Less than six months shelf life (23°C room air) and sixteen months of normal operation at ambient air. |

# 11.8 Ventilator accuracy data

The minimum detectable breath size is 20 ml..

| | |
|---|---|
| **Volume control:** | Greater than 100 ml tidal volume - accuracy better than ± 20% VT |
| | Less than 100 ml tidal volume - accuracy better than ± 30 ml |
| **Resolution:** | 10 ml |
| **Note:** Gas composition errors may be in addition to the above normalized accuracy. When adding errors, positive errors can have the effect of nulling the negative errors. | |
| **Note:** Use anesthetic agent could affect the errors by approximately -0.95%/% volume agent. | |




## Corporate Office

GE Healthcare Finland Oy
Kuortaneenkatu 2
Helsinki, Finland
FI-00510
Tel 358 10 394 11
Fax 358 9 146 3310

## North America

**United States**
***Customer Service, Technical Support and Distribution Center***
Datex-Ohmeda, Inc.
PO Box 7550
Madison, WI
53707-7550, USA
Tel 1 800 345 2700
Fax 1 608 221 4384

***Equipment Service Center***
GE Healthcare
1701 Military Trail
Suite 150
Jupiter FL 33458-7887
USA
Tel 1 561 575 5000
Fax 1 561 575 5070

**Canada**
Datex-Ohmeda
(Canada) Inc.
c/o GE Canada
2300 Meadowvale Blvd.
Mississauga, Ontario
L5N 5P9
Canada
Tel 800 268 1472
Fax 905 858 6208

## Asia/Pacific

**China**
Datex-Ohmeda Pte. Ltd.
Room B416, COFCO Plaza
8 Jianguomennei Avenue
Beijing 100005, PR China
Tel 86 10 6526 9773
Fax 86 10 6526 0653

Datex-Ohmeda Pte. Ltd.
Room 1708, Yunlong Mansion
No. 122 Luoguo Street
Chengdu 610017,
PR China
Tel 86 28 661 4424
Fax 86 28 676 2703

Datex-Ohmeda Pte. Ltd.
403 Huan Shi Dong Road
Room 1602, GIE Tower
Guangzhou, 510095,
PR China
Tel 86 20 8732 2521
Fax 86 20 8732 2518

Datex-Ohmeda Pte. Ltd.
Room 2509 Lippo Plaza
No. 222 Huaihai Road (M)
Shanghai 200021,
PR China
Tel 8621 5382 5657
Fax 8621 5382 1691

Datex-Ohmeda Pte. Ltd.
Room 809, Truroll Plaza
Wusheng Road
Wuhan 430033, PR China
Tel 86 27 8571 2536
Fax 86 27 8571 2655

**India**
Datex-Ohmeda (India)
Pvt. Ltd.
Block EP & GP, Sector V
Plot XI-16, Salt Lake City
Calcutta 700091
India
Tel 91 33 3574002
Fax 91 33 3574001

**Indonesia**
Datex-Ohmeda Pte. Ltd.
Wisma Danamon Aetna
Life 19th Floor
Jln. Jend Sudirman Kav.
45-46 Jakarta 12930,
Indonesia
Tel 62 21 575 0864
Fax 62 21 575 0865

**Japan**
GE Yokogawa
Medical Systems
TRC Annex 9F
6-1-1 Heiwajima,
Ohta-ku, Tokyo 143-0006
Japan
Tel 81 3 5763 6801
Fax 81 3 5763 6838

GE Yokogawa
Medical Systems
Technical Center
TRC A Bldg. AE 4-8
6-1-1 Heiwajima
Ohta-ku, Tokyo 143-0006
Japan
Tel 81 3 5763 6850
Fax 81 3 5763 6852

**Korea**
Datex-Ohmeda Pte. Ltd.
10th Floor,
Sam Sung Building
36 - 1, Yoido-Dong,
Youngdeungpo-Ku
Seoul, Korea
Tel 82 2 786 7421
Fax 82 2 786 7420

**Malaysia**
Datex-Ohmeda Pte. Ltd.
Level 2 Bangunan
O'Connor
13 Jalan 223
46100 Petaling Jaya
Selangor, West Malaysia
Tel 60 3 754 7872
Fax 60 3 757 6948

**Singapore**
Datex-Ohmeda Pte. Ltd.
152 Beach Road
#12-05/07 Gateway East
Singapore 189721
Tel 65 391 8618
Fax 65 291 6618

**Taiwan and Philippines**
Datex-Ohmeda Pte. Ltd.
2nd Floor, No. 85,
Chien-Kuo North Road,
Sec. 2
Taipei, Taiwan
Republic of China
Tel 886-2 2515-0457
Fax 886-2 2501-9136

**Thailand**
Datex-Ohmeda Pte. Ltd.
12th Floor (Unit F) Grand
Amarin Tower
1550 New Petchburi
Road, Makasan,
Rajathevi,
Bangkok 10320, Thailand
Tel 66 2 2071012/13
Fax 66 2 207 1014

**Vietnam**
Datex-Ohmeda Pte. Ltd.
522G Nguyen
Tri Phuong St.
Ho Chi Minh City, Dist. 10
Vietnam
Tel 848 865 5875
Fax 848 862 5501

## Australia

Datex-Ohmeda Pty. Ltd.
Units 1
149 Arthur Street
Locked Bag 356
Homebush
NSW 2140
Australia
Tel 61 1300 722 229
Fax 61 2 9746 1796

## Europe

**CIS/Baltics**
Datex-Ohmeda
Regional Head Office
PO Box 70071
GR-16610 Glyfada -
Athens
Greece
Tel +30 10 9625136-7
Fax +30 10 9623687

**France**
Datex-Ohmeda S.A.S.
ZAC de Sans-Souci
1211 Chemin de la Bruyère
F-69760 Limonest
France
Tel 33 (0) 4 78 66 62 10
Fax 33 (0) 4 78 43 26 58

**Germany**
Datex-Ohmeda GmbH
Munzinger Strasse 3
79111 Freiburg
Germany
Tel +49 761 4543 0
Fax +49 761 4543 233

GE Service Center
T: 0800 434325842273
T: 0800 GEHealthcare

**Italy**
Datex-Ohmeda S.p.A.
Via Cassanese 100
20090 Segrate, Milan
Italy
Tel 39 2 21693431
Fax 39 2 26926226

**Netherlands**
Datex-Ohmeda B.V.
De Wel 18
Post Box 22
3870 CA Hoevelaken
Netherlands
Tel 31 33 2541 222
Fax 31 33 2541 223

**Spain**
Datex-Ohmeda S.L.
C/Manuel Tovar 26
28034 Madrid
Spain
Tel 34 1 334 26 00
Fax 34 1 358 12 84

**United Kingdom**
Datex-Ohmeda Ltd.
Ohmeda House
71 Great North Road
Hatfield Hertfordshire
AL9 5EN England
Tel 44 1707 263570
Fax 44 1707 260191

## Latin America, Caribbean

Datex-Ohmeda
9155 South Dadeland
Blvd. Suite 1218
Miami, FL 33156, USA
Tel 1 305 670 8540
Fax 1 305 670 2316

## Middle East/ Africa

Datex-Ohmeda
Regional Head Office
PO Box 70071
GR-16610 Glyfada -
Athens
Greece
Tel +30 10 9625136-7
Fax +30 10 9623687

GE Healthcare
P.O. Box 7550
Madison, WI 53707-7550
USA

www.gehealthcare.com

GE Healthcare Clinical Systems (Wuxi)., Ltd.
Block B-15, Wanghuang Industrial Zone Phase II,
Wuxi, Jiangsu Provence, PR China 214028
Tel. 0510-85360178
Fax 0510-85360119



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