Drägermedical
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Technical Documentation

Primus
Anaesthetic Workstation

Revision 6.0
5132.300
9036004

Because you care

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WARNING

A WARNING statement provides important information about a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION
A CAUTION statement provides important information about a potentially hazardous situation which, if not avoided, may result in minor or moderate injury to the user or patient or in damage to the equipment or other property.

NOTE
A NOTE provides additional information intended to avoid inconvenience during operation.

Definitions according to German standard DIN 31051:

Inspection	=	examination of actual condition
Maintenance	=	measures to maintain specified condition
Repair	=	measures to restore specified condition
Servicing	=	inspection, maintenance, and repair

2 Notes

This Technical Documentation conforms to the IEC 60601-1 standard.

Read each step in every procedure thoroughly before beginning any test. Always use the proper tools and specified test equipment. If you deviate from the instructions and/or recommendations in this Technical Documentation, the equipment may operate improperly or unsafely, or the equipment could be damaged.

It is our recommendation to use only Dräger parts and supplies.

The maintenance procedures described in this Technical Documentation may be performed by qualified service personnel only. These maintenance procedures do not replace inspections and servicing by the manufacturer.

The information in this Technical Documentation is confidential and may not be disclosed to third parties without the prior written consent of the manufacturer.

This Technical Documentation is for the purpose of information only. Product descriptions found in this Technical Documentation are in no way a substitute for reading and studying the Instructions for Use/Operating Manual enclosed with the product at the time of delivery.

Know-how contained in this Technical Documentation is subject to ongoing change through research and development and Dräger Medical reserves the right to make changes to this Technical Documentation without notice.

NOTE
Unless otherwise stated, reference is made to laws, regulations or standards (as amended) applicable in the Federal Republic of Germany for equipment used or serviced in Germany. Users or technicians in all other countries must verify compliance with local laws or applicable international standards.

Version 3.0_ Released_Printed on_02.06.06_General_Technical_Documentation.fm

Function Description

1 General

1.1 Medical purpose

Primus is an anaesthetic workstation for automatic and manual ventilation and spontaneous breathing, usable for adults, children and infants.

Application:

- Inhalation anesthesia in rebreathing systems.
- Inhalation anesthesia in virtually closed systems for low-flow and minimum-flow applications.
- Inhalation anesthesia in non-rebreathing systems with separate fresh gas output for connection of “Bain” or “Magill” system, for example, with a fresh gas flow of 0.2 L/min to 18 L/min.

Changed ventilation modes (software 2.n or higher):

- Volume-controlled ventilation “**Volume Mode**”. Switchable functions:
  - Synchronization.
  - Pressure support (optional).
- Pressure-controlled ventilation “**Pressure Mode**” Switchable functions:
  - Synchronization.
  - Pressure support (optional).
- Manual ventilation “MAN”.
- Spontaneous breathing “SPONT”.
- Pressure-assisted ventilation “**Pressure Support**” (optional).

Ventilation modes (up to software ≤1.06):

- Volume-controlled ventilation “IPPV, SIMV”.
- Pressure-controlled ventilation “PCV”
- Manual ventilation “MAN”.
- Spontaneous breathing “SPONT”.

Displayed values:

- Peak pressure “Ppeak”, mean pressure “Pmean”, plateau pressure “Pplat, PEEP”.
- Expiratory minute volume “MV”, tidal volume “VT”, respiratory frequency “f”.
- Inspiratory and expiratory concentrations of O2, N2O, anesthetic gas and CO2.
- System compliance and leakage minute volume.
- Functional oxygen saturation “SpO2” and pulse rate (optional).

Curve diagrams:
- Airway pressure “Paw”.
- Inspiratory and expiratory flow “V”.
- Inspiratory and expiratory concentrations of O2, CO2 and anesthetic gas.
- Plethysmogram (optional).
- P/V loops and flow/V loops (optional in software 2.n or higher).

Bargraph:
- Display of inspiratory tidal volume, expiratory tidal volume and leakage tidal volume.
- Volumeter.
- Econometer (optional in software 2.n or higher).

Time trends of measured values (trends) are additionally available.

Monitoring:
- By programmable alarm limits which can be adjusted automatically to the respective ventilation situation.

Monitored parameters:
- Airway pressure “Paw”.
- Expiratory minute volume “AMV”.
- Apnea (deactivated in heart-lung machine mode (HLM mode)).
- Inspiratory and expiratory anesthetic gas concentrations.
- Detection of anesthetic gas mixtures.
- Inspiratory O2 and N2O concentrations (breathing-phase independent measurement in HLM mode).
- Inspiratory and expiratory CO2 concentrations (breathing-phase independent measurement in HLM mode).
- Optional: Oxygen saturation (alarms deactivated in HLM mode), pulse rate.

1.2 Product classification

- Class II b, according to rules 2, 9 and 11 of the Medical Products Directive.

1.3 Protection classes

- Protection class I, type B according to EN 60601-1.
- With optional SpO2: Protection class I, type BF.

1.4 Short description of Primus

The following sections provide an overview of the Primus components.

1.4.1 Ventilator

Figure 1 Ventilator with breathing system

The electronically controlled and driven ventilator has the following features:

– Tidal volumes of 20 mL (10 mL with software 2.n or higher) to 1400 mL at frequencies of 3/min to 80/min.
– Peak flow of up to 150 L/min.
– Ventilation modes such as IPPV, PCB, SIMV (plus adjustable trigger, plus adjustable PEEP) and MAN/SPONT (up to software 1.n).
– Ventilation modes such as volume mode, pressure mode, pressure support (optional) and MAN/SPONT with switchable synchronization and pressure assistance (optional).

1.4.2 Breathing system

The breathing system comprises the following components:

– Integrated absorber, either reusable or disposable.
– Electronic interfaces for inspiratory and expiratory flow measurement.
– Direct patient section heating is integrated into the valve plate of the breathing system.
– Pneumatic interface to ventilator.
– Fresh gas isolation and minimized compliance.

1.4.3 Mixer (fresh gas metering)

The electronic mixer offers the following features:

– Gas metering for O2, N2O and AIR.
– Metering range from 200 mL/min to 18 L/min.
– Alarm monitoring for the pressure values of the central supply (CS) and the cylinder supply. LEDs on the front panel indicate the pressure status.
– ORC function for low-flow and minimum-flow applications.
– O2 flush and mechanical safety O2 adjuster (see Figure 2).

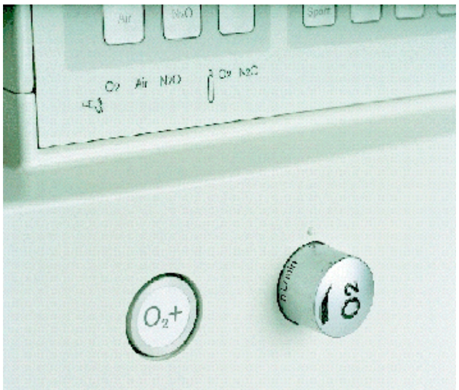

Figure 2 O2 flush (O2+), mechanical safety O2 adjuster

– Double Vapor plug-in system with interlock.
– Optional external A-cone as fresh gas outlet.

1.4.4 Monitor control panel

Figure 3 Monitor control panel

The parameters for fresh-gas flow control, ventilation, and gas monitoring are displayed on a 12-inch color screen.

The following parameters are monitored:

– Airway pressure.
– Inspiratory and expiratory flow.
– Circle system leakage.
– Inspiratory and expiratory O2 concentration.
– CO2 measurement and anesthetic gas measurement.
– Anesthetic gas detection.
– Quantitative measurement of mixed-gas values and MAC calculation (age-relevant).

A data view, a trend view (graphical) and a log view can be selected.

As from software release 2.n the following settings are possible:

– Free configuration of 3 real-time curves and different numerical values.
– Body-weight-relevant ventilator presettings (Vt and frequency) and age-relevant calculation of minimum alveolar concentration (MAC) according to “Mapleson” as well as age-relevant scaling of volumeter and influence on ventilation monitoring.

The safety concept incorporates the following tests:

– Automatic self-test with mixer test, ventilator test and test of the breathing system.
– Test and automatic calibration of all sensors.

1.4.5 Options

Primus is prepared for future upgrading with the following options:

– Integrated SpO2 measurement.
– Consumption-free O2 measurement (with software 2.n or higher).
– PAW preview – display of expected airway pressure curve when changing parameters.
– P/V and flow/V loops (with software 2.n or higher).
– Econometer function (with software 2.n or higher).
– Additional ventilation modes (e.g. autoflow, CPAP).
– Additional languages available for display texts.

1.5 Primus component structure

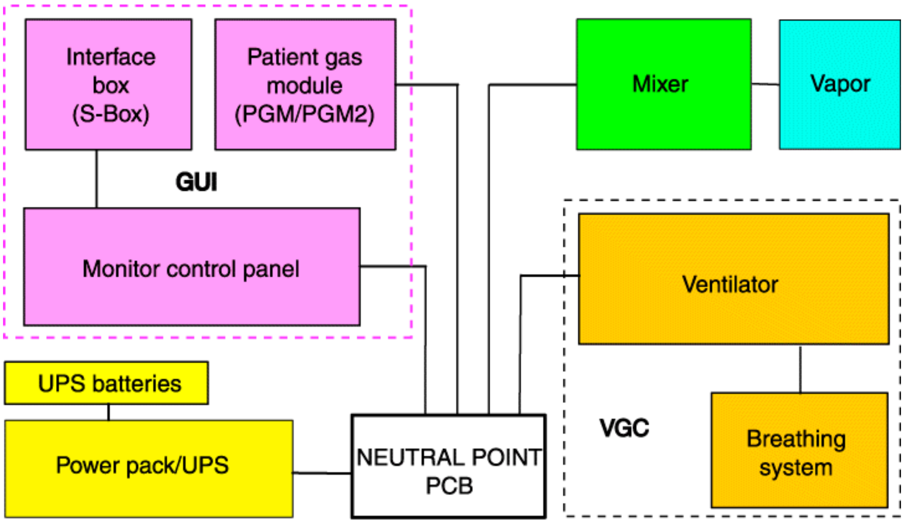

Figure 4 Primus component structure

In the “Block diagrams” section, you will find a detailed block diagram of the Primus.

1.5.1 NEUTRAL POINT PCB

The NEUTRAL POINT PCB connects the components of the Primus to the power supply, additional signal wires and the CAN bus.

More details are given in the following section on the NEUTRAL POINT PCB.

1.5.2 Graphical User Interface (GUI)

The GUI has the following components:

– On the Monitor Control Panel (**MoBi**) the ventilation mode is displayed. Limit and target values are specified and the ventilation and anesthesia parameters are displayed.
– **S-Box** (Interface box). PC interfaces and optional measuring functions such as SpO2 and BIS^{TM}.
– **P**atient **G**as **M**odule (**PGM**) for measurement of O2, CO2 and anesthetic gas.

For more details refer to the section headed GUI.

1.5.3 Mixer

The mixer comprises the following function units:

– Electronically controlled and monitored mixer.
– Vapor plug-in system for one or two conventional vaporizer types.
– External fresh gas outlet, A-cone (optional).
– Pressure monitoring for CS and compressed gas cylinders.

More details are given in the following section on the mixer.

1.5.4 VGC (Ventilation and Gas Controller)

The VGC comprises the following function units:

– Electronically controlled and driven ventilator.
– Integrated breathing system for “low flow” and “minimum flow” applications.

For more details refer to the section headed VGC.

1.5.5 Power pack

The power pack comprises:

– Switched-mode power supply unit.
– Uninterruptible power supply (UPS) with one battery pack consisting of two 12 V lead-gel batteries.
– Battery charging management.

For more details refer to the section headed Power pack.

1.5.6 Cylinder pressure regulator

The cylinder pressure regulators reduce the pressure of the optional compressed gas cylinders.

For more details refer to the section headed Cylinder pressure regulators.

The function description relating to the NEUTRAL POINT PCB follows.

2 NEUTRAL POINT PCB

The NEUTRAL POINT PCB is the central signal and voltage distributor.

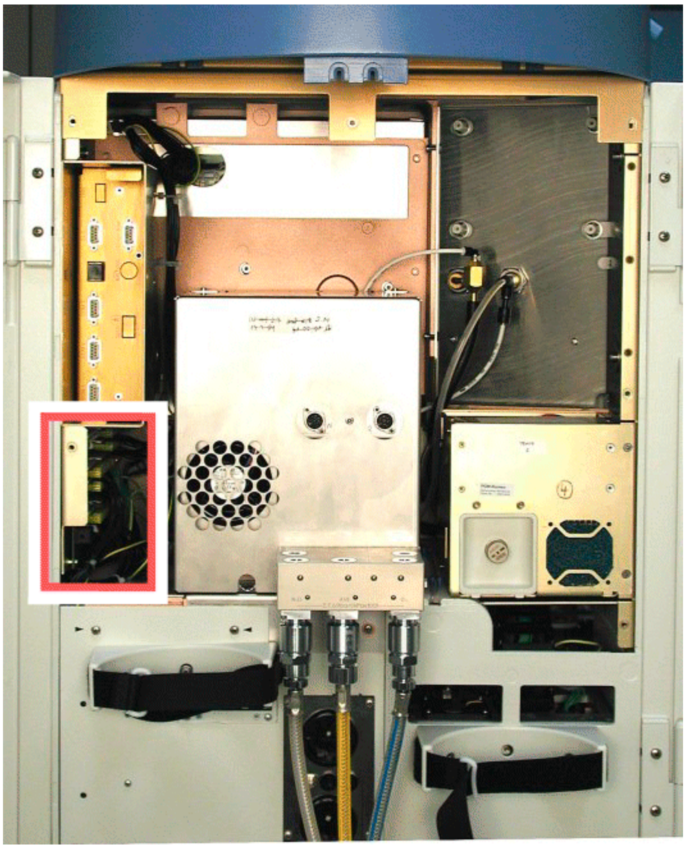

Figure 5 Location of the Neutral Point PCB

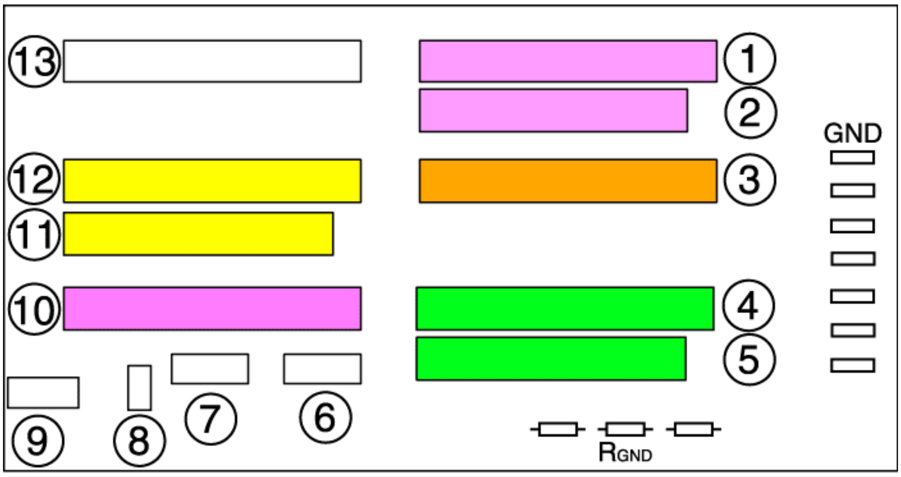

Figure 6 Component mounting diagram, NEUTRAL POINT PCB, for legend see Table 1

Table 1 Legend to Figure 6

Item	Connector
1	Monitor Control Panel (MoBi).
2	Monitor Control Panel (MoBi).
3	Ventilation and Gas Controller (VGC).
4	Mixer B.
5	Mixer A.
6	Safety O2 flow valve (microswitch).
7	Power switch (main switch).
8	Halogen lamp
9	Jack plug (production tests).
10	PGM.
11	Power pack A.
12	Power pack B.
13	Not assigned.

The function description relating to the GUI follows.

3 GUI

The following section describes the user interface ("**GUI = G**raphical **U**ser **I**nterface").

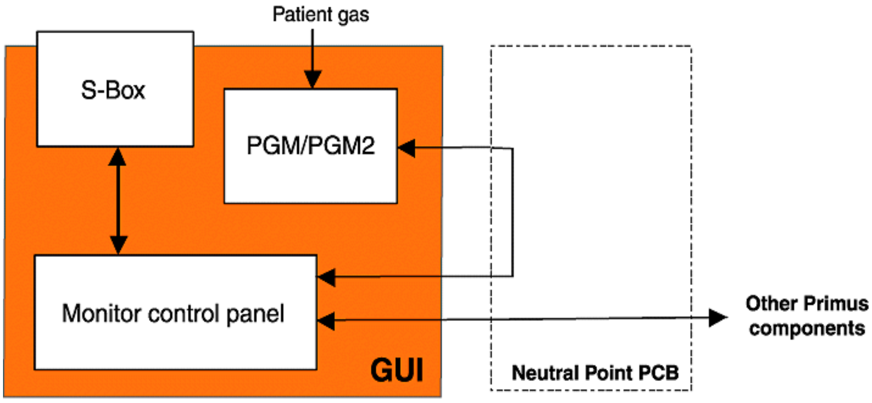

Figure 7 GUI block diagram

In the "Block diagrams" section, in the block diagram of the Primus, you will find a block diagram of the GUI.

The GUI has the following components:

– MoBi (monitor control panel).
– **S-Box** (Interface Box).
– **P**atient **G**as **M**odule (PGM). The function description relating to the Patienten Gas Module (PGM) follows.

3.1 Monitor Control Panel (MoBi)

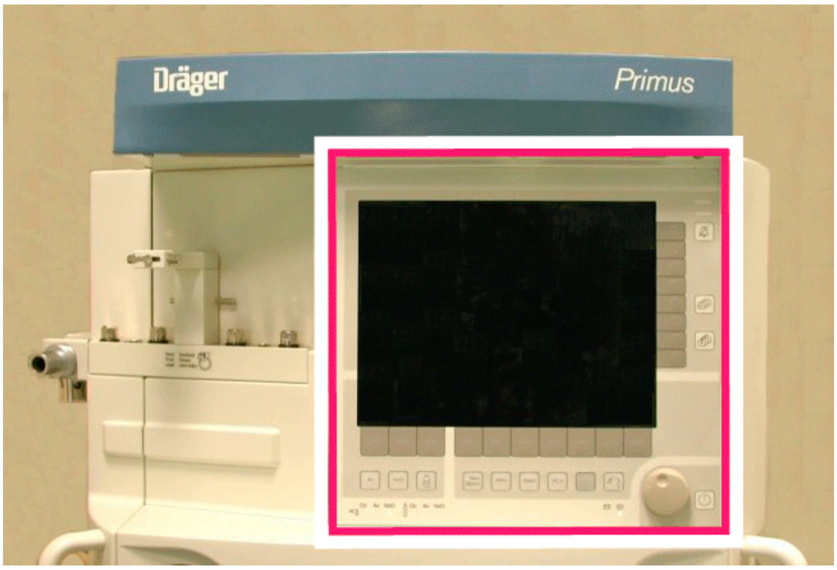

Figure 8 Position of Monitor Control Panel (MoBi)

In the "Block diagrams" section, you will find a block diagram of the MoBi.

The user and Primus communicate via the MoBi. The MoBi display presents system and patient information. It is here that the user sets the parameters and ventilation modes.

The Patient Gas Module (PGM) is connected to the GUI.

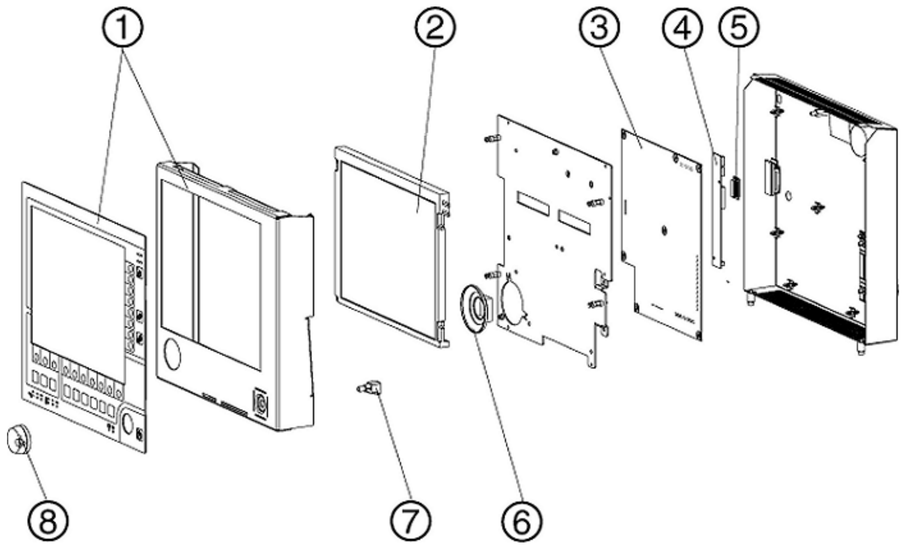

Figure 9 Exploded view of MoBi, for legend see Table 2

Table 2 Legend to Figure 9

Item	Components
1	Front panel with membrane keypad. Includes keypad membrane covering with design imprint, keys, LEDs (e.g. for CS gases), the carrier plate and the shielding, anti-glare glass screen.
2	12 inch color display (TFT, resolution: 800 x 600).
3	MONITOR CONTROL PANEL PCB (motherboard).
4	Backlight converter (display backlighting).
5	LCD800 PCB (adapter PCB for connection of different makes of display).
6	Loudspeaker.
7	Rotary transducer.
8	Control knob (central operator control element).

3.1.1 MONITOR CONTROL PANEL PCB

The following software is installed on the PCB:

– GUI software.
– Monitoring and evaluation software for the PGM.
– Software for Medibus connections and SpO2.

A 2-processor system is in operation on the PCB. It comprises a **Di**splay **Ma**ster (**DiMa**) and a **Co**mmunication **Ma**ster (**CoMa**).

The powerful **DiMa** processor incorporates the following components:

– Motorola processor (MPC823) with 48 MHz clock frequency and 32-bit address and data buses.
– Flash-PROM (program memory).
– RAM (data memory).
– CAN controller.
– RS232 interface for in-house development purposes.
– Serial communication channel for Ethernet.

The LCD controller is a programmable logic device (“PLD”). A “DRAM” serves as the video memory.

The **CoMa** processor system primarily controls communication with the other Primus components.

The CoMa incorporates the following components:

– Motorola processor (M68332) with 16.7 MHz clock frequency, internal 32-bit bus and external 16-bit data bus.
– Flash-PROM (program memory).
– RAM (data memory).
– RS232 interface for communication with the SPO2, PGM and Medibus 1 - 3 modules.
– Real-time clock (RTC).
– Keyboard and rotary knob scan, LED actuation and sound output.
– CAN interface.

Both processor systems communicate by way of a Dual-Port RAM (DPR). This memory device is battery-buffered. The buffering is provided primarily by the UPS batteries of the Primus. If they fail, the lithium battery on the MONITOR CONTROL PANEL PCB ensures data is retained.

The operating voltage is provided by an unstabilized voltage of 20 V to 30 V (Vcc). DC converters on the MONITOR CONTROL PANEL PCB generate all other voltages on the PCB.

The MoBi is interconnected over the CAN bus with the other components of the Primus (power pack, mixer and VGC).

3.2 S-Box (interface box)

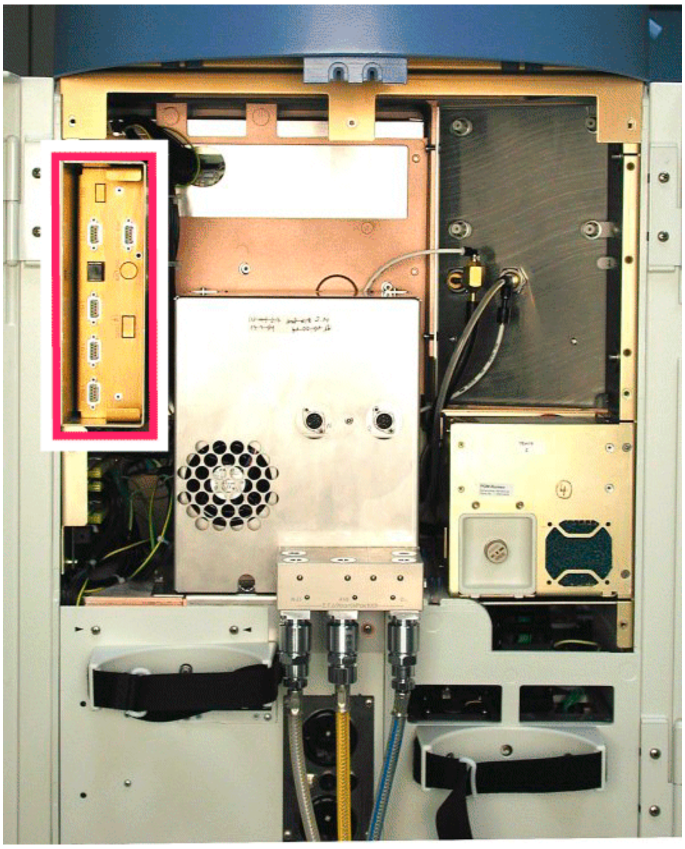

Figure 10 Position of S-Box

In the “Block diagrams” section, you will find a block diagram of the S-Box.

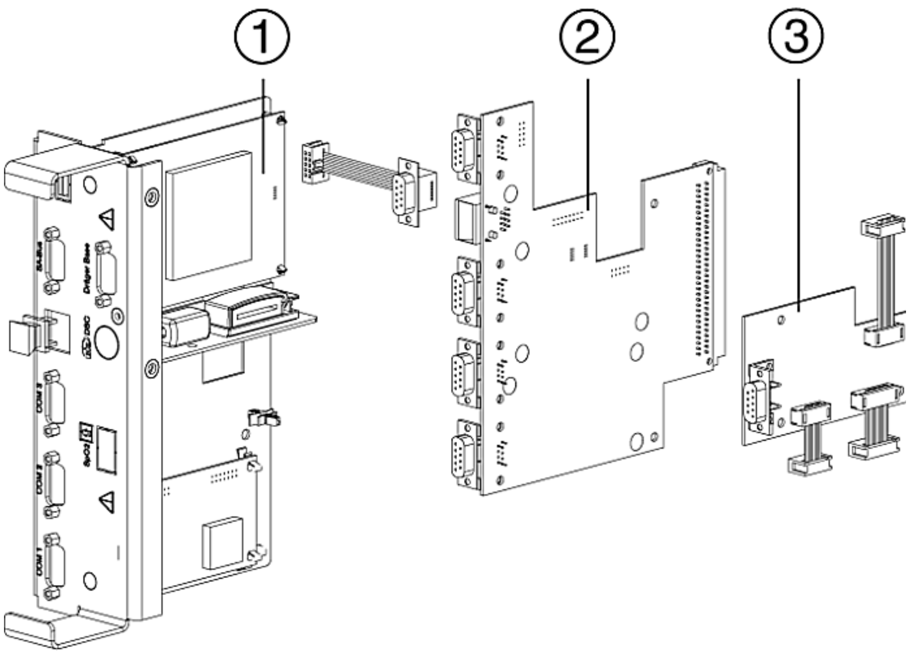

Figure 11 Layout of the S-Box, for legend see Table 3

Table 3 Legend to Figure 11

Item	Components
1	Drawer unit components fully mounted.
2	BACKPLANE PCB.
3	SpO2 ADAPTER PCB (SpO2 PCB not shown).

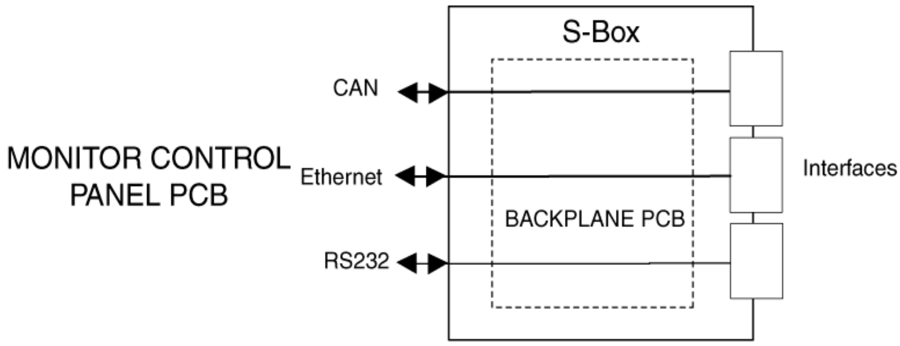

Figure 12 S-Box, block diagram

The S-Box as standard includes the BACKPLANE PCB and thus the externally available Medibus ports (COM 1-3), IV-System (Ethernet for TIVA) and a CAN port (SABUS exclusively for debug purposes).

The S-Box is prepared for the SpO2 option.

3.2.1 BACKPLANE PCB

The BACKPLANE PCB is the base component for additional modules and the insulated interfaces to external devices.

In the “Block diagrams” section, you will find a block diagram of the BACKPLANE PCB

The BACKPLANE PCB has the following functions:

– Electrical isolation and level conversion of the 3 Medibus ports (RS232).
– Connects the MoBi with the CAN (SABUS) and Ethernet (TCP/IP) connectors.
– Connects the optional hardware (SPO2, IV-System) with the MoBi (as from SW 1.n).

3.2.2 SpO2 sampling function (option)

The SpO2 sampling function has the following tasks:

– Non-invasive measurement of functional oxygen saturation in the arterial blood. The upper and lower alarm limits are monitored on the MONITOR CONTROL PANEL PCB by the CoMa processor.
– Measurement of pulse rate.
– Monitoring of the pulse rate with upper and lower alarm limits.

The SpO2 sensor essentially comprises two LEDs (light-emitting diodes) which alternatingly emit infrared light with typical wavelengths of 920 nm and 660 nm respectively. An opposing photodetector measures the radiant intensity. The sensor is placed on a part of the body on which arterial blood vessels can be X-rayed, such as the fingers, toes or bridge of the nose.

The new SpO2 sensor “DS-100A” incorporates a memory chip. The Nellcor module used in the Primus now detects only this SpO2 sensor. The new sensor is identifiable by the fact that all nine pins are present on the connector.

The SpO2 sensor is connected without a pre-amplifier to the module. The module communicates through a serial port with the MONITOR CONTROL PANEL PCB. On the BACKPLANE PCB the module is electrically isolated with 1.5 kV.

The function description relating to the Patienten Gas Module (PGM) follows.

4 Patient gas module

The PGM (patient gas module) or PGM2 is an integral part of the GUI functional unit (see function description GUI.

There are two versions of the patient gas module:
– PGM.
– PGM2.

In the “Block diagrams” section, you will find the block diagrams of the PGM/PGM2 electronics

Differences between PGM2 and PGM:

	PGM	PGM2
Anesthetic gas measurement.	IRIA.	ILCA2.
O2 sampling.	Electrochemical O2 cell.	Servomex sensor or Pato sensor.
O2 measurement electronics.	AMO O2 PUMP PCB	AMO MFM PCB.
Pump flow.	150 mL	200 mL
Flush flow.	200 mL	250 mL

4.1 Version PGM2

The following illustration shows the location of the PGM2 (rear panel of unit is open).

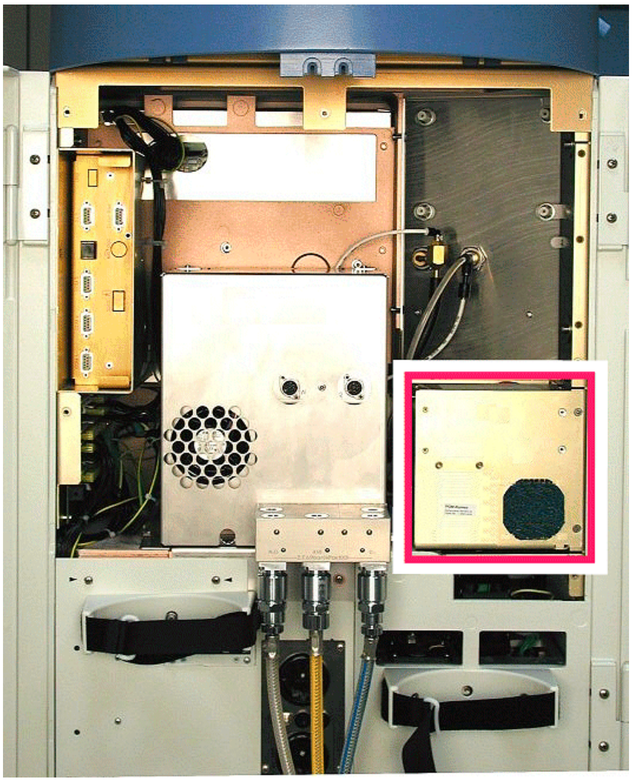

Figure 13 Location of the PGM2

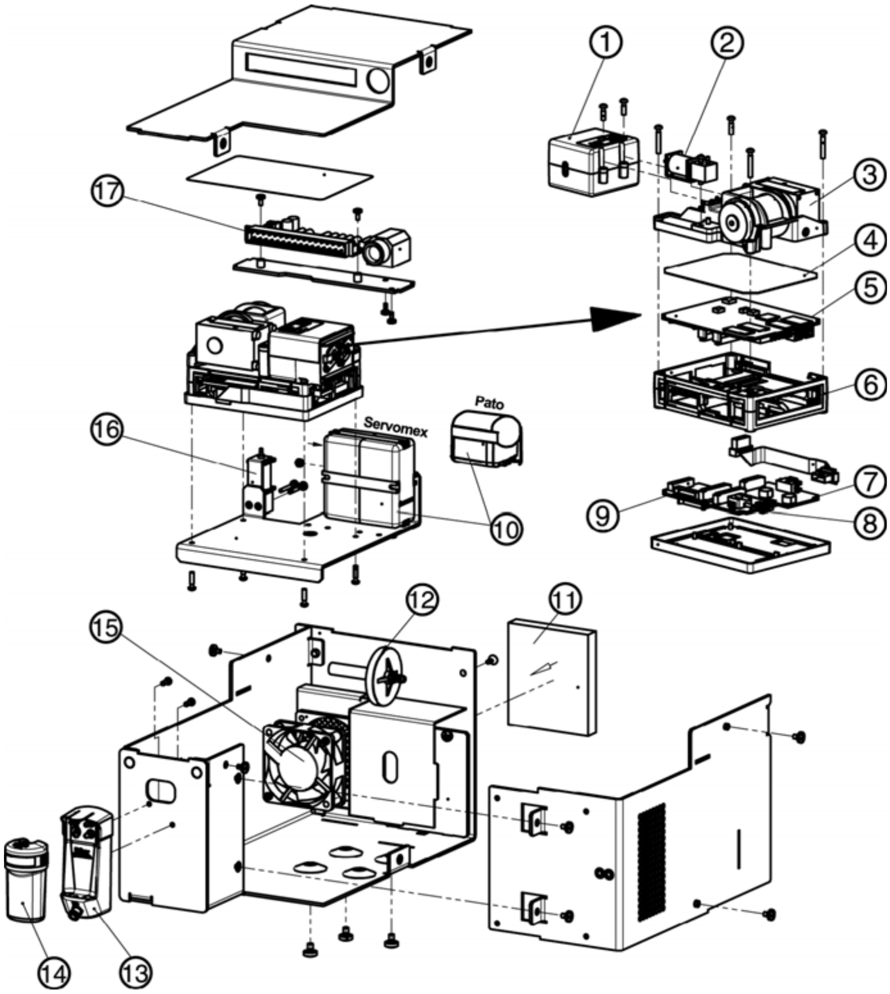

Figure 14 Exploded view of PGM2, for legend see Table 4

Table 4 **Legend to Figure 22**

Item	Component
1	ILCA2 sensor head.
2	Solenoid valve V1.
3	Pump (200 mL).
4	Insulating foil.
5	MOPS PCB (central processor).
6	PCBs mounting frame.
7	AMO ILCA2 PCB (anesthetic gas analysis).
8	AMO Flow ILCA PCB (flow measurement, pump control, and valve control).
9	AMO MFM PCB (O2 analysis).
10	“Servomex” O2 sensor or “Pato” O2 sensor.
11	Filter mat.

Item	Component
12	Bacterial filter.
13	Holder for WaterLock (water trap).
14	WaterLock.
15	Fan.
16	Solenoid valve V2.
17	Adapter board (connection board).

The PGM2 automatically detects and measures the anesthetic gas in use - Halothane, Enflurane, Isoflurane, Desflurane or Sevoflurane. It also detects and measures mixtures of two of the above anesthetic gases. If it encounters a mixture of more than two anesthetic gases, the warning “AGas mixture” is delivered.

CO2, O2 and the anesthetic gas mixture are presented as a real-time curve.

Some of the parameters measured by the PGM2 (etCO2, inCO2 etN2O, inN2O, etO2 and inO2) are presented on the GUI as digital values.

One component of the PGM2 is the water trap. The water trap is accessible from the front panel. For position see following diagram.

Figure 15 Position of water trap

4.1.1 ILCA2 function

ILCA2 is a gas measuring module for the analgesic N2O, the anesthetic gases Halothane, Enflurane, Isoflurane, Desflurane and Sevoflurane, and for measurement of mixtures. ILCA2 conforms to the measurement accuracy specified by ISO standards.

The ILCA2 module is capable of automatically detecting the above mentioned gases.

ILCA2 module design

The ILCA2 module principally comprises the following components:

– Sensor head with double-optics, pressure sensor, and electronics.
– Diaphragm pump.
– Pneumatic low pass.
– Solenoid valve for zero calibration.
– Module rack with 3 PCBs.

In the “Block diagrams” section, you will find a block diagram of the ILCA2 module.

Sensor head

The sensor head houses 2 PCBs with the following functions:

– Pre-amplifier PCB for the two multi-channel detectors.
– Base PCB with emitter activation, temperature regulation, absolute pressure measurement and a serial EEPROM holding the serial number, setting and calibration data for operation of the sensor head.

The module rack of the ILCA2 module contains 4 additional PCBs with the following functions:

– AMO FLOW ILCA PCB - Control of the diaphragm pump and the zero calibration solenoid. A serial EEPROM stores the necessary data such as the serial number, hardware/software revision, control parameters etc.
– AMO ILCA2 PCB - Here the necessary supply voltages are generated and the data transfer from the ILCA2 sensor to the MOPS PCB is implemented.
– AMO MFM PCB - This circuit board amplifies the signal from the Servomex sensor.
– MOPS PCB - Primarily delivers the data for further processing via an RS 232 interface.

Measurement principle

The measurement principle of the ILCA2 module is based on the absorption of infrared light by the various media (see Figure 16). The sensor head consists of a double measuring head with one emitter each which emits a broad spectrum of infrared light. The light beam passes through a cuvette, through which the gas being measured is also drawn by means of a diaphragm pump. Downstream of the cuvette the light beam hits a multi-channel detector with IR filters. The filters are dimensioned so that only the light in the absorption wavelength of the measured gases is transmitted. If a gas is present light is absorbed. The higher the partial pressure of the gas, the greater the absorption of the light and the smaller the sensor signal.

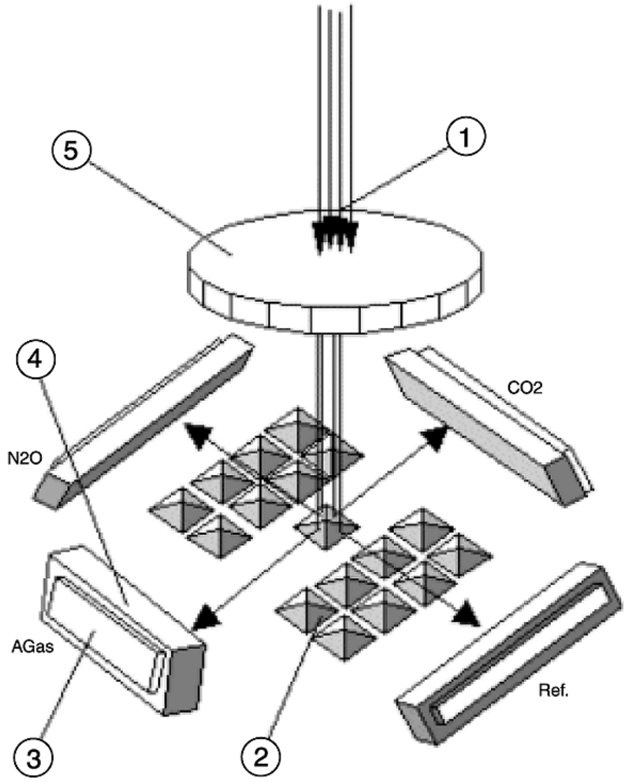

Figure 16 Principle of multi-channel detector with IR filters

Table 5 Legend to Figure 16

Item	Meaning
1	Infrared light.
2	Beam splitter.
3	Sensor chip.
4	Infrared filter.
5	Sensor window.

4.1.2 PGM2 with Pato O2 sensor

The oxygen analyser measures the patient's O2 concentration at the Y-piece.

Measurement principle

The oxygen sensor uses the effect that oxygen molecules are attracted very much more strongly to a magnetic field (paramagnetism) than the molecules of other gases, which in some cases are repelled by the magnetic field (diamagnetism).

Layout

The Pato houses a cuvette containing a sensor system, the cuvette is located between two electromagnets.

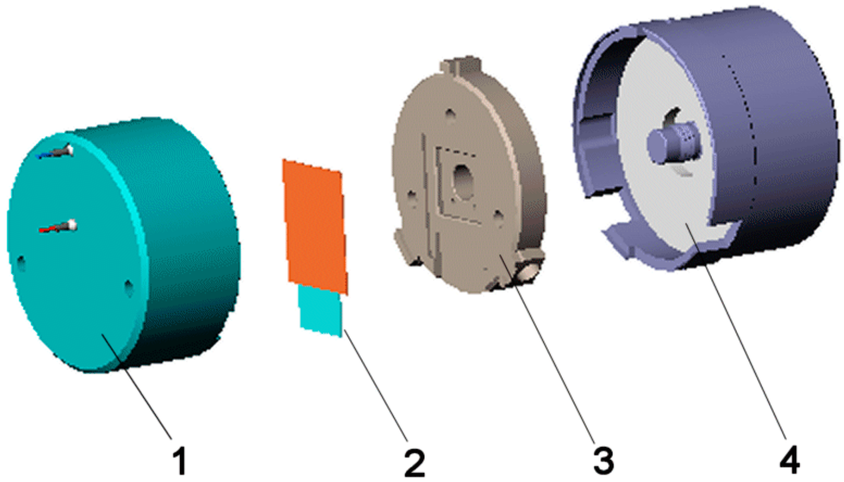

Figure 17 Pato system structure

Table 6 **Legend to Figure 17**

Item	Component
1	Magnetic system
2	Sensor system
3	Cuvette
4	Magnetic system

This sensor system comprises the gas path (cuvette) and the sensor inside the measurement compartment.

The measurement compartment is designed as a bulge in the gas path.

The sensor consists of a heating element and thermoelement assembly.

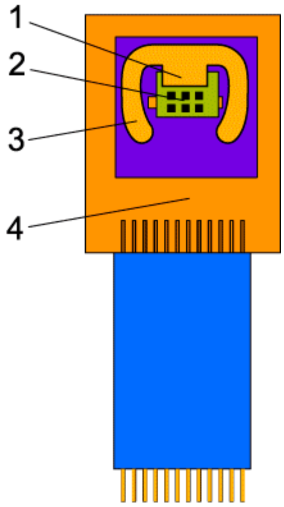

Figure 18 Pato sensor system

Table 7 Legend to Figure 18

Item	Name
1	Measurement compartment
2	Heating element and thermoelement assembly
3	Gas path
4	Sensor element

Function

The electromagnets generate an alternating field.

The sampling gas flows through the cuvette and the gas path in the sensor system.

The heating element heats up the sampling gas to operating temperature, the thermoelement measures the temperature.

The outer alternating magnetic field influences the mobility of the oxygen contained in the sampling gas.

The changing mobility alters the heat transfer in the sampling gas which results in the thermoelement measuring a changing temperature.

The exent of the heat transfer variation depends on the oxygen concentration in the sampling gas.

The ILCA2 module converts the temperature change in an oxygen concentration value which is then displayed on the connected patient monitor.

4.1.3 PGM2 with Servomex O2 sensor

The Servomex sensor uses the fact that oxygen molecules have a stronger paramagnetic characteristic (attracted to a magnetic field) than the molecules of other gases that are sometimes even diamagnetic (repulsed by a magnetic field).

The following position numbers refer to Figure 19.

The permanent magnets (7 and 12) in the sensor create a symmetric magnet field (11). The magnet field contains two nitrogen-filled quartz spheres (9) arranged in the form of dumbbells. The dumbbell is suspended rotating from a taut platinum band. A reel of platinum wire is wound around the dumbbell as a feedback coil (10).

When oxygen flows through the measuring cell (1 and 6), the magnetic field (11) changes based on the paramagnetic effect of the oxygen dependent on its concentration. This rotates the quartz spheres (9) of the dumbbells out of the magnetic field.

A mirror attached to the pivot of the dumbbell (8) reflects a light beam (5) onto a photocell pair (4). The photocells are connected to an amplifier (3) of which the output signal supplies the feedback coil (10) of the dumbbell. The dumbbell is rotated back by the current in the feedback coil (10) until the light beam (5) is illuminating both photocells (4) equally by means of the mirror (8). Then the system is at equilibrium. The current flowing through the feedback coil (10) is proportional to the paramagnetism of the oxygen and thus a measure of the oxgen concentration, which is displayed on the display instrument (2).

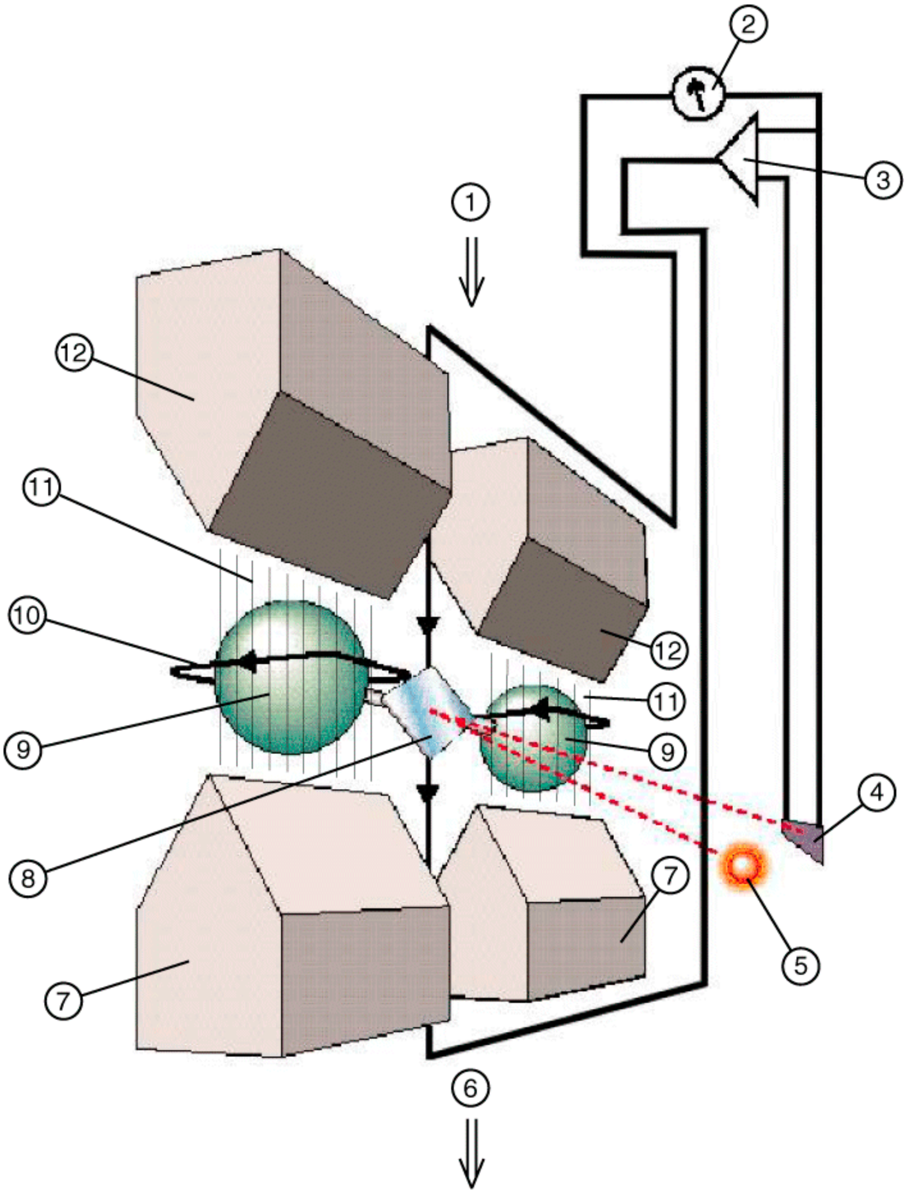

Figure 19 Schematic representation of the Servomex sensor

4.1.4 Pneumatics of the PGM2

In the “Block diagrams” section, you will find a schematic of the PGM2 pneumatic components.

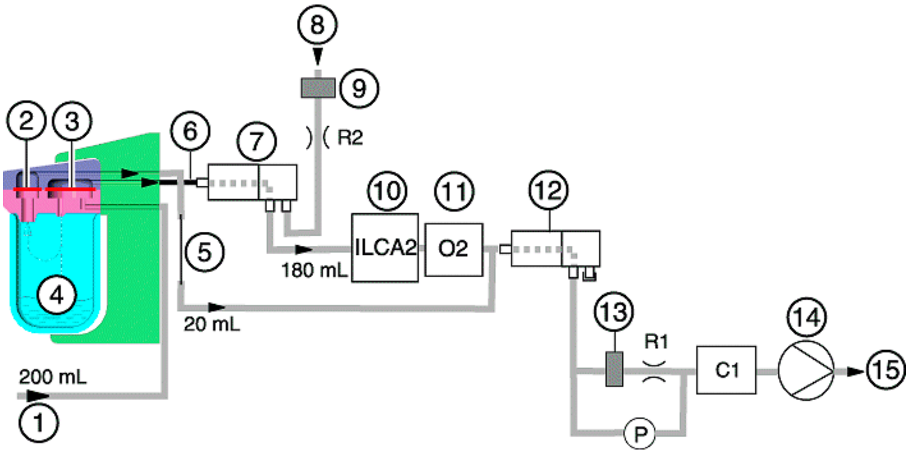

Figure 20 Schematic of PGM2 pneumatic components, see legend Table 10

Table 8 Legend to Figure 24

Item	Meaning
1	Sampling gas.
2	Goretex membrane (flow 20 mL).
3	Goretex membrane (flow 180 mL).
4	Water trap.
5	Teflon tube.
6	Nafion tube.
7	ILCA2 solenoid valve (pneutronics).
8	Room air (calibration).
9	Filter.
10	ILCA2 (anesthetic gas analysis).
11	O2 sensor.
12	Solenoid valve (pneutronics).
13	Filter.
14	OLC pump 200 mL (DC diaphragm pump).
15	Gas outlet.
C1	Volume.
R1	Restrictor.
R2	
P	Differential pressure sensor.

The item numbers and abbreviations occurring in this section relate to Figure 24.

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The sample gas (1) enters the water trap (4). In the water trap are two Goretex membranes (1, 2). The moisture in the sample gas cannot pass through the Goretex membranes. This prevents water from reaching the ILCA2 (flow approx. 180 mL/min). Consequently no water can penetrate the bypass branch (flow approx. 20 mL/min) either. An approximately 10 cm long Teflon tube (5) serves as a resistor, and meters the flow in the bypass branch.

If the water in the water tank reaches to the level of the membranes, they are closed off by the water. An error message is displayed on-screen. A filling level detector is therefore no longer necessary.

The sample gas flows through the Nafion tube (6) and is additionally dried. The sample gas then passes on to the ILCA2 solenoid valve (7). Depending on the valve switching state, either the sample gas (1) or, during calibration, the room air (8) reaches the ILCA2. The sample gas is fed through the cuvette (10) of the ILCA2 and passes on to the “Servomex” O2 sensor (11).

When the Primus is in leak test mode, and the PGM2 in standby, the pump (14) is shut off. Whenever the pump is off, the solenoid valve (12) interrupts the gas flow to the system. This does not increase the leakage value.

The following low-pass filter comprises the restrictor (R1) and the volume (C1).

R1 is dimensioned as follows:

– R1 is small enough for the pump not to be placed under unnecessary strain.
– R1 is large enough so that the pump pressure surges occurring in the ILCA2 cuvette do not impair the signal ratio and noise ratio in gas sampling.
– The pressure drop at R1 is measured. The measured value is used for pump control.

The pneumatic low-pass components are integrated into the module housing of the electronics. The low-pass minimizes the pressure surges generated by the pump. Downstream of the pneumatic low-pass filter the sample gas passes to the pump.

The flow through the pump (14) in measuring mode is approx. 200 mL/min (flush flow approx. 250 mL/min). The supply voltage of the pump is in the range from 2.5 VDC to 7.5 VDC at a current of up to 150 mA.

Dimensioning of R2:

In a calibration, the switching of the ILCA2 solenoid valve (7) is tested with the pressure sensor (in the sensor head). In this case the pressure drop via R2 and the filter (9) must be significantly less than the minimum pressure drop through the water trap and the sample gas tube. In the event of an error, an error log entry is generated.

In substitution for a flowmeter, the pressure is measured with a differential pressure sensor (P) upstream and downstream of the low pass.
The AMO FLOW ILCA PCB controls the pump with the pressure signal as the input variable.

In order to ensure an adequate measurement accuracy, an automatic zero calibration is performed periodically. For this, room air is drawn in by the diaphragm pump through the ILCA2 solenoid (zero calibration valve) and passed through the sensors. The zero calibration valve is controlled by the AMO Flow ILCA PCB.

Further measures to safeguard measurement accuracy:

– Heating of the cuvette so the intensity of the light beam is not affected by condensation. As the temperature also influences the measurement result, the cuvette temperature is kept constant by means of a control loop.
– The pressure in the cuvette likewise influences the result. So the pressure is measured and entered as a correction variable into the system.

4.2 Version PGM

The following diagram shows the position of the PGM with the rear panel open.

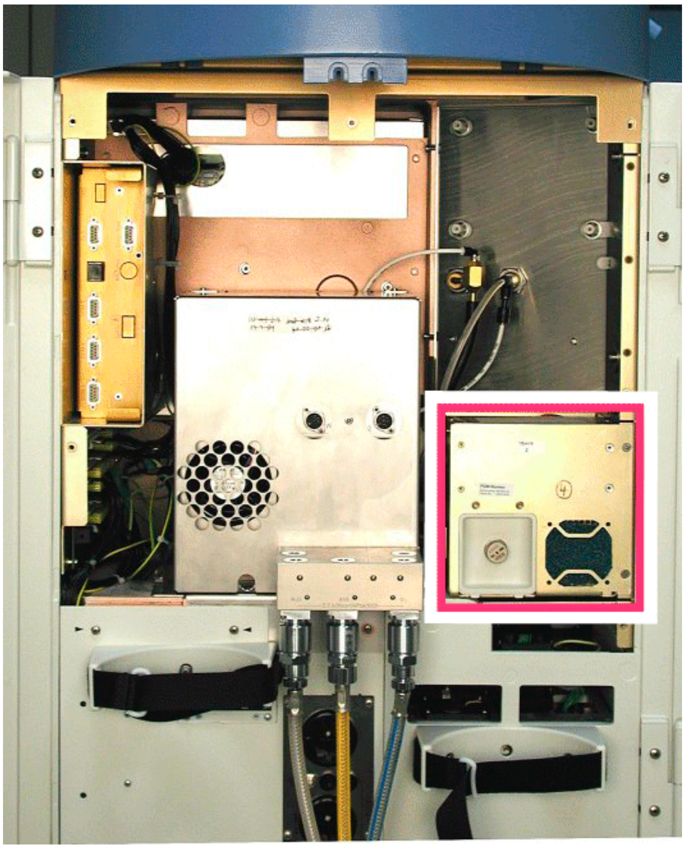

Figure 21 Position of the Patient Gas Module (PGM)

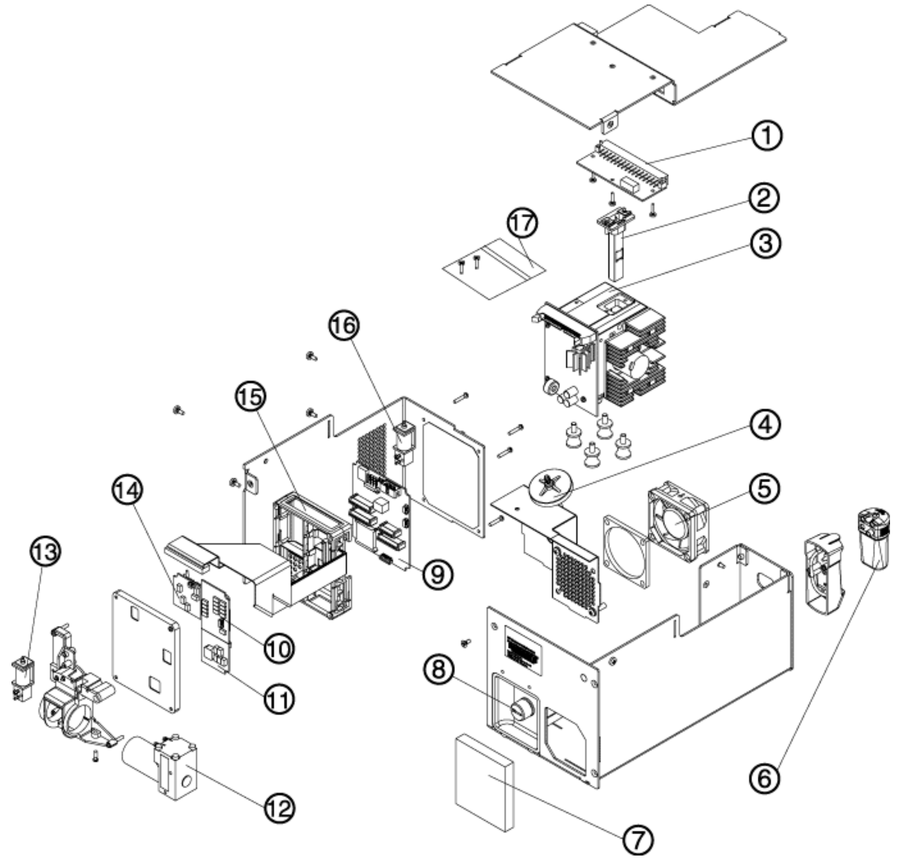

Figure 22 Exploded view of the PGM, legend Table 9

Table 9 **Legend to Figure 22**

Item	Components
1	Connection board.
2	IRIA cuvette.
3	IRIA = “Infrared Rapidly Identifying Analyzer”. Sensor head of anesthetic gas analyzer.
4	Bacterial filter.
5	Fan.
6	Water trap.
7	Filter mat.
8	O2 cell (fast O2 analysis).
9	MOPS PCB (electronics).
10	AMO IRIA PCB (anesthetic gas analysis).
11	AMO O2 PUMP PCB (O2 analysis).
12	Pump.
13	ILCA solenoid valve (room air/sampling gas).

Item	Components
14	AMO FLOW ILCA PCB (actuation and monitoring of valve, pump and flow values).
15	ILCA component carrier (for items 9 - 14).
16	ILCA solenoid valve (leakage).
17	Board (Teflon plate).

The PGM automatically detects and measures the anesthetic gas in use - Halothane, Enflurane, Isoflurane, Desflurane or Sevoflurane. It also detects and measures mixtures of two of the above anesthetic gases. If it encounters a mixture of more than two anesthetic gases, the warning “AGas mixture” is delivered.

CO2, O2 and the anesthetic gas mixture are presented as a real-time curve.

Some of the parameters measured by the PGM (etCO2, inCO2 etN2O, inN2O, etO2 and inO2) are presented on the GUI as digital values.

One component of the PGM is the water trap. The water trap is accessible from the front panel. For position see following diagram.

Figure 23 Location of the water trap

4.2.1 PGM pneumatic components

In the “Block diagrams” section, you will find a schematic of the PGM pneumatic components.

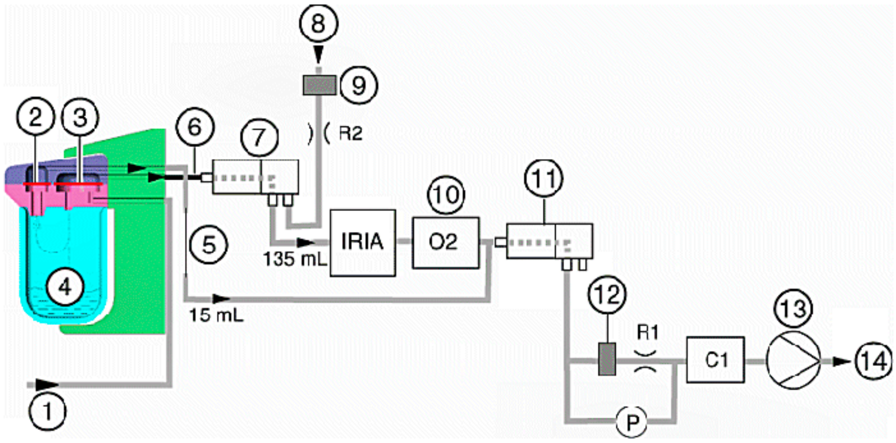

Figure 24 Schematic of PGM pneumatic components, legend Table 10

Table 10 Legend to Figure 24

Item	Meaning
1	Sampling gas.
2	Goretex membrane (flow 15 mL).
3	Goretex membrane (flow 135 mL).
4	Water trap.
5	Teflon tube.
6	Nafion tube.
7	ILCA solenoid valve (pneutronics).
8	Room air (calibration).
9	Filter.
10	Electrochemical O2 cell (fast O2 analysis).
11	Solenoid valve (pneutronics).
12	Filter.
13	Pump (DC diaphragm pump).
14	Gas outlet.
C1	Volume.
R1	Restrictor.
R2	
P	Differential pressure sensor.

The item numbers and abbreviations occurring in this section relate to Figure 24.

The sample gas (1) enters the water trap (4). In the water trap are two Goretex membranes (1, 2). The moisture in the sample gas cannot pass through the Goretex membranes. This prevents water reaching the IRIA (flow 135 mL/min). Consequently no water can penetrate the bypass branch (flow approx. 15 mL/min) either. An approximately 9 cm long Teflon tube (5) serves as a resistor, and meters the flow in the bypass branch.

If the water in the water tank reaches to the level of the membranes, they are closed off by the water. An error message is displayed on-screen. A filling level detector is therefore no longer necessary.

The sample gas flows through the Nafion tube (6) and is additionally dried. The sample gas then passes on to the ILCA solenoid valve (7). Depending on the valve switching state, either the sample gas (1) or, during calibration, the room air (8) reaches the IRIA. The sample gas is fed through the IRIA cuvette and passes on to the O2 sensor (10).

When the Primus is in Leak Test mode, and the PGM in Standby, the pump (13) is shut off. Whenever the pump is off, the solenoid valve (11) interrupts the gas flow to the system. This does not increase the leakage value.

The following low-pass filter comprises the restrictor (R1) and the volume (C1).

R1 is dimensioned as follows:

– R1 is small enough for the pump not to be placed under unnecessary strain.
– R1 is large enough so that the pump pressure surges occurring in the IRIA cuvette do not impair the signal ratio and noise ratio in gas sampling.
– The pressure drop at R1 is measured. The measured value is used for pump control.

The pneumatic low-pass components are integrated into the module housing of the electronics. The low-pass minimizes the pressure surges generated by the pump. Downstream of the pneumatic low-pass filter the sample gas passes to the pump.

The flow through the pump (13) in measuring mode is approx. 150 mL/min (flush flow approx. 200 mL/min). The supply voltage of the pump is in the range from 2.5 VDC to 7.5 VDC at a current of up to 150 mA.

Dimensioning of R2:

In a calibration, the switching of the valve is tested with the pressure sensor in the IRIA. In this case the pressure drop via R2 and the filter (9) must be significantly less than the minimum pressure drop through the water trap and the sample gas tube. In the event of an error, an error log entry is generated.

4.3 Operating modes

4.3.1 "Reduced Accuracy" mode (PGM only)

The sampling bank of the PGM/PGM2 is in so-called “Reduced Accuracy” mode after approx. 5 minutes. During that time, the measured values are outside the specified accuracy. During that time, a calibration of the O-point is carried out every 2 minutes.

4.3.2 "ISO" mode (ISO accuracy) (PGM/PGM2)

Following “Reduced Accuracy” mode the sampling bank has ISO accuracy. After a maximum of 30 minutes the switch is made to “Full Accuracy” mode.

4.3.3 "Full Accuracy" mode (PGM only)

After power-up, the IRIA takes around 30 minutes to reach its operating temperature for maximum accuracy. During this time, a calibration of the O-point is carried out every 2 hours.

4.3.4 "Standby" response of the Primus (PGM/PGM2)

The filter wheel in the IRIA (PGM only) and the sampling gas pump are switched off after approximately 30 minutes. After 90 minutes the emitter and the heater are shut off. This is done to extend service life and reduce noise.

4.3.5 IRIA/ILCA2 calibration

The IRIA/ILCA2 is calibrated automatically. The user cannot initiate manual calibration. Nor is calibration possible during the ventilator leak test. This prevents a possible increase in volume resulting from intake of ambient air.

4.3.6 Auto-Wake-up function

If the Primus is switched to a ventilation mode following a cold-start, the alarm monitoring is initially disabled. This applies to all the parameters of the CO2 sampling bank except the alarm CO2/AGENT INOP. Alarm monitoring is activated when a respiration phase is detected.

4.3.7 O2 sensor/Servomex

The electrochemical O2 sensor and the Servomex sensors are calibrated during the cold start. In operation, the electrochemical O2 sensor is calibrated automatically every 8 hours. The Servomex sensor is calibrated every 2 hours. During calibration, the ILCA/ILCA2 solenoid valve is switched to room air.

When the zero point of the IRIA/ILCA2 is calibrated the plausibility of the electrochemical O2 sensor signal is also checked. The Servomex sensor is calibrated with 21% O2.

If non-linearity occurs, the user is offered a 100% O2 calibration. In 100% O2 calibration the user is responsible for connecting 100% O2 to the sampling line.

4.4 PGM/PGM2 electronics

4.4.1 MOPS PCB (PGM/PGM2)

In the “Block diagrams” section, you will find a block diagram of the MOPS PCB

“**MOPS**” stands for “Modular Platform for Sensors”. It is a modular concept by which suitable sensor components (pneumatic and mechanical components) can be operated together by way of a processor board.

The resultant arrangements are supported by a software program with a uniform communications interface. In this way, the user is provided with a uniform view of the parameters on offer, irrespective of the components deployed.

The software is automatically configured for the connected components when the system starts up.

With this concept, different gas sampling modules (for example “ILCA2” and “IRIA”) can be configured for specific customer needs using standard components.

The MOPS PCB calculates the values of the patient parameters and controls the sensor head signals.

4.4.2 AMO IRIA PCB (PGM)

“AMO” stands for “Adapter MOPS”. The PCB has the following tasks:

- Convert digital target values from the MOPS PCB into analog voltages for the IRIA emitter.
- Generate the IRIA supply voltage.
- Data transfer from the IRIA sensor to the MOPS PCB (data evaluation).

4.4.3 AMO ILCA2 PCB (PGM2)

“AMO” stands for “Adapter MOPS”. The PCB has the following tasks:

- Convert digital target values from the MOPS PCB into analog voltages for the ILCA2 emitter.
- Generate the ILCA2 supply voltage.
- Data transfer from the ILCA2 sensor to the MOPS PCB (data evaluation).

4.4.4 AMO O2 PUMP PCB (PGM)

The PCB has the following task:

- Transfer the O2 sensor data to the MOPS PCB (data evaluation).

4.4.5 AMO MFM PCB (PGM2)

The PCB has the following task:

- Transfer the O2 sensor data (Servomex) to the MOPS PCB (data evaluation).

4.4.6 AMO FLOW ILCA PCB (PGM/PGM2)

The AMO FLOW ILCA PCB controls the pump and the valves of the PGM/PGM2. The PCB is controlled and powered by the MOPS PCB. The actual regulation of the pump flow is handled by the software of the controller on the MOPS PCB.

The AMO FLOW ILCA PCB holds the following components:

– A DC/DC converter generates the pump voltage (2.5 - 7.5 V/DC). The output voltage of the DC/DC converter is controlled with a digital potentiometer on the PCB. The digital potentiometer is regulated by the MOPS PCB.
– The output stage to operate the valve.
– Service LEDs for the pump voltage, the valves and the supply voltage
– The temperature-compensated differential pressure sensor for flow measurement. The sensor offset is corrected with a digital potentiometer.
– The analog electronics for evaluation of the pump voltage, pump current, valve current and differential pressure.

The flow is measured by way of the differential pressure of restrictor R1 plus the upstream (sintered-metal) filter. The measuring range is 0 mbar to 350 mbar.

The AMO FLOW ILCA PCB is connected directly to a 60-pin connector on the MOPS PCB and is detected automatically by the MOPS PCB.

The function description relating to the mixer follows.

5 Mixer

This section describes the mixer for the AIR, N2O and O2 gases. The newly generated fresh gas is fed through the vaporizer to the VGC.

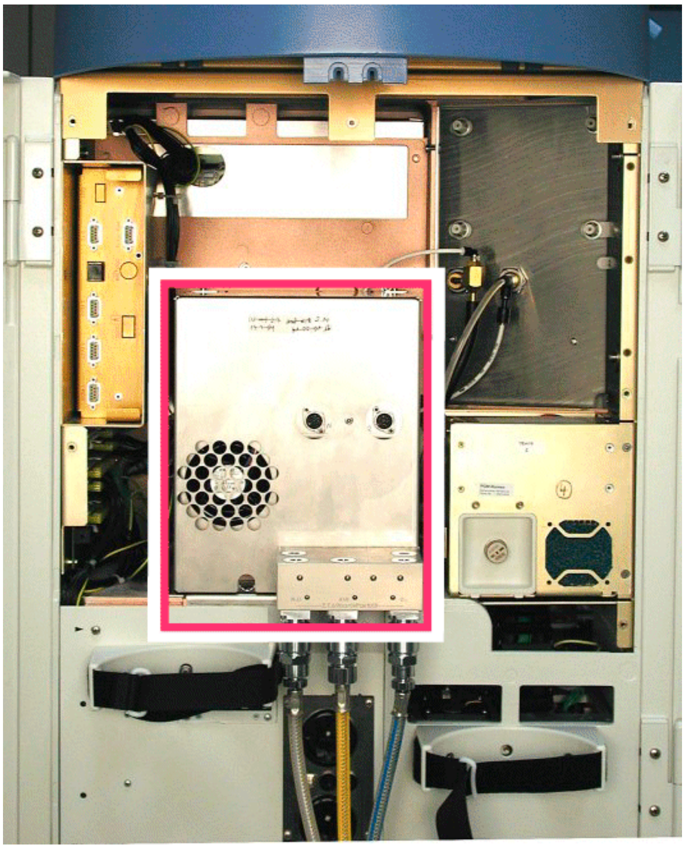

Figure 25 Mixer position, with rear panel open

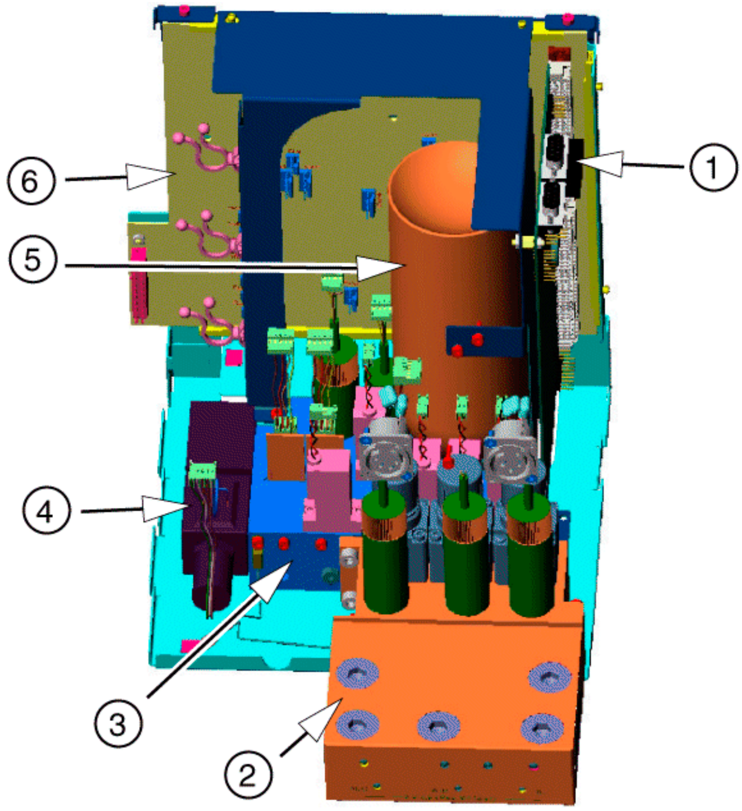

Figure 26 Mixer without hood, for legend see Table 11

Table 11 Legend to Figure 26

Item	Components
1	PRIMUS CPU PCB
2	Gas inlet block
3	Mixer block
4	A-cone valve
5	Fresh gas tank
6	MIXER PCB

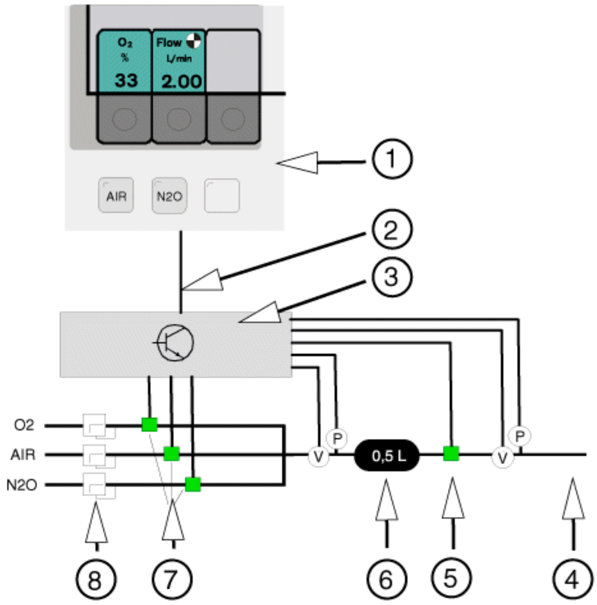

Figure 27 Block diagram of fresh gas metering, legend Table 12

Table 12 Legend to Figure 27

Item	Component
1	Monitor Control Panel (MCP)
2	CAN bus
3	Mixer electronics (PRIMUS CPU PCB/MIXER PCB)
4	Fresh gas outlet
5	Fresh gas flow valve
6	Fresh gas tank
7	Gas inlet valves
8	Pressure regulator

The item numbers and abbreviations occurring in this section relate to Figure 27 .

On the MCP (1) the user selects the carrier gas AIR or N2O as well as the fresh gas flow and the O2 concentration.

A CAN bus (2) transfers the setup parameters to the mixer electronics (3). The mixer electronics generate the actuation signals for the gas inlet valves (7).

At the inlet of the fresh gas tank (6) the flow (V) is measured. With the measured flow value the switching times for the gas inlet valves (7) are calculated. The selected gas concentration is set in the fresh gas tank. The pressure in the tank (6) and at the fresh gas outlet (4) is measured and monitored.

The fresh gas flow valve (5) delivers the selected fresh gas flow. The flowmeter at the fresh gas outlet (4) regulates the fresh gas flow valve.

5.1 Operating modes

The operating mode is regardless of whether the Primus is powered from the mains via its power plug or is powered up in battery mode.

5.1.1 10 VA mode

Internal leakage may mean that the O2 concentration in the Primus is above 21% when operation is begun. “10 VA” mode prevents dangerous operating states from occurring.

When the power plug is connected to the mains power but the power switch is not yet switched on, the following safety rule applies:

– A supply voltage of only 10 VA is fed into the interior of the mixer (10 VA is the product of the no-load voltage and short-circuit current of the supply voltage “24 V PLUG-IN”. Only the DC/DC converters (-15 V, +15 V) for the pressure sensor amplifiers are supplied).
– The pressure sensors for the gases from the central supply (CS) system and the cylinder supply are read and the compressed gas supply status is indicated by LEDs on the front panel (see 5.3.2 Pressure status LEDs).

When the Primus is switched on at the power switch (mains or battery powered) the following safety rule applies:

– Before other modules receive operating voltage, the fan in the mixer is switched on for at least 10 seconds. Only then is “Normal” mode activated.

5.1.2 'Normal' mode

In this mode the mixer CPU PCB controls normal mixing. All DC/DC converters (+5 V, +24 V, -15 V, +15 V) are supplied with “24 V SWITCH”.

5.2 Layout

5.2.1 MIXER PCB

In the “Block diagrams” section you will find a block diagram of the MIXER PCB.

The MIXER PCB holds the following components:

– DC/DC converters (+5 V, + 15 V, - 15 V, +24 V) with voltage monitoring
– Amplifiers of the pressure and temperature sensors
– Valve power switch and monitoring circuits
– Fan actuation and monitoring
– Logic device for the safety O2 adjuster

A cable harness connects the mixer with the NEUTRAL POINT PCB and with the other unit components. By way of the cable harness the mixer receives the unstabilized 18 V to 30 V supply voltage and the 12 V fan power from the power pack as well as the CAN bus.

The mixer fan is switched on 10 seconds before the other components and is powered directly by the power pack (see 5.1.1 10 VA mode).

When the fan wheel rotates a proportional square signal is generated (approx. 90 Hz). This square signal is monitored by the PRIMUS CPU PCB.

The valves on the mixer block are actuated by the Master CPU (PRIMUS CPU PCB). Power drivers on the MIXER PCB operate the valves. When one of the valves is actuated, the current flows through a shunt. The voltage drop at the shunt is evaluated by a comparator circuit and monitored by the supervisor processor on the PRIMUS CPU PCB. An exception to this is the fresh gas flow valve “VMGS”. The proportional valve cannot be monitored by this procedure.

For safety shut-off of all valves, the supply voltage can be cut to all valves.

5.2.2 PRIMUS CPU PCB (mixer)

In the “Block diagrams” section you will find a block diagram of the PRIMUS CPU PCB.

The PRIMUS CPU PCB is based on a 2-processor system with Master and Supervisor. Both 16-bit processor systems are identical in structure. The peripherals are controlled by way of an interface.

Each processor has the following components:
- Quartz
- undervoltage detector
- External watchdog
- Flash-PROM
- RAM
- EEPROM (system configuration)

A Dual-Port RAM is placed between the two processor systems for data exchange. A logic circuit prevents both processors writing to a memory cell simultaneously.

Each processor system has an isolated serial port and a CAN bus.

Configuration options for the serial port by jumper:
- Independent serial ports, RS232 level, isolation on jack plug.
- Independent serial ports, TTL level, no isolation, output to connector strip.

7-segment displays are provided for visual indication of operating states of the Master and the Supervisor.

5.3 Gas inlet block (AIR, O2 and N2O)

In the “Block diagrams” section you will find a detailed layout of the pneumatic components of the Primus.

On the underside of the gas inlet block are the ISO ports for the CS gases (Figure 28/1) e.g. Nist or DISS and the compressed gas cylinder ports for N2O and O2 (Figure 28/2).

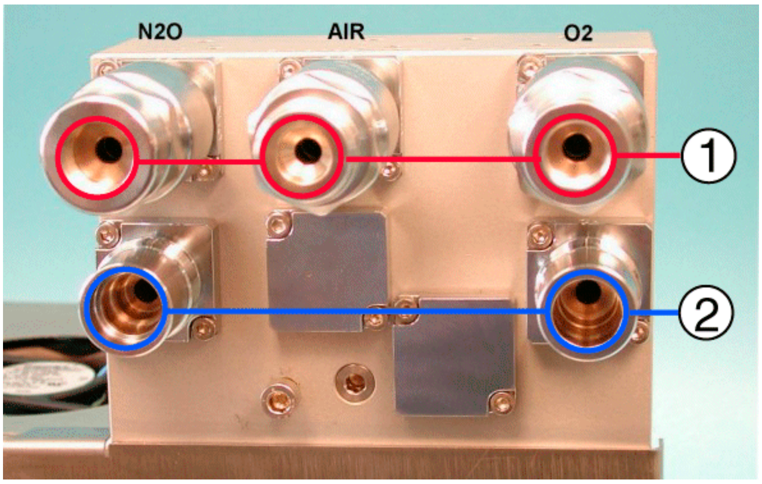

Figure 28 CS/compressed gas cylinder ports

Optional outlets for a bronchial suction device with AIR (Figure 29/1) and for a O2 flowmeter (Figure 29/2) are prepared.

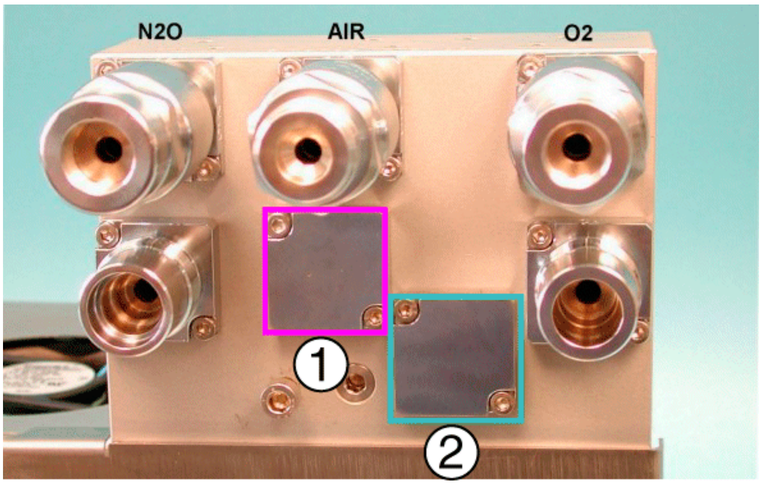

Figure 29 Optional outlets AIR (1) and O2 (2)

The following specifications apply to the CS and the compressed gas cylinders:

– The pressure values of the CS gases must be between 270 kPa and 690 kPa (19 psi to 80 psi).

– If the CS pressure falls below 270 kPa, the user must open the O2 or N2O compressed gas cylinder, as appropriate. If the cylinder pressure is too low, the user is warned on the MCP display. The maximum cylinder pressure is 19000 kPa.

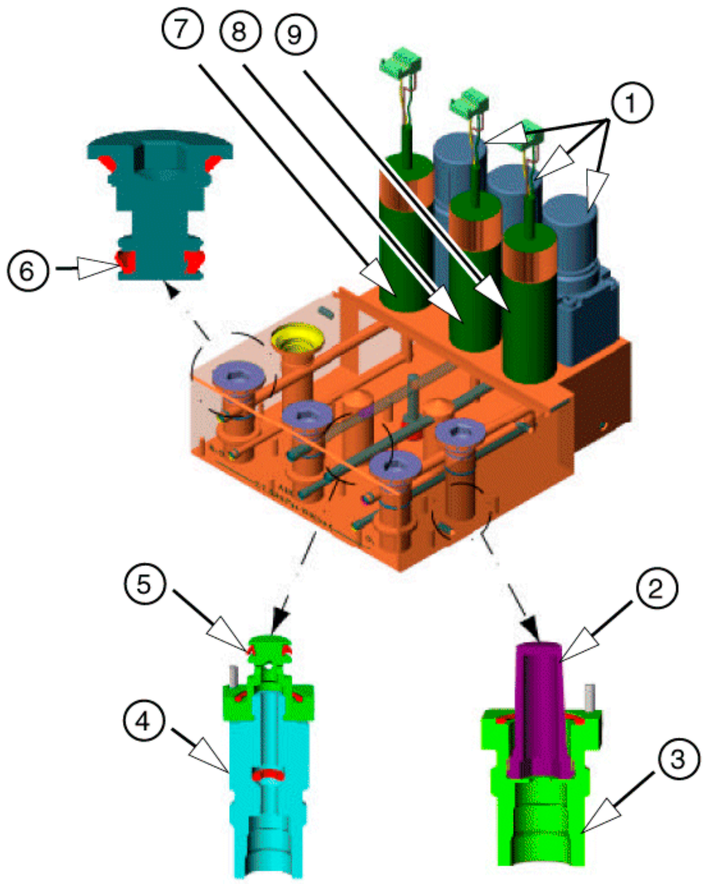

Figure 30 Detail, gas inlet block, for legend see Table 13

Table 13 Legend to Figure 30

Item	Component
1	Pressure regulators (N2O, AIR, O2) regulate the input pressure to the mixer to 2.3 ±0.1 bar
2	Sintered-metal filter
3	ISO port (e.g. NIST for O2 cylinder supply)
4	Optional gas outlet (plug-in connection for AIR)
5	Non-return valve
6	Non-return valve for N2O gas inlet
7	CS sensor N2O
8	CS sensor AIR
9	CS sensor O2

5.3.1 Pneumatic components, gas inlet block

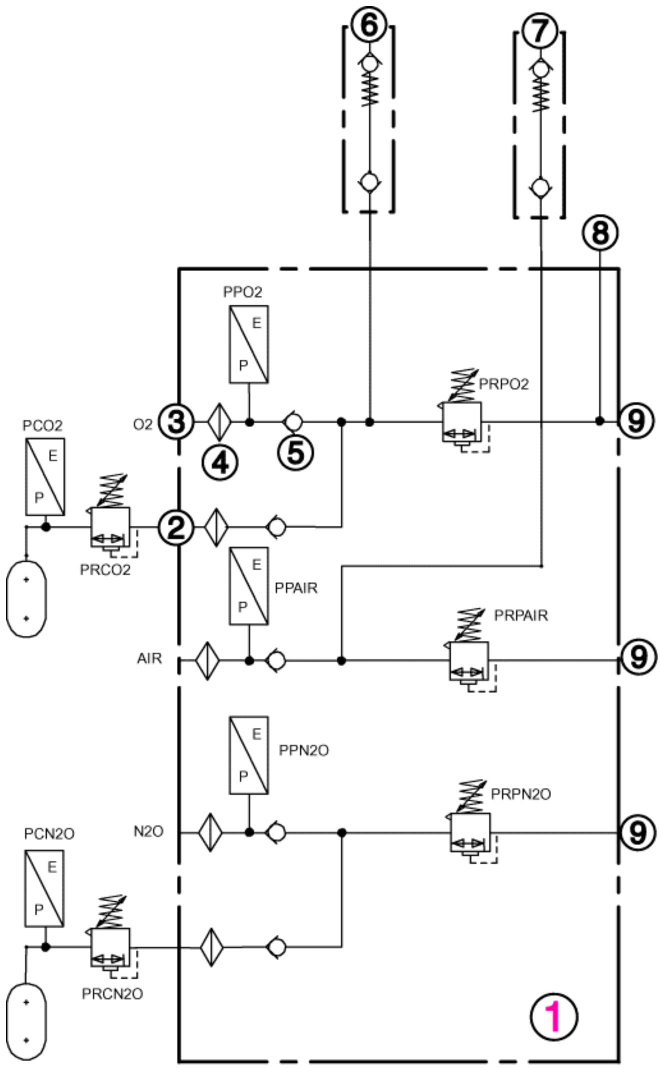

Figure 31 Pneumatic components diagram, gas inlet block, for legend see Table 14

Table 14 Legend to Figure 31

Abb./Item	Component
PPO2	Relative pressure sensors with integral amplifier for CS pressure measurement
PPAIR	
PPN2O	
PCO2	High-pressure sensor cylinder pressure O2
PCN2O	High-pressure sensor cylinder pressure N2O
PRPO2	Pressure regulator, O2 line
PRPAIR	Pressure regulator, AIR line
PRPN2O	Pressure regulator, N2O line
PRCO2	Pressure regulator, O2 compressed gas cylinder

Abb./Item	Component
PRCN2O	Pressure regulator, N2O compressed gas cylinder
1	Gas inlet block (complete)
2	HP ISO port O2 (NIST or DISS)
3	CS ISO port O2 (NIST or DISS)
4	Sintered-metal filter in CS ISO port
5	Non-return valve, CS inlet O2
6	ISO outlet O2 (optional)
7	ISO outlet AIR (optional)
8	To flush button and safety O2 adjuster
9	To the CS flow metering inlet valves

The item numbers and abbreviations occurring in this section relate to Figure 31 .

For the following description the O2 gas path was chosen.

The CS gas (3) passes through the ISO port to the gas inlet block.

By way of the sintered-metal filter (4) the gas passes to the pressure sensor “PPO2”. The relative pressure sensor delivers a signal proportional to the pressure.

The sintered-metal filter (4) prevents the non-return valve (5) from being contaminated by particles.

If the CS fails, no CS pressure is indicated. The non-return valve (5) prevents O2 from escaping out of the compressed gas cylinder (2) into the CS system.

The pressure regulator PRPO2 generates a constant input pressure for the mixer (2.3 bar ±0.1 bar). The O2 pressure regulator additionally supplies (8) the flush button “VO2+” and the safety O2 adjuster “VSFC”.

An optional compressed gas supply for an external bronchial suction device (7) or an external O2 flowmeter (6) is provided for.

5.3.2 Pressure status LEDs

The mixer measures and monitors the pressure of the CS and the compressed gas cylinders. Depending on the measured values, LEDs on the MCP indicate the pressure status.

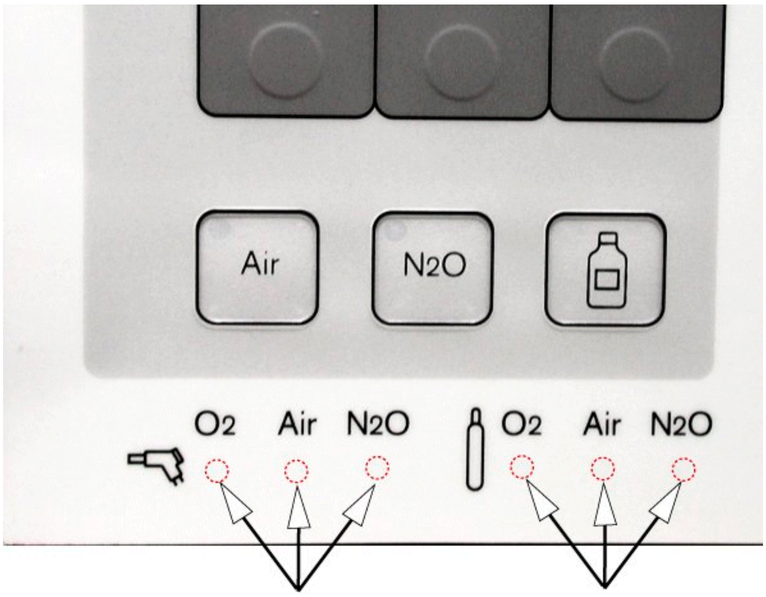

Figure 32 Position of LEDs (front panel)

The CS pressure and the cylinder pressure is indicated by five LEDs on the front of the MCP. The sixth LED is intended for an optional AIR compressed gas cylinder.

The LEDs are lit either green or red or are unlit, depending on operating status. The LEDs are made to change colour by reversing the polarity of the supply voltage.

If the mixer is in “10 VA” mode, the LEDs are either green or unlit.

The initial condition for Table 15 is:

– Primus is off, but power is connected.

Table 15 LED status, Primus off

Gas supply	Pressure value	LED status
O2-CS	p < 2.7 bar	Off
	p = 2.7 bar	Green
AIR-CS	p < 2.7 bar	Off
	p = 2.7 bar	Green
N2O-CS	p < 2.7 bar	Off
	p = 2.7 bar	Green

Gas supply	Pressure value	LED status
O2 cylinder	p < 20 bar	Off
	p = 20 bar	Green
	Pressure sensor not connected	Off
AIR cylinder	p < 20 bar	Off
	p = 20 bar	Green
	Pressure sensor not connected	Off
N2O cylinder	p < 10 bar	Off
	p =10 bar	Green
	Pressure sensor not connected	Off

The initial condition for Table 16 is:

– Primus is on. The mixer is in normal mode.

Table 16 LED status, Primus in normal mode

Gas supply	Pressure value	LED status
O2-CS	p < 2.7 bar	Off
	p = 2.7 bar	Green
	Pressure sensor error	Flashing green
AIR-CS	p < 2.7 bar	Off
	p = 2.7 bar	Green
	Error	Flashing
N2O-CS	p < 2.7 bar	Off
	p = 2.7 bar	Green
	Pressure sensor error	Flashing green
O2 cylinder	p < 20 bar and CS O2 pressure is = 2.7 bar	Off
	p = 20 bar	Green
	p < 20 bar and the CS O2 pressure is < 2.7 bar	Flashing red at 1.4 to 2.8 Hz
	Pressure sensor not connected	Off
AIR cylinder	p < 10 bar and the CS N2O pressure is < 2.7 bar	Flashing red at 1.4 to 2.8 Hz
	p = 10 bar	Green
	Pressure sensor not connected	Off
	p < 10 bar and CS N2O pressure is = 2.7 bar	Off

Gas supply	Pressure value	LED status
N2O cylinder	p < 10 bar and CS N2O pressure is = 2.7 bar	Off
	p = 10 bar	Green
	p < 10 bar and CS N2O pressure is < 2.7 bar	Flashing red at 1.4 to 2.8 Hz
	Pressure sensor not connected	Off

5.4 Mixer block

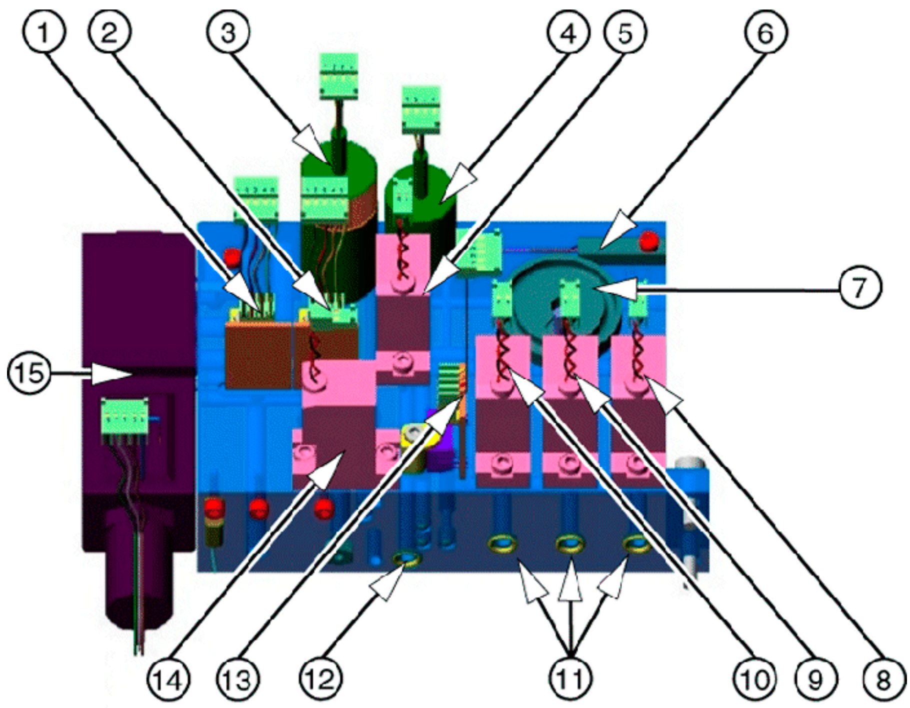

Figure 33 Mixer block, for legend see Table 17

Table 17 Legend to Figure 33

Item	Component	Short name
1	Differential pressure sensors with piezo measuring bridge	PDMGSHI
2		PDMGSLO
3	Absolute pressure sensors with integral amplifier	PSYS
4		PTANK
5	Tank vent valve	VTANK
6	Temperature sensors	TANKTEMP, MGSTEMP
7	Connection for tank volume	TANK
8	Gas inlet valves	VMIXO2
9		VMIXAIR
10		VMIXN2O
11	Pressure inlets (N2O, AIR, O2) to the gas inlet valves	
12	O2 inlet to safety O2 adjuster and flush button	
13	Differential pressure sensor with piezo measuring bridge	PDMIX
14	Fresh gas flow valve (proportional valve)	VMGS
15	A-cone valve	VSWAK

5.5 Pneumatic system

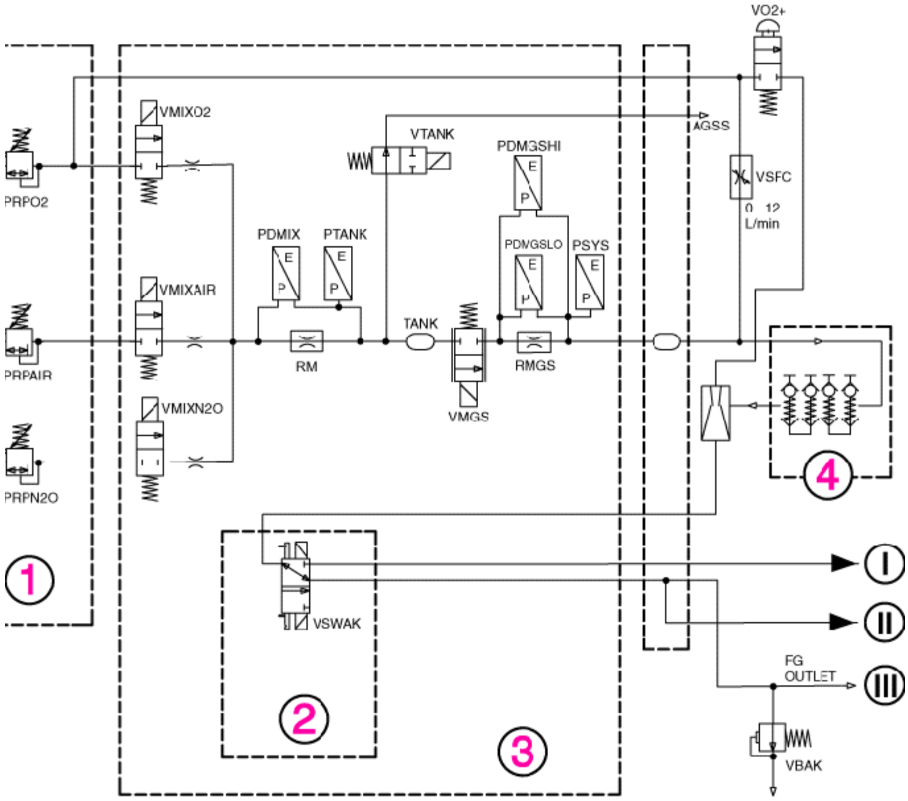

Figure 34 Pneumatic components diagram, mixer, for legend see Table 18

Table 18 Legend to Figure 34

Item	Component/Meaning
1	Gas inlet block
2	A-cone valve (optional)
3	Mixer, flow metering
4	Vaporizer
I	To compact breathing system
II	To A-cone valve/compact breathing system switching valve (MV3) for airway pressure measurement
III	To A-cone outlet

In the “Block diagrams” section you will find a detailed layout of the pneumatic components of the Primus.

The abbreviations occurring in the following sections relate to Figure 34 and Figure 33.

5.5.1 VMIX valves

The “VMIX” valves mix the desired gas concentration. By way of the “VMIX” valves the CS gas (N2O, AIR, O2) passes to the differential pressure sensor “PDMIX”, to the pressure sensor “PTANK” and to the flowmeter section “RM”.

The “VMIX” valves fill “TANK”. The pressure range in 'TANK“ is between 1 bar and 1.5 bar. The pressure difference of 0.5 bar and the “TANK” volume of 0.5 L produce a usable “TANK” volume of 0.25 L (0.5 bar x 0.5 L = 0.25 L).

At a fresh gas flow setting of 18 L/min, the “VMIX” valves are opened 72 times a minute. The following equation illustrates the TANK filling process (72 /min x 0.25 L = 18 L/min).

5.5.2 PDMIX and RM

With the differential pressure sensor “PDMIX” and the flowmeter “RM” the gas flow and volume of the gas flowing into the TANK are measured (flow x time = volume). If a constant usable 'TANK' volume of 0.25 L is used then any given gas concentration can be mixed.

The differential pressure sensor “PDMIX” and the absolute pressure sensor “PTANK” form a single functional unit. The output signal of the pressure sensor “PTANK” is used for the bridge supply voltage for “PDMIX”. The output voltage of “PDMIX” is evaluated on the PRIMUS CPU PCB (mixer).

5.5.3 PTANK (pressure sensor)

The pressure sensor “PTANK” has the following tasks:

- Tank pressure monitoring
- Compensation for effect of ambient pressure fluctuations on flow metering with “PDMIX”.
- Monitoring of flowmeter “RM” by means of the proportional pressure rise in “TANK”.

The pressure sensor “PTANK” has a resolution of 2 mbar and a maximum measuring range of 2.558 bar absolute. The pressure sensor “PTANK” also has a second amplification branch to the AD converter of the PRIMUS CPU PCB (mixer). To be able to measure higher pressures for service purposes, the resolution is 4 mbar per digit. The maximum measured value is 4.092 bar absolute.

5.5.4 VTANK valve

The tank vent valve “VTANK” opens when:

- O2 and AIR are missing.

5.5.5 VMGS (fresh gas flow valve)

The fresh gas flow valve is a proportional valve. It delivers a fresh gas flow of 0.2 L/min to 18 L/min. The flowmeter at the fresh gas outlet regulates the valve.

5.5.6 PDMGSHI / PDMGSLO (differential pressure sensors)

The differential pressure sensors each have a press-dependent resistance measuring bridge.

The differential pressure sensors measure the flow through the flowmeter section “RMGS”. With the measured value the PRIMUS CPU (mixer) PCB regulates the fresh gas flow valve “VMGS”.

5.5.7 PSYS (pressure sensor)

The pressure sensor “PSYS” compensates for the effect of ambient pressure fluctuations on the flow metering of “PDMGSHI” and “PDMGSLO”.

The pressure sensor “PSYS” has a resolution of 1 mbar.

5.5.8 VSWAK (A-cone valve)

The A-cone valve actuated by the MIXER PCB has a bistable switching response.

The valve is switched with a time-limited voltage pulse. The polarity of the voltage pulse determines the switching direction.

The valve position is detected by a proximity sensor in the valve and monitored by the PRIMUS CPU (mixer) PCB.

5.5.9 VBAK (safety valve)

A mechanical safety valve for the A-cone valve. Opening pressure 80 mbar at 18 L/min +15%.

5.5.10 TEMPTANK / TEMPBLOCK (temperature sensors)

The volume of the gases “N2O, AIR, O2” is dependent on the temperature. Consequently, the measured values of the temperature sensors “NTC” are incorporated into the mixing process. The temperature sensors (“TEMPTANK”, “TEMPBLOCK”) used for temperature compensation generate voltages proportional to the temperature. The PRIMUS CPU (mixer) PCB compares and monitors the sensor voltages.

5.5.11 VSFC (safety O2 adjuster)

The safety O2 adjuster is located outside the mixer unit. With the manual safety O2 adjuster the user can set an additional O2 flow of 3 to 12 L/min ±30%.

When the overall system power-up test is running the flow adjuster must be closed. The operating status is registered by a microswitch in the safety O2 adjuster. The microswitch is plugged into the NEUTRAL POINT PCB. The signal is transmitted via the cable harness to the mixer.

5.5.12 VO2+ (flush button)

Mechanical flush button. Output min. 35 L/min.

The function description relating to the VGC follows.

6 VGC

This section describes the VGC (**V**entilation and **G**as **C**ontroller). The VGC consists of the ventilator and the compact breathing system.

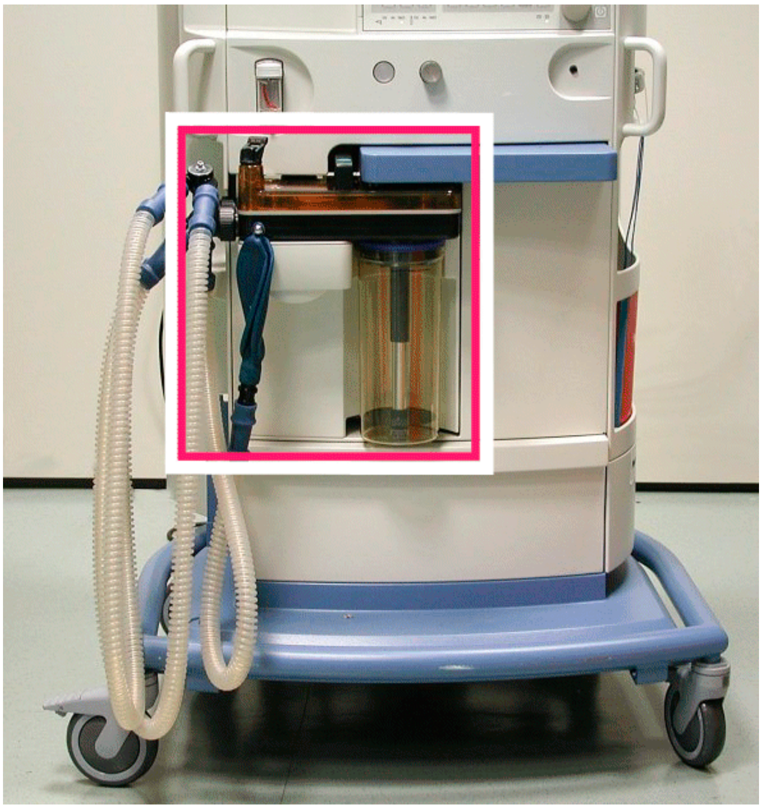

Figure 35 VGC position

The patient is ventilated by the VGC according to the ventilation mode and parameters set on the MCP.

The VGC also measures the airway pressure and the inspiratory and expiratory flow (two flow sensors).

A cable harness connects the VGC with the NEUTRAL POINT PCB. From there, the VGC is connected to other Primus components.

By way of the cable harness the VGC receives the following voltages and signals:

– The unstabilized supply voltage of 18 V to 30 V.
– The 12 V for the VGC fan (there immediately).
– The 12 V for the pneutronics valves (there after approx. 10 seconds).
– CAN bus.

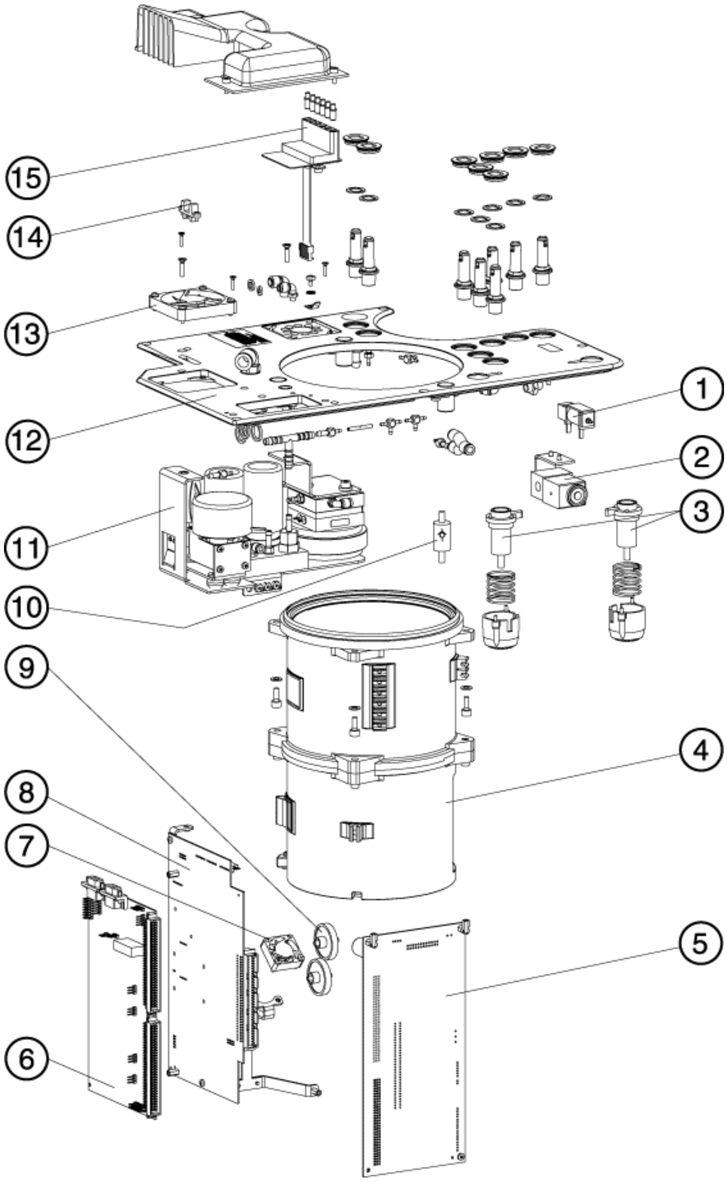

Figure 36 Exploded view of VGC, legend Table 19

Table 19 Legend to Figure 36

Item	Component
1	MV4 “Pneutronics”
2	MV2, calibration and venting
3	Electrical connections for inspiratory and expiratory flow sensor
4	Piston-cylinder unit.
5	VGC POWER PCB.
6	CPU PRIMUS PCB.
7	Electronics fan.
8	PRIMUS ANALOG PCB (VGC).

Item	Component
9	Bacterial filter.
10	Non-return valve RV3.
11	VGC pneumatic block.
12	Interface plate.
13	Interface plate fan.
14	Light barrier.
15	Breathing system heater contacts.

6.1 VGC electronics

In the “Block diagrams” section, you will find a block diagram of the VGC electronics.

The supply voltages required for the VGC to function (5 V, 15 V, +24 V) are generated by the VGC itself.

The interface plate holds the connecting pneumatic tubes and the plug-in flow sensor connectors.

The interface plate is the carrier for all other VGC components, and includes the breathing system lock. The complete interface unit is inserted from above into the VGC housing.

6.1.1 VGC POWER PCB

The following functional units are provided on the PCB:

- 5 V voltage regulator (Imax 2 A).
- Driver for the DC motor (M2) of the piston cylinder unit (PCU).
- Valve control.
- Breathing system heater control. Temperature monitoring with 2 independent NTCs in the heater mat.
- Control for the DC pump (M1). Output voltage 8 to 18 V.
- Monitoring of the PCB supply voltages.

6.1.2 PRIMUS ANALOG PCB

The following functional units are provided on the PCB:

- +15 V voltage regulator (Imax 300 mA). 15 V is only connected if 5 V is present.
- -15 V voltage regulator (Imax ca. 100 mA).
- PEEP valve control (0 to 430 mA).
- Pressure measurement with two airway pressure sensors and a vacuum sensor.
- 12-bit A/D converter for the airway pressure sensors and the flow sensors.
- Incremental encoder evaluation. Evaluation of direction of rotation, rotation angle and velocity of the PCU motor (M2).
- Light barriers. One light barrier each for the end position of the PCU and for detection of a fully inserted ventilator drawer unit.

6.2 Piston cylinder unit (PCU)

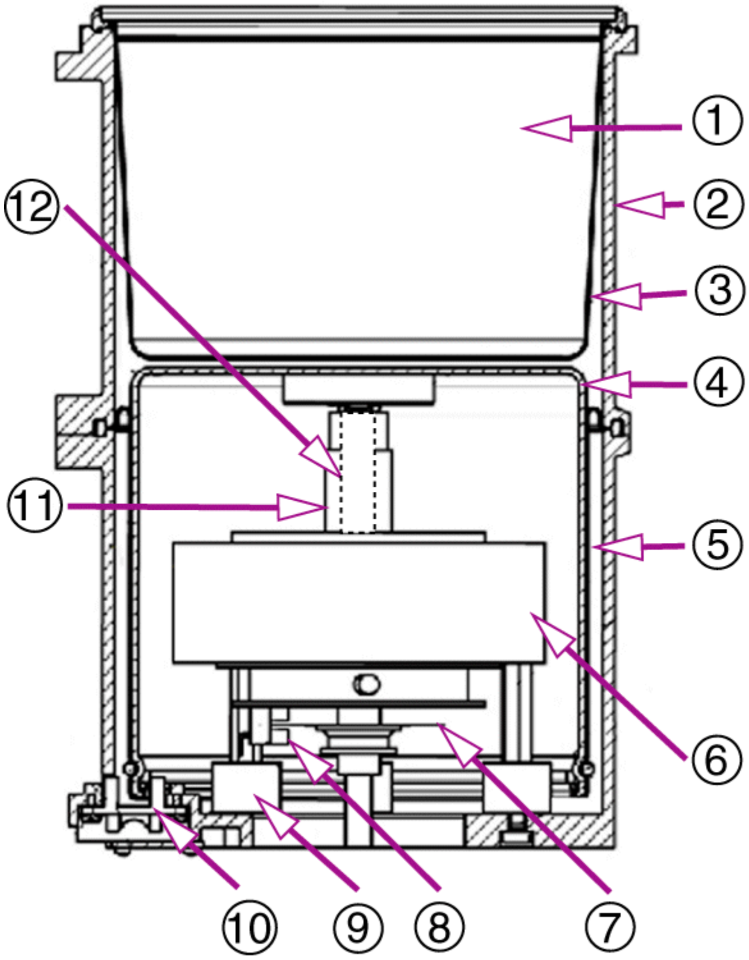

Figure 37 Piston cylinder unit layout, for legend see Table 20

Table 20 **Legend to Figure 37**

Item	Component
1	Breathing volume dependent on piston position.
2	Cylinder.
3	Rolling seal (loose).
4	Piston.
5	Diaphragm (fixed).
6	Piston motor.
7	Perforated disk for incremental encoder.
8	incremental encoder.
9	Rubber buffer.
10	Light barrier.
11	Spindle nut.
12	Spindle.

The items cited in the following text relate to Figure 37.

The ventilator unit consists of a piston cylinder unit and two diaphragms. The vacuum for the rolling seal (3) comes from the pneumatic system of the VGC and is generated in the space between the cylinder (2) and the rolling seal (3).

The spindle (12) is permanently fixed to the piston. The spindle nut (11) is permanently fixed to the hollow shaft axle of the piston motor. When the motor shaft, and thus the spindle nut, rotates the spindle is moved vertically. This sends a corresponding volume through to the compact breathing system and consequently to the patient. Also, the motor is permanently fixed with rubber buffers (9) to the drive housing.

When the spindle nut rotates once, a volume displacement of 38.5 mL is produced. So to achieve a volume change of 1400 mL, around 37 revolutions are required.

The piston motor (6) is powered by direct voltage and operated by way of the PCBs of the VGC. The actuator requires the signal from the incremental encoder (8). The incremental encoder has a resolution of 1024 pulses per motor revolution.

When the VGC is switched on, the counter of the incremental encoder must be set. To do so, the piston is lowered until it reaches the light barrier (10). This position is then recorded as the reference position.

Only when the vacuum is applied to the rolling seal is the piston motor activated. An exception is possible, however. If the roller diaphragm is not inserted, a vacuum may be created. The roller diaphragm can only be inserted without difficulty when the piston is at its bottom end position, however. If the control detects this state, it will slowly move the piston to the bottom end position in “Standby” mode. With software version 2.n or higher, the piston motor (6) is additionally switched on as an active brake as soon as the light barrier (10) is touched. This is to avoid that the spindle (12) gets stuck in the bottom end position.

6.3 VGC pneumatic block

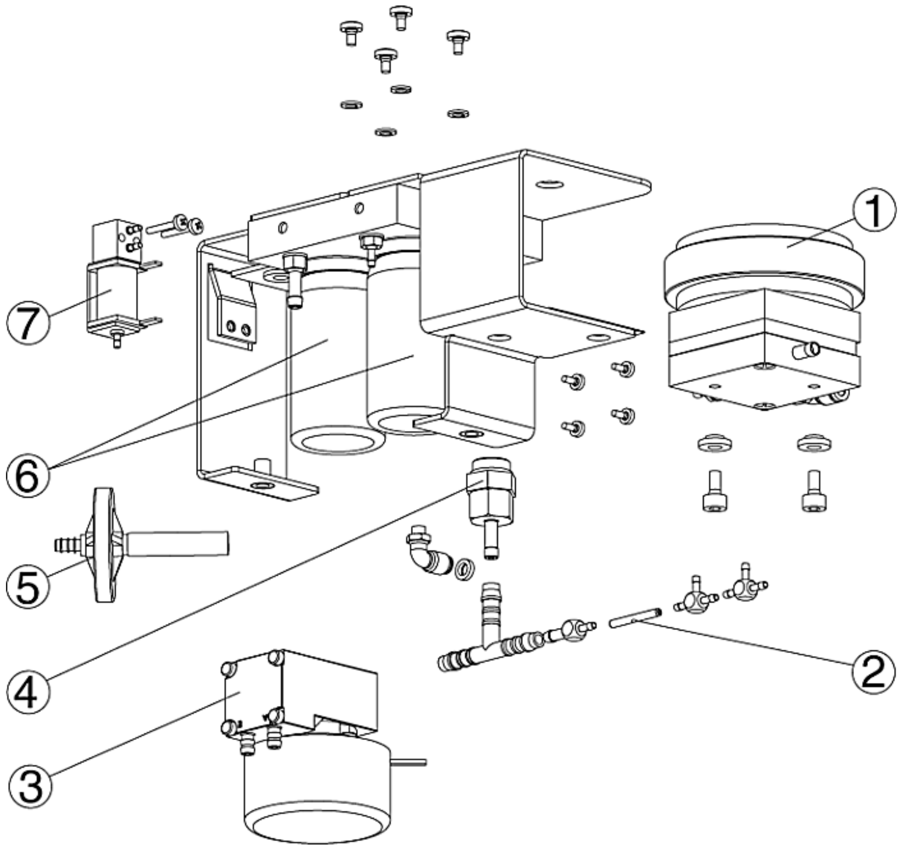

Figure 38 Exploded view of VGC pneumatic system, legend Table 21

Table 21 **Legend to Figure 38**

Item	Components
1	PEEP valve “MV1”.
2	Restrictor “R2”.
3	Pump motor “M2” with vacuum pump “VP”.
4	Vacuum valve “Vu”.
5	Bacterial filter “BF”.
6	Volume “V” (2 containers).
7	Solenoid valve “MV3”“Pneutronics”.

The components of the pneumatic block are detailed in the following section.

6.4 VGC pneumatic system

In the “Block diagrams” section, you will find a detailed schematic of the Primus pneumatic components.

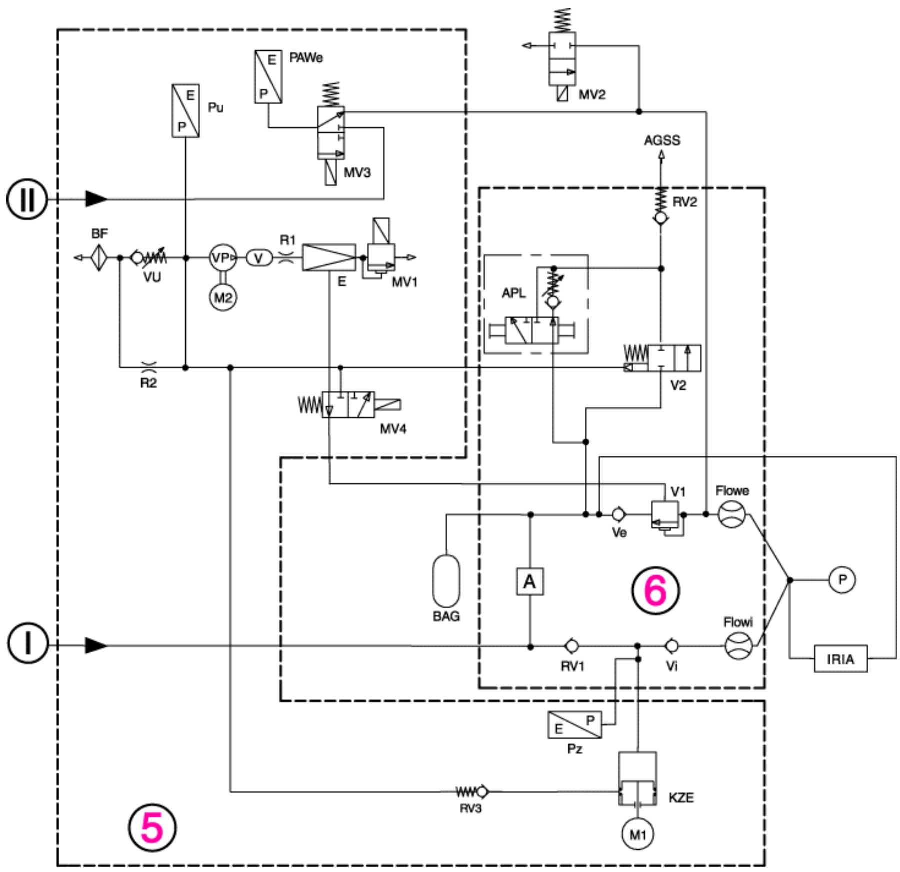

Figure 39 VGC pneumatic system and breathing system, for legend see Table 22

Table 22 Legend to Figure 39

Item	Component/Meaning
5	VGC ventilator unit.
6	Breathing system.
I	Fresh gas inlet.
II	From A-cone valve (if fitted).
E	Ejector.
BF	Bacterial filter.
M2	Vacuum pump motor.
MV1	PEEP/Pmax valve.
MV2	Calibration and vent valve.
MV3	Breathing system/A-cone outlet switching valve.
MV4	PEEP valve/control valve.

Item	Component/Meaning
PAWe	Expiratory airway pressure sensor.
Pu	Vacuum sensor.
R1	Restrictor to smooth pressure peaks.
R2	Restrictor to reduce vacuum (when pump “VP” is off).
RV3	KZE vacuum non-return valve.
V	Volume.
VP	Vacuum pump.

The position numbers mentioned in this section refer to Figure 39.

The vacuum sensor “Pu” is connected to the intake side of the vacuum pump “VP”. In operation, the vacuum sensor “Pu” measures the vacuum for the roller diaphragm of the KZE. Another port is connected during operation to the switching valve “V2”“AUTO-MAN/SPONT”. When the vacuum pump is running, the software checks the pressure value at the vacuum sensor “Pu”. The drive motor is only activated if the vacuum pump is able to build up a vacuum of between 120 mbar and 250 mbar (hPA).

The vacuum pump “VP” draws the air in through the bacterial filter “BF”. The following valve “Vu” is preset to approx. 200 mbar. The air is pumped in two consecutive volumes “V”.

To smooth pressure peaks, the outlet of the volumes is designed as a fine hole “R1”. From there, the gas flows through the PEEP valve “MV1”. If the PEEP valve is not actuated, the integral ejector “E” generates a low-level vacuum in its control line. This smoothes the zero of the PEEP characteristic.

So that the vacuum is reduced when the vacuum pump is shut off, the vacuum valve is bridged by a restrictor “R2”.

When the user switches the ventilation mode from automatic ventilation to “MAN/SPONT”, the vacuum pump is switched off. The vacuum is reduced with “R2”. The non-return valve “RV3” prevents the vacuum in the diaphragm volume from being reduced too. This considerably reduces the switching time from automatic ventilation to “MAN/SPONT”. At the same time, “RV3” also prevents a reduction of the vacuum in the diaphragm volume in “MAN/SPONT” mode. The vacuum can then be built up faster when the user switches to an automatic ventilation mode.

With valve “MV2” the system is calibrated and vented.

6.5 Interface plate

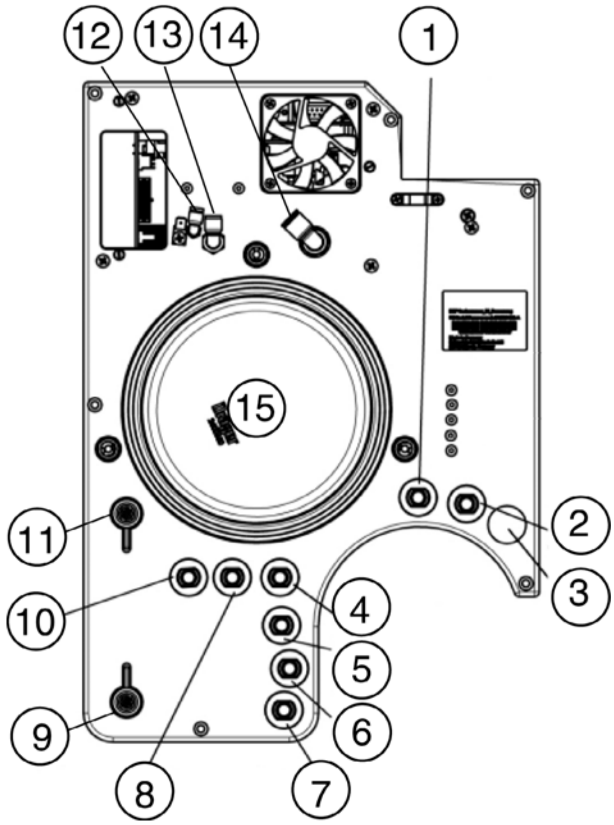

Figure 40 Layout of interface plate measuring points, for legend see Table 23

Table 23 Legend to Figure 40 and Figure 41

Item	Connection/Meaning
1	Pressure sensor “Pz”.
2	Fresh gas outlet.
3	Anesthetic gas scavenging system AGSS.
4	ILCA suction device (optional).
5	PEEP valve “V1”.
6	APL bypass valve “V2”.
7	“PAWe” / “MV2”.
8	ILCA sampling gas return line (optional).
9	Expiratory flow sensor (electric).
10	IRIA sampling gas return line.
11	Inspiratory flow sensor (electrical).
12	A-cone airway pressure.
13	IRIA sampling gas return line.
14	Fresh gas.

Item	Connection/Meaning
15	Piston of piston cylinder unit.

The following diagram Figure 41 permits allocation of the measuring points/connections on the interface plate to the pneumatic components diagram.

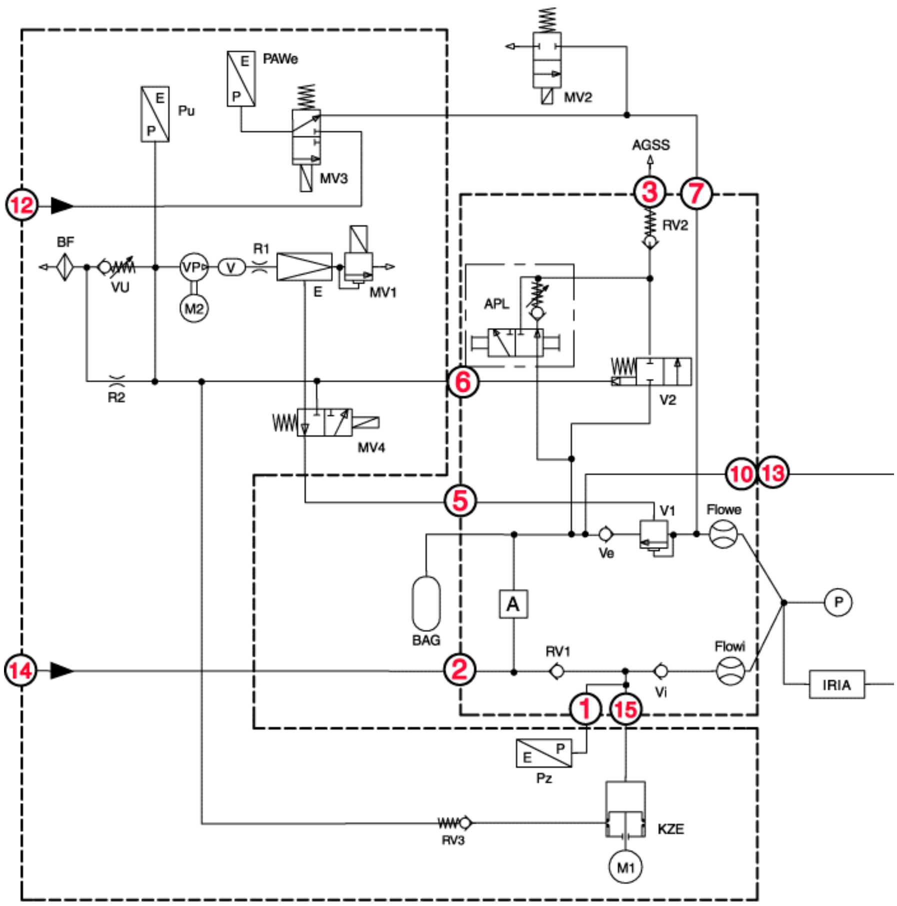

Figure 41 Allocation of measuring points/connections, for legend see Table 23

6.6 Breathing system

There can be two different types of breathing systems. The difference lies in the design of the APL valve (adjustable pressure-limiting valve, see Figure 42).

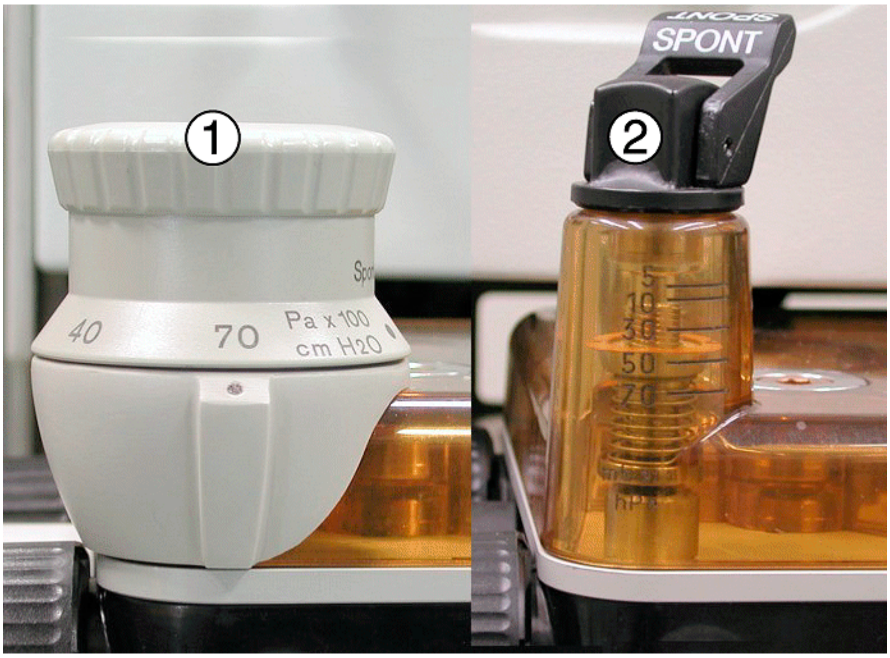

Figure 42 APL valves, new type (1) and old type (2)

The new type (Figure 42/2) has a toggle mechanism for toggling between MAN and SPONT mode. The new type (Figure 42/1) uses a locking function.

This results in different types of breathing system covers (see breathing system cover Figure 43/1). The valve plate (Figure 43/5) and the breathing system block (Figure 43/6) remain unchanged.

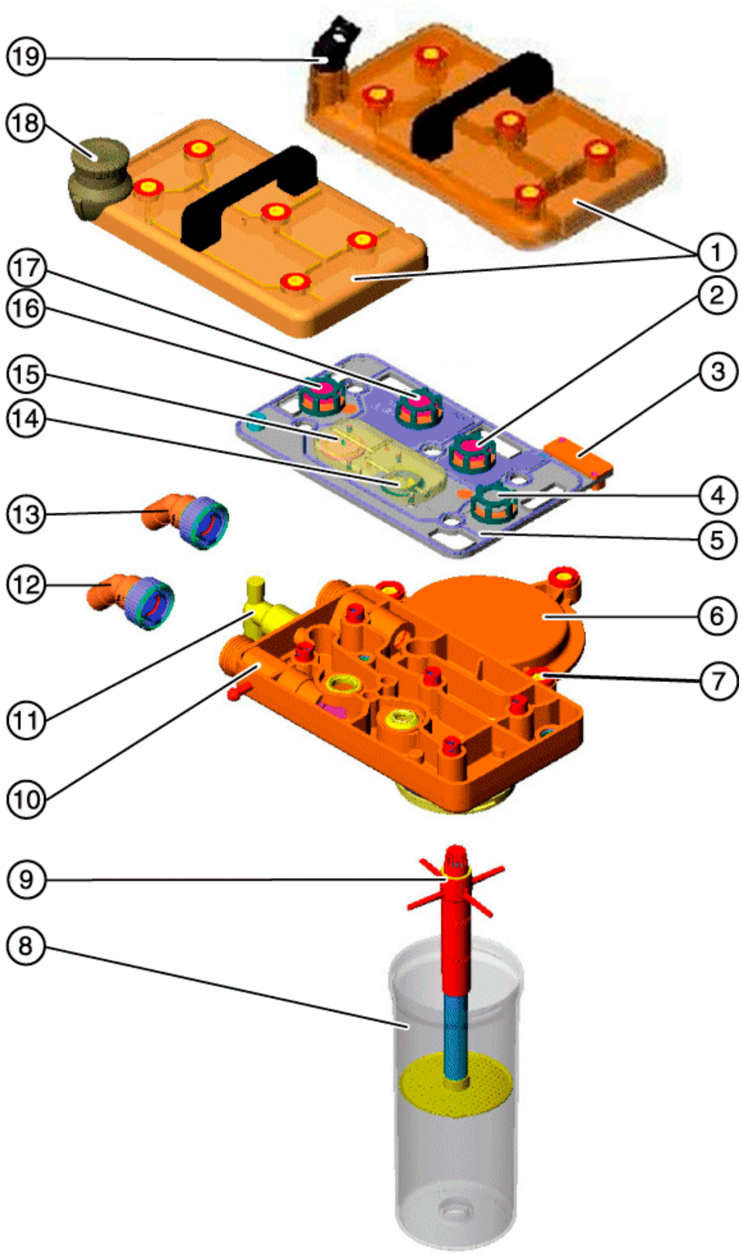

Figure 43 Overview of the breathing system, see legend Table 24

Table 24 **Legend to Figure 43**

Item	Component
1	Breathing system cover with fixing screws.
2	Valve “RV1”.
3	Breathing system heater contacts.
4	Valve “RV2” (new design).
5	Valve plate.
6	Breathing system block.

Item	Component
7	Fixing screws.
8	Absorber canister.
9	Absorber element.
10	Expiratory flow sensor “Flowe”.
11	Connection for manual breathing bag “Bag”.
12	Expiratory socket.
13	Inspiratory socket with downstream inspiratory flow sensor “Flowi”.
14	APL bypass valve “V2”.
15	Valve “V1”, PEEP diaphragm.
16	Expiratory valve “Ve”.
17	Inspiratory valve “Vi”.
18	“APL” valve, new type.
19	“APL” valve, old type.

The compact breathing system permits the following ventilation modes:

– Manual ventilation.
– Spontaneous breathing.
– Automatic, pressure-limited ventilation modes (IPPV, SIMV and PCB) or “Volume Mode” and “Pressure Mode” with optional synchronization and pressure support.
– (Optional) pressure-assisted ventilation “Pressure Support” for spontaneously breathing patients.

The switch of the APL valve can be set to MAN or SPONT.

In the “MAN” position, the breathing system is closed to atmosphere. The APL valve opening pressure can be adjusted from 5 to 70 hPa (mbar). This switch setting is the default for manual ventilation.

In the “SPONT” position the APL valve is open to atmosphere. This switch setting is the default for spontaneous breathing.

The pressure limitation “Pmax” can also be adjusted between 20 hPa (mbar) and 70 hPa (mbar) on the GUI during automatic ventilation.

The following section permits allocation of the components to the pneumatic components diagram.

6.6.1 Compact breathing system pneumatic components

In the “Block diagrams” section, you will find a detailed schematic of the Primus pneumatic components.

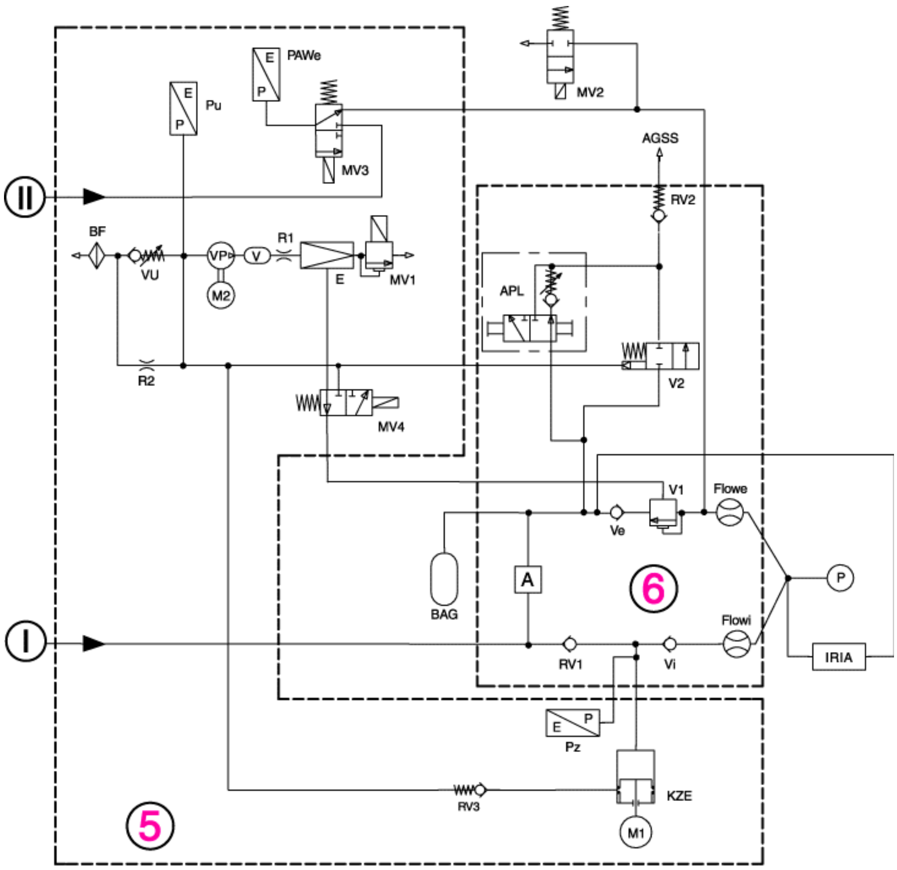

Figure 44 Breathing system and VGC pneumatic components, for legend see Table 25

Table 25 Legend to Figure 44

Item / Abbreviation	Component
6	Breathing system pneumatic components.
A	Absorber
V2	APL bypass valve.
APL	APL valve.
Ve	Expiratory valve.
PAWe	Expiratory pressure sensor.
FLOWe	Expiratory flow sensor.
FG	Fresh-gas port.
RV1	Fresh-gas decoupling valve.
BAG	Breathing bag.
Vi	Inspiratory valve.

Item / Abbreviation	Component
Pz	Inspiratory pressure sensor.
FLOWi	Inspiratory flow sensor.
Piston cylinder unit	Piston cylinder unit.
AGSS	Anesthetic gas scavenging system.
V1	PEEP valve.
RV2	AGSS non-return valve.

6.7 Automatic ventilation

A prerequisite for automatic ventilation (IPPV/PCV or “Volume Mode” and “Pressure Mode”) is that the patient is supplied with a sufficient amount of fresh gas.

The APL bypass valve “V2” is actuated by the VGC and is open. The setting of the APL valve has no effect in automatic ventilation. The pressure limit (Pmax) is adjustable on the GUI.

6.7.1 Inspiration

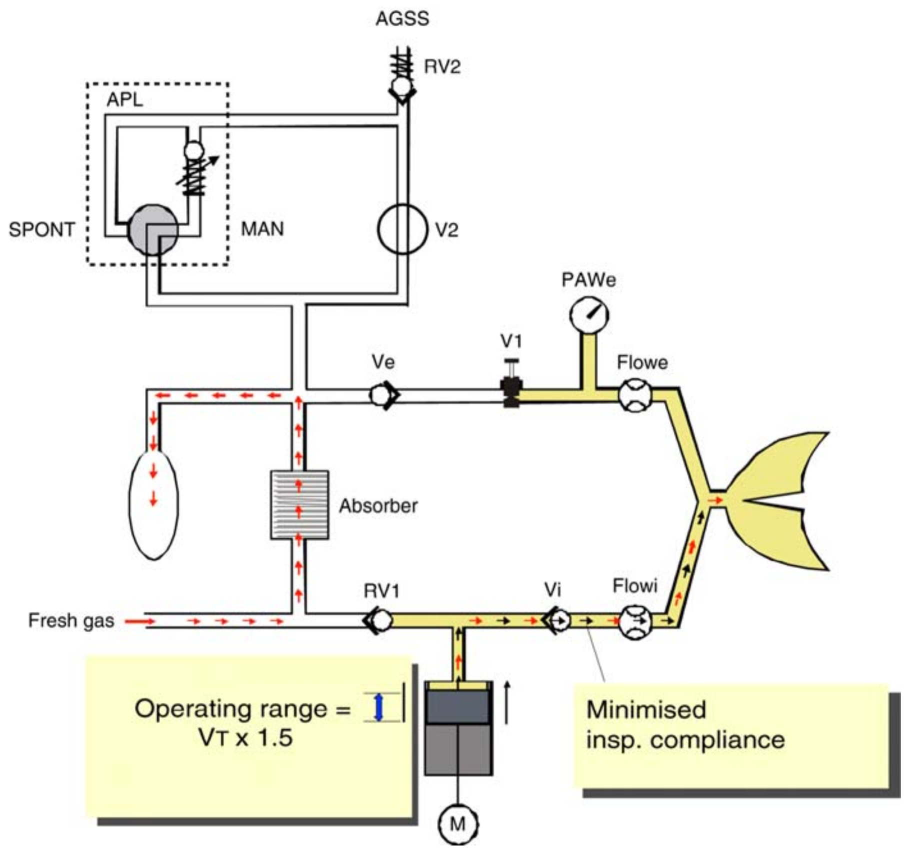

Figure 45 Block diagram of mandatory inspiration

The abbreviations occurring in the following text relate to Figure 45 .

Mandatory inspiration process:

– The fresh gas isolation valve “RV1” is closed.
– The PEEP valve “V1” is closed during inspiration. Depending on the preset maximum pressure “Pmax”, an appropriate control pressure is applied to the PEEP valve.
– The piston of the PCU rises according to the preset parameters (F, VT, I:E...). The mixed gas (expiratory gas and fresh gas) flows through the inspiratory valve “Vi”, the flow sensor “Flowi”, the inspiratory patient tube, and through the Y-piece into the patient’s lung.
– The inspiratory pressure is measured.
– For inspiratory compliance only the volume between “RV1”, “Vi” and “V1” is active.
– The manual breathing bag serves as a mixed gas reservoir.

If the ventilation pressure exceeds the maximum pressure (Pmax) set on the GUI, the PEEP “V1” opens. The gas from the patient's lung flows either into the manual breathing bag or through the open APL bypass valve “V2”. Depending on the non-return valve opening pressure “RV2”, the mixed gas flows into the anesthetic gas scavenging system AGSS.

Advantage of this method:

– The fresh gas isolation valve “RV1” minimizes the inspiratory compliance (without absorber and manual breathing bag).

6.7.2 Expiration

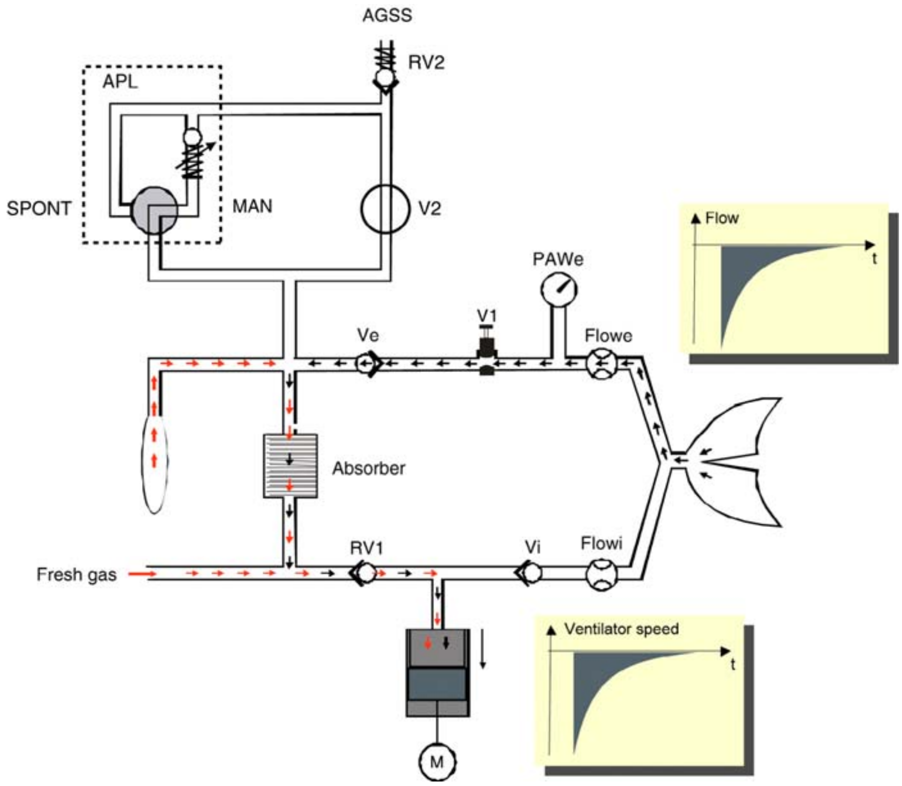

Figure 46 Block diagram of mandatory expiration

The abbreviations mentioned in this chapter refer to Figure 46.

Mandatory expiration process:

- The PEEP valve "V1" opens.
- The motor of the PCU is activated such that the piston follows the physiological expiration curve. This means the patient is able to exhale at an optimum flow rate.
- The downward movement of the piston opens "RV1".
- "Vi" is closed, and prevents breathing back into the inspiratory branch.
- The expiratory flow flows through the expiratory flow sensor "Flowe", the PEEP control valve "V1", the expiratory valve "Ve" and the absorber and back into the piston chamber of the piston cylinder unit.
- The patient gas is additionally enriched with fresh gas.
- Surplus mixed gas flows into the manual breathing bag or through the APL bypass valve "V2" and the non-return valve "RV2" into the anesthetic gas scavenging system AGSS.

Advantages of flow-optimized piston guidance:

– The gas loss through the AGSS valve is minimized, because no non-physiological overpressure is created in the expiratory phase.
– The fresh gas consumption via the absorber is high as long as the fresh gas flow is lower than the minute tidal volume “AMV”.
– No non-physiological overpressure in the expiration phase. Consequently there is also no intake of the diaphragm by “V1” (PEEP valve in breathing system).

6.8 Manual ventilation

During manual ventilation of the patient, the switch of the APL valve is set to the MAN position.

Only the warnings/alarms for the lower O2 alarm, for the upper airway pressure (Paw) and for CO2 are enabled.

The piston of the VGC is in the upper end position in order to reduce the dead space volume of the ventilator.

The APL bypass valve “V2” is not actuated and is closed.

6.8.1 Inspiration

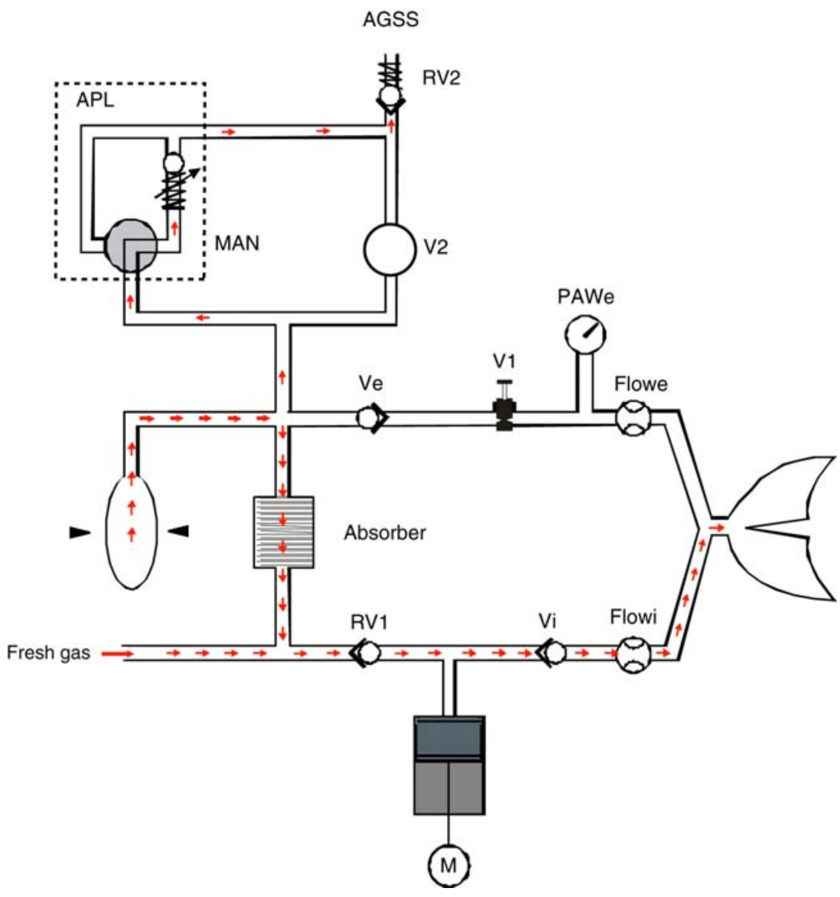

Figure 47 Block diagram of manual inspiration

The expiratory valve “Ve” is closed during the inspiratory phase.

Manual inspiration process:

- When the manual breathing bag is compressed, the mixed gas (expiratory gas and fresh gas) flows through the absorber, the fresh gas isolation valve “RV1”, the inspiratory valve “Vi” and the flow sensor “Flowi” and then into the patient’s lung.
- The pressure sensor “PAWe” measures the airway pressure.
- The APL valve limits the ventilation pressure.
- The surplus mixed gas flows via the APL valve and the non-return valve “RV2” into the anesthetic gas scavenging system AGSS.

6.8.2 Expiration

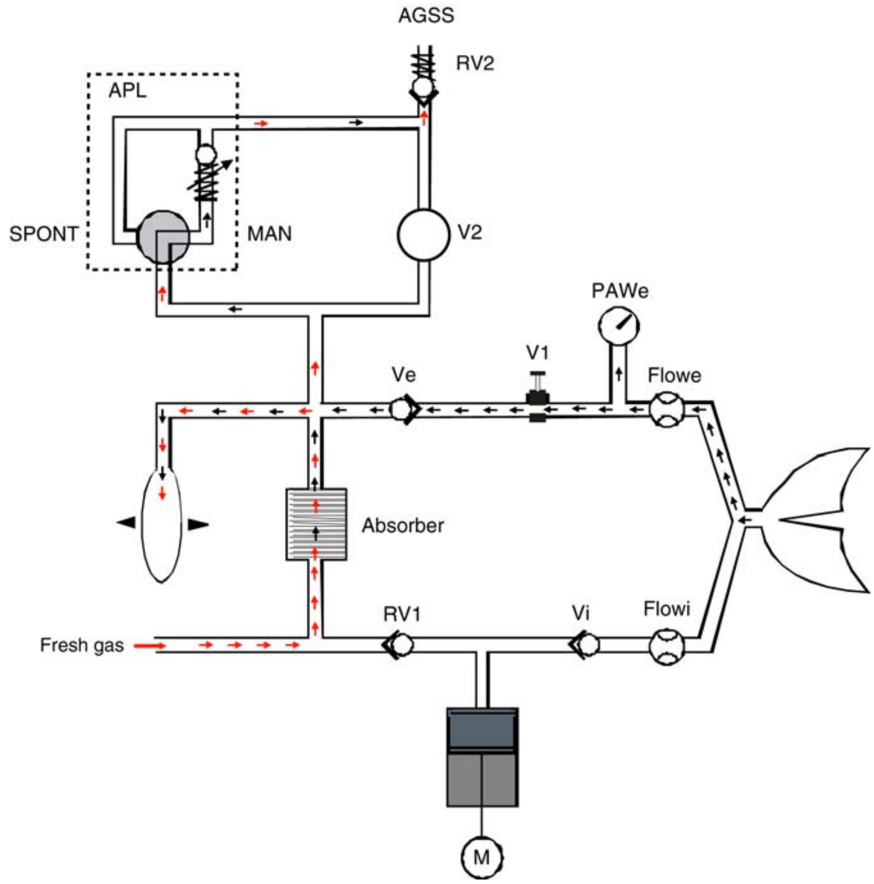

Figure 48 Block diagram of manual expiration

The inspiratory valve “Vi” is closed, and prevents expiratory gas from flowing back into the inspiratory branch.

Manual expiration process:

– When the pressure is relieved from the manual breathing bag, the expiratory gas flows through the expiratory flow sensor “Flowe”, the PEEP control valve “V1” and the expiratory valve “Ve” and then into the manual breathing bag.

– At the same time, fresh gas flows continuously during inspiration and expiration into the manual breathing bag.

6.9 Spontaneous breathing

During spontaneous breathing of the patient, the switch of the APL valve is set to the SPONT position. No gas pressure builds up in the compact breathing system. Only the warnings/alarms for the lower O2 alarm, for the upper airway pressure (Paw) and for CO2 are enabled. The piston of the KZE is moved to the upper end position in order to reduce the dead space volume of the ventilator. The APL bypass valve “V2” is not actuated.

6.9.1 Inspiration

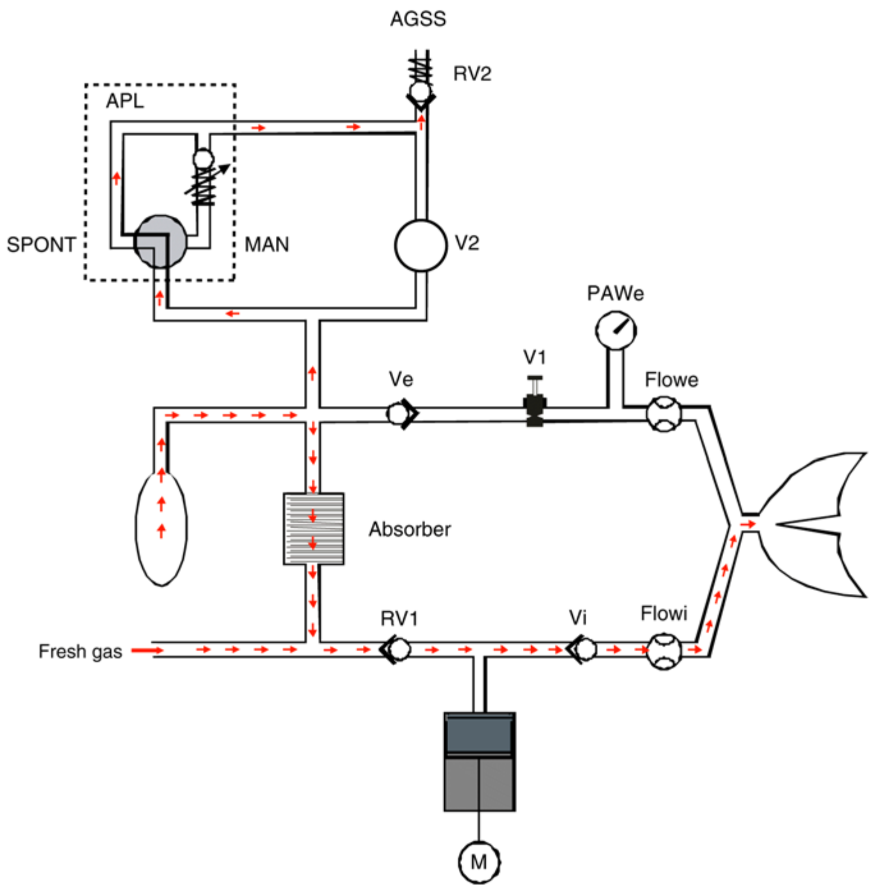

Figure 49 Block diagram of spontaneous inspiration

The expiratory valve “Ve” is closed during the inspiratory phase, and so prevents inhalation of expiratory gas with CO2.

Inspiration process:

– The patient inhales independently. During inhalation, the gas flows out of the manual breathing bag through the absorber and is additionally enriched with fresh gas. The enriched mixed gas passes through the fresh gas isolation valve “RV1”, the inspiratory valve “Vi” and the inspiratory flow sensor “Flowi” and then enters the patient’s lung.

6.9.2 Expiration

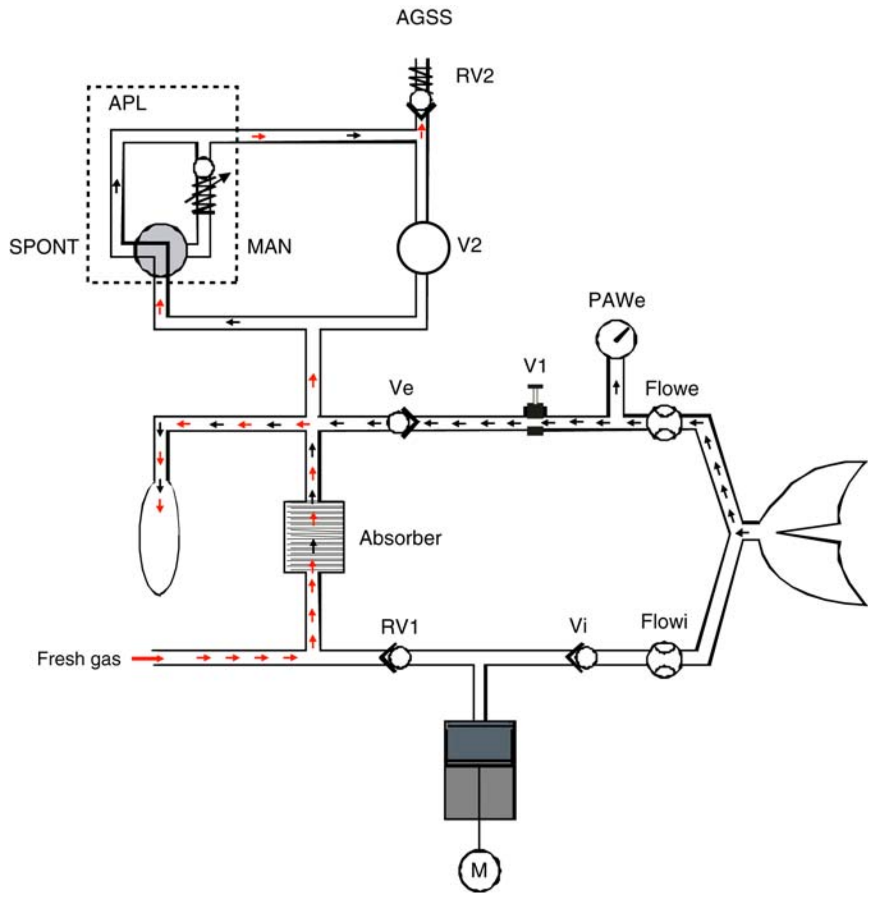

Figure 50 Block diagram of spontaneous expiration

During expiration, the inspiratory valve “Vi” remains closed thus preventing the expiratory gas from flowing back into the inspiratory branch.

Spontaneous expiration process:

– During exhalation, the expiratory gas flows out of the patient’s lung through the expiratory flow sensor “Flowe”, the PEEP control valve “V1” and the expiratory valve “Ve” into the manual breathing bag and the absorber.

– At the same time, fresh gas flows into the breathing bag.

– If the pressure in the manual breathing bag is greater than the opening pressure of “RV2”, the surplus gas mixture flows into the anesthetic gas scavenging system AGSS.

7 Ventilation modes with software version 2.n or higher

As of Primus software version 2.n, the ventilation modes terms for synchronization and pressure support of spontaneously breathing patients will be changed into the four following terms:

– “**Volume Mode**”.
– “**Pressure Mode**”.
– “**Pressure Support Mode**” (optional).
– “**Man./Spont Mode**”.

7.1 “Volume Mode”

Ventilation mode	Intended use
Volume-controlled ventilation mode with fixed mandatory tidal volume “VT” and frequency “Freq.”, including switchable synchronization and adjustable pressure support for spontaneous breaths (optional “Pressure Support”).	Anesthesia in relaxed or partially relaxed patients with healthy lungs and in patients with cranio-cerebral trauma. The goal is to maintain a constant volume or a constant “et CO2”.

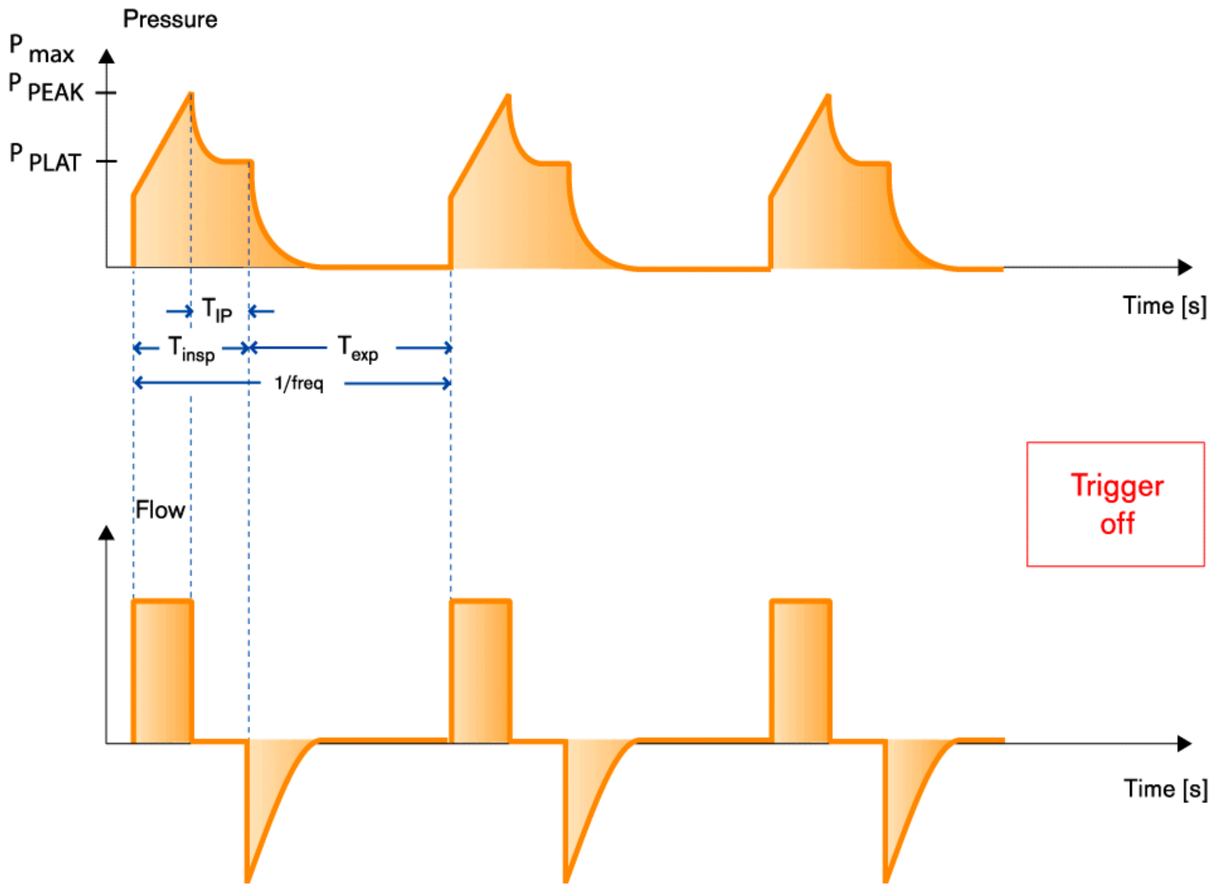

Figure 51 Volume-controlled ventilation with constant inspiratory flow

The following parameters determine the breathing cycle (see Figure 51):

– Frequency “1/freq”.
– Inspiratory time “Tinsp”.
– Inspiratory flow level.
– Inspiratory pause time “TIP:Tinsp”.
– Tidal volume “VT”.

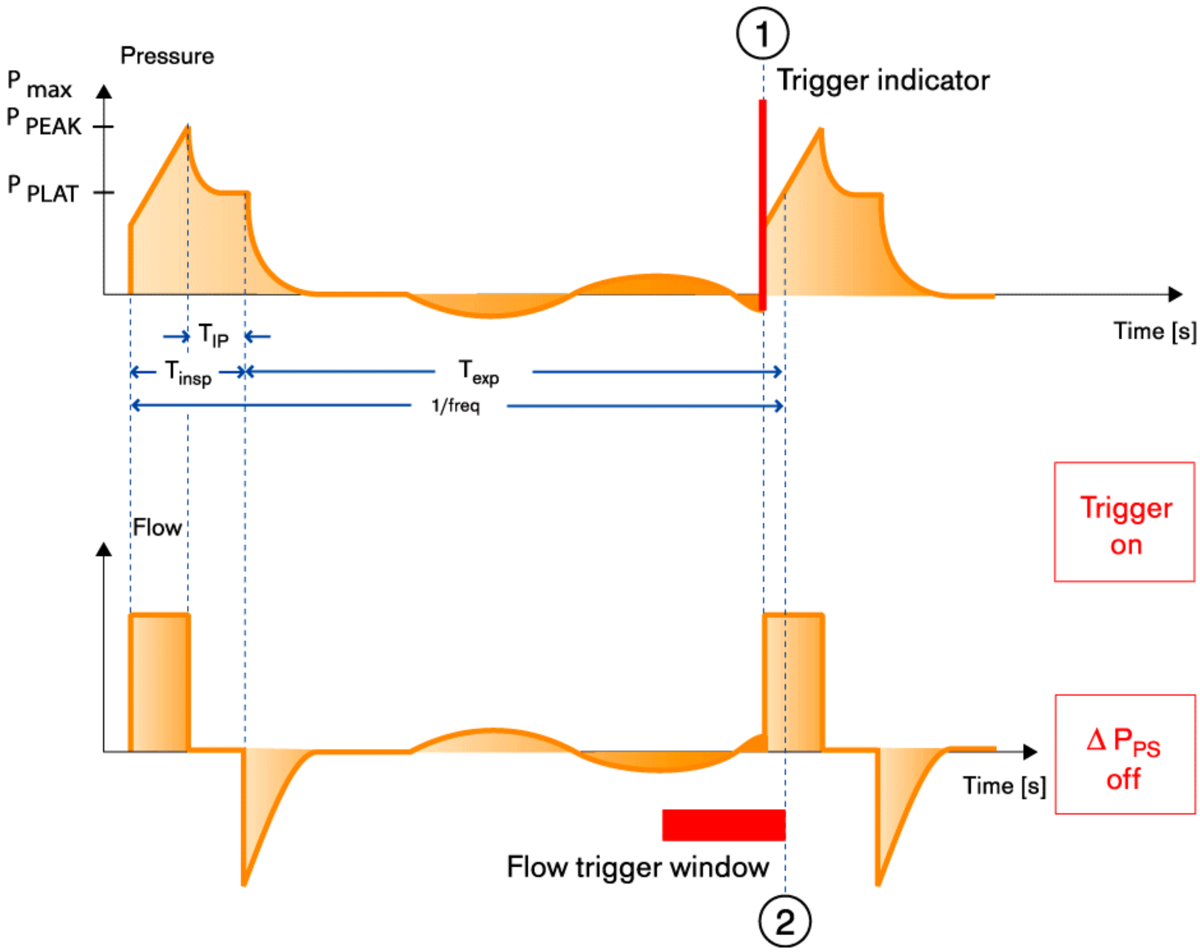

Figure 52 Synchronization of volume-controlled ventilation and spontaneous breathing

Synchronization is activated as soon as a trigger sensitivity value is entered. The message “sync” is displayed in the ventilation mode status field on the screen.

The flow trigger sensitivity controls the synchronization. The maximum time delay between the controlled ventilation breaths is adjusted by means of the frequency. To keep the frequency constant in the event of a premature triggering, the time is equalized in the next ventilation cycle.

A ventilation breath triggered by the patient is indicated by a continuous line (Figure 52/1) in the pressure curve and in the flow curve (trigger indicator). The active flow trigger window (Figure 52/2) corresponds to the last 25% of the relevant expiratory time.

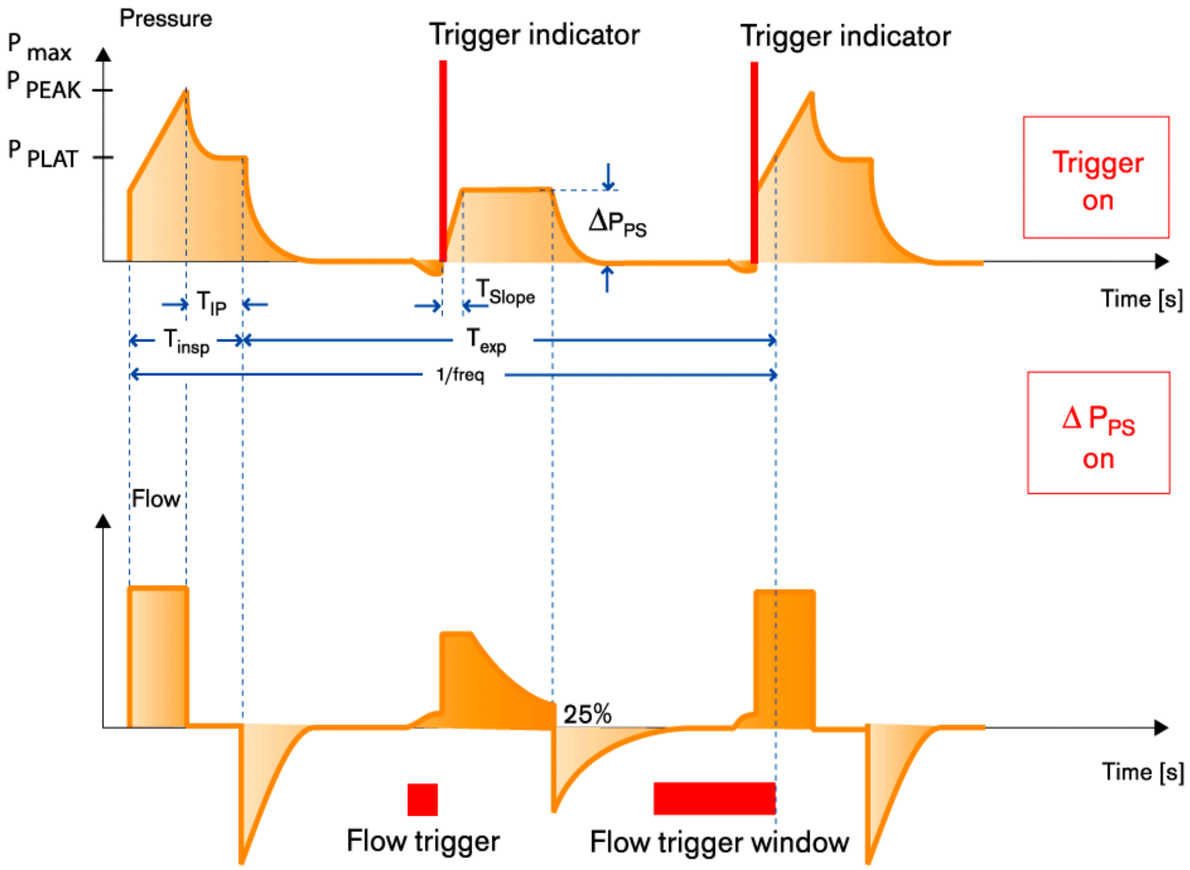

Figure 53 Synchronization of volume-controlled ventilation and “Pressure Support” of spontaneous breathing

Pressure support is activated if, during volume-controlled ventilation, a value is entered for the level of the pressure support “Δpps”.

The message “PressSupp” is displayed in the ventilation mode status field on the screen.

The flow trigger sensitivity and the “Δpps” level control the synchronization or the pressure support. The maximum time delay between the controlled ventilation breaths is adjusted by means of the frequency. To keep the frequency constant in the event of a premature triggering, the time is equalized in the next cycle.

If, at the time of pressure support activation, the patient was being ventilated without synchronization, automatic activation of the synchronization is initiated with the last trigger setting used.

If pressure support is deactivated with “OFF”, the synchronization is maintained with the set value.

If the trigger is deactivated with “OFF”, then the pressure support will be deactivated automatically.

7.2 “Pressure Mode”

Ventilation mode	Intended use
Pressure-controlled ventilation with decelerating flow (PCB), with synchronization of mandatory breaths (SIMV-PC) and with pressure support of spontaneous breathing (“Pressure Support”).	Anesthesia in patients suffering from a lung disease (inhomogeneous lung), neonates, children mask ventilation, pulmonary fistulae, laryngeal masks, inversed ratio ventilation, in relaxed or partially relaxed patients.

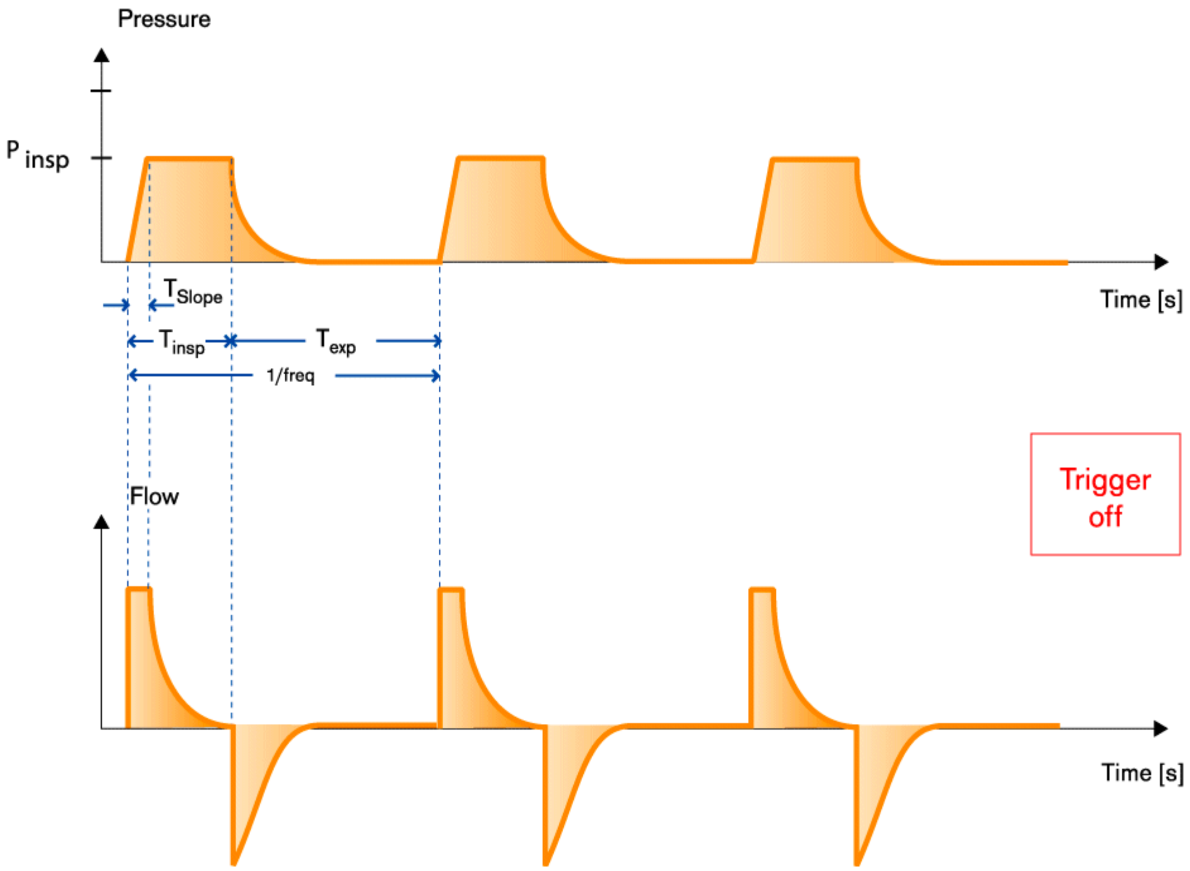

Figure 54 Pressure-controlled ventilation with decelerating flow

Pressure-controlled ventilation with fixed pressure limit “Pinsp” and frequency “1/freq”. Synchronization and adjustable pressure support of spontaneous breaths (optional) are switchable.

A continuous flow is applied to the patient during the inspiratory time “Tinsp”. The curve's rate of rise can be preset with the slope increase time “TSlope”. The maximum time delay between the controlled ventilation breaths is adjusted by means of the frequency. To keep the frequency constant in the event of a premature triggering, the time is equalized in the next cycle.

Changes to the lung compliance and the ventilation parameters affect the tidal volume.

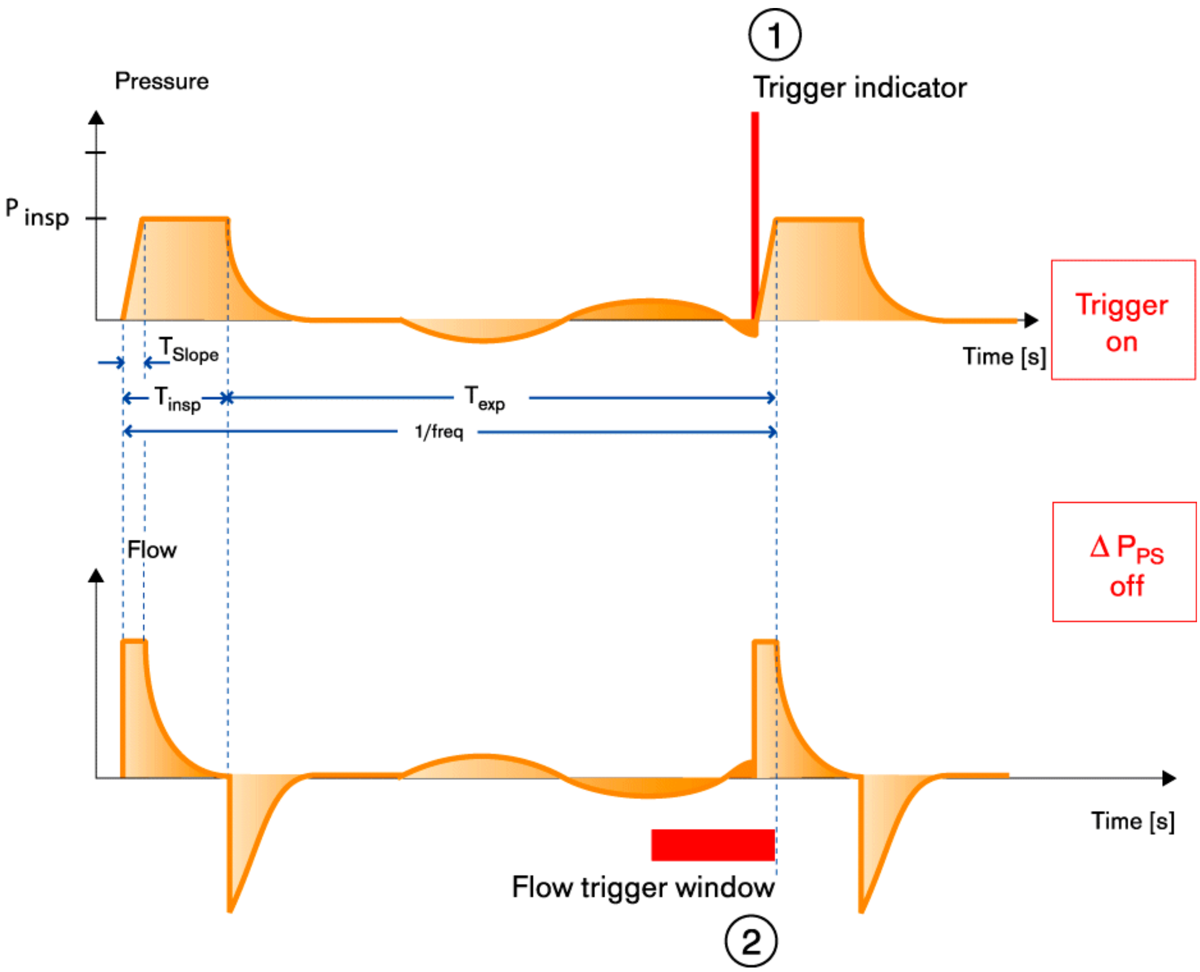

Figure 55 Synchronization of pressure-controlled ventilation and spontaneous breathing

Synchronization is activated as soon as a trigger value is entered.

The message “sync” is displayed in the ventilation mode status field on the screen.

The flow trigger sensitivity controls the synchronization.

A breath triggered by the patient is indicated by a continuous line (Figure 55/1) in the pressure curve and in the flow curve (trigger indicator). The active flow trigger window (Figure 55/2) corresponds to the last 25% of the relevant expiratory time.

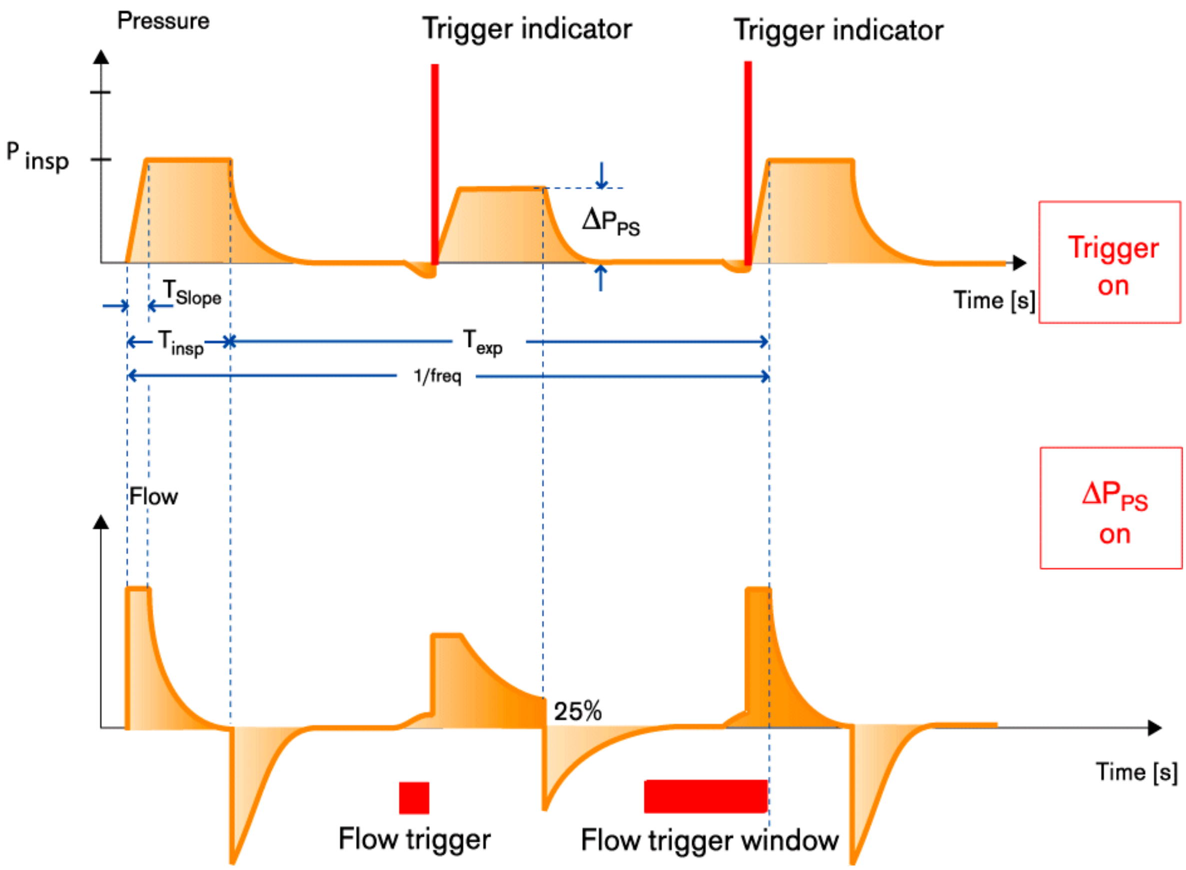

Figure 56 Synchronization of pressure-controlled ventilation and “Pressure Support” of spontaneous breathing

Activation of pressure support during pressure-controlled ventilation is initiated by entering a value for the pressure support level “Δpps”. The message “PressSupp” is displayed in the ventilation mode status field on the screen.

The flow trigger sensitivity and the “Δpps” level control the synchronization or the pressure support.

If, at the time of pressure support activation, the patient was being ventilated without synchronization, automatic activation of the synchronization is initiated with the last “trigger” setting used.

If pressure support is deactivated with “OFF”, the synchronization is maintained with the set value.

If the trigger is deactivated with “OFF”, then the pressure support will be deactivated automatically.

7.3 “Pressure Support Mode”

The ventilation mode “**Pressure Support Mode**” is an optional feature that must be activated.

Ventilation mode	Intended use
Pressure support for spontaneous brathing. This option can be used in all mechanical ventilation modes. At the same time, this option is an independent ventilation mode. The patient's spontaneous breathing effort is supported by the following factors: – The flow trigger sensitivity controls the synchronization. – The adjusted pressure setting is a measure of the pressure support. The curve's rate of rise can be preset with the slope increase time “Tslope”. In addition, an apnea ventilation can be set via the minimum frequency “Freqmin”. If the patient does not breathe spontaneously, the ventilator is activated automatically dependent on the set minimum frequency “Freqmin”. The subsequent ventilation breath is not a mandatory ventilation breath. The patient can always stop the mandatory ventilation breath by his/her own breathing activity.	Anesthesia in spontaneously breathing patients with laryngeal masks during surgeries without muscle relaxants.

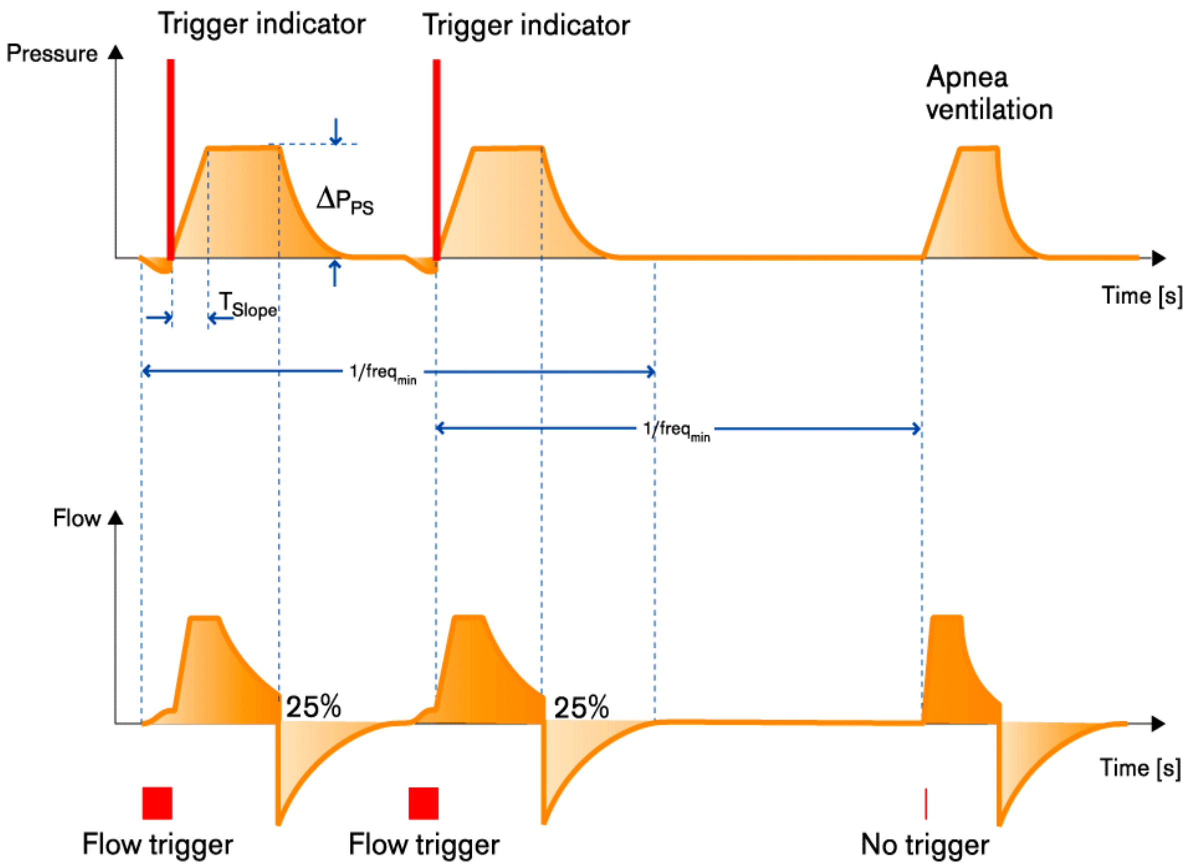

Figure 57 Spontaneous breathing support

The flow trigger sensitivity and the “Δpps” level control the synchronization or the pressure support of the spontaneous breathing effort. The curve's rate of rise can be preset with the slope increase time “Tslope”.

In addition, an apnea ventilation can be set via the minimum frequency “1/freqmin”. “1/freqmin” controls the automatic triggering of the ventilator when the patient is not breathing spontaneously. It is not a mandatory ventilation breath from the ventilator. The patient can always stop the breath triggered by the ventilator by his/her breathing activity. This breath is not provided with a trigger indicator.

7.4 “Man./Spont Mode”

Ventilation mode	Intended use
Manual ventilation or assisted ventilation and spontaneous breathing.	Anesthesia induction/recovery and in emergency situations.

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7.5 Switching ventilation modes

When switching to another ventilation mode, the presettings of the previous mode's parameters are transferred or usefully derived.

Identical parameters in both ventilation modes (Freq., TINSP, PEEP, Δpps, trigger) are transferred directly.

Switching ventilation modes	Transfer of settings
Volume-controlled to pressure-controlled.	The measured parameter “Pplat” is applied as new parameter “Pinsp”.
Pressure-controlled to volume-controlled.	The new tidal volume “VT” is transferred from the measured minute volume “MV” and the set frequency “Freq.”. Only the mechanically applied minute volume is used in this case. Pressure-supported breaths by the patients are not taken into consideration.
Automatic ventilation modes to “Pressure Support” (optional).	The set PEEP, “Δpps” and trigger are transferred. If “Δpps” and/or trigger were set to “OFF”, the most recently used values are transferred to pressure support, otherwise the configured default settings.
Pressure support (optional) to automatic ventilation modes.	The set PEEP, “Δpps” and the trigger are transferred. The other parameters correspond to the most recently used settings, otherwise to the configured default settings.

7.6 HLM mode

The HLM mode (“HLM” = heart-lung machine) enables an alarm-free patient monitoring during extracorporeal oxygenization of the patient by means of a heart-lung machine.

The following conditions apply in the HLM mode:
– All gas concentrations are measured independent of the breathing phase.
– The CO2 apnea alarm, the pressure apnea alarm, and the SpO2 monitoring alarms are deactivated.

The HLM mode remains active when switching from one ventilation mode to another. Switching to standby mode will deactivate the HLM mode.

The function description relating to the Power pack follows.

8 Power pack

This section describes the power pack. The power pack comprises the electronics component and two UPS batteries (UPS = **U**ninterruptible **P**ower **S**upply).

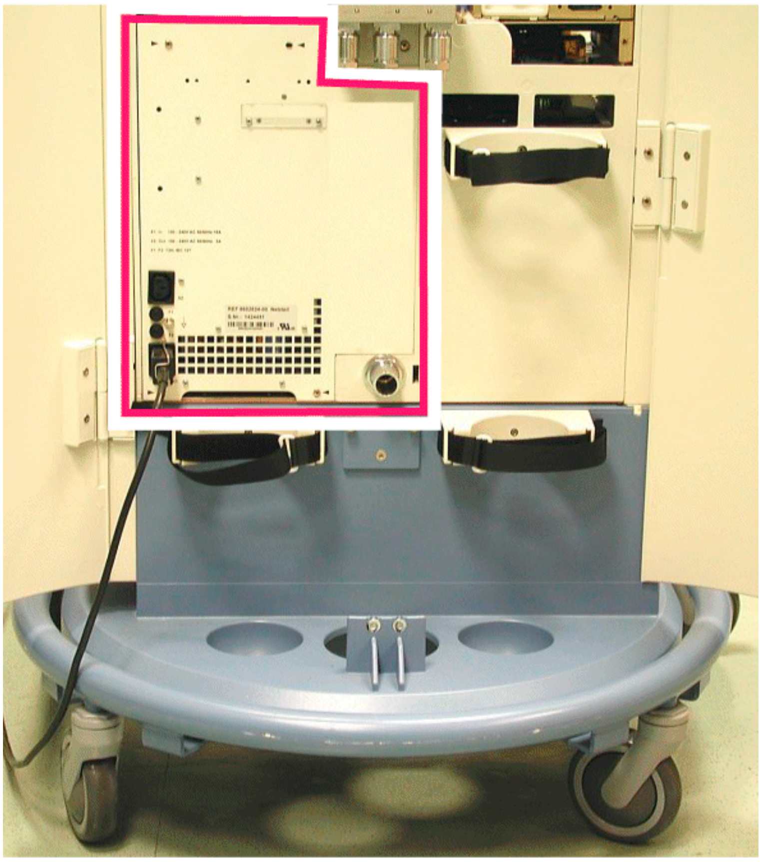

Figure 58 Power pack position

In the 'Block diagrams' section you will find a block diagram of the power pack.

8.1 Power pack input

The power pack generates the direct voltage for the Primus components and the charging voltage for the UPS batteries.

The power pack input processes alternating voltages from 85 to 265 V (45 to 65 Hz).

In the event of a power failure or power pack failure, an automatic switch is made to the UPS. The connection to the mains voltage is via a 16 A inlet connector for non-heating apparatus.

The inlet connector for non-heating apparatus is protected by a mechanical locking device (to EN 740) to prevent it being pulled out unintentionally.

The power pack has a grounding connection with a 6.3 mm contact.

8.2 Power switch

Figure 59 Power switch position

The power switch is connected via the NEUTRAL POINT PCB to the power pack. The power switch switches an auxiliary voltage of 5 V.

8.3 Output voltages and currents

The power pack delivers the following output voltages:

– 3x 20 to approx. 30 Volts (battery voltage)

– 3x regulated output voltage of 12 Volts.

The voltages are battery-buffered.

Voltage	Unit on	Unit off	applies to:
U1: 24 V, 10 mA	Always present		Battery-buffered RAM in GUI
U2: 24 V, 10 VA	Present as soon as mains plug is connected or unit is switched on.		Pressure sensors of CS and compressed gas cylinders. CS LEDs, mixer LEDs

Voltage	Unit on	Unit off	applies to:
U3: 24 V, 1-23 A	Present 10 seconds after the power switch is switched on (independent of mains voltage).	Releases with a delay of approx. 10 s after operation of the switch	- GUI - Mixer - VGC
U4: 12 V, 1-10 A			- IRIA - ILCA - VGC - small pneutronic valves
U5: 12 V, 10 VA	Present as soon as the unit is switched on.		Fan for VGC and mixer
U6: 12 V, 10 VA			Fan for IRIA and optical Diva

A higher power demand than 600 W is supplied from the batteries.

The switched output voltages (U3 to U6) release with a delay after operation of the switch. The delay is 10 seconds, but can be altered with the CAN protocol to between 5 and 15 seconds.

The power pack is short-circuit-proof and shuts off if operating current = Imax and U < Umin for t > 20 ms.

8.4 Secondary connector

The connector for the voltage outputs is a 24-pin plug. The connector additionally carries the CAN signals, the switching contacts of the power switch and the control wires for the power and battery LEDs on the front panel.

8.5 UPS batteries

The two UPS batteries are fitted separately in the housing, behind the power pack. The battery capacity is sufficient to run the Primus for at least 30 minutes.

The Primus power pack performs an automatic battery test every 30 days. The battery test has no effect on the operation of the Primus. In testing, the batteries are discharged by 20% of the available capacity. The battery condition is determined from the resultant battery curve.

The charging time for fully discharged batteries is a maximum of 10 hours. The batteries’ charging management system takes into account the battery temperature. The battery temperature is measured with a temperature sensor (NTC) directly at the batteries.

The battery charging management system prevents exhaustive discharge. If the battery voltage falls below 20 V the power pack shuts down the Primus. If the battery voltage is below 20 V the power pack cannot be powered up.

8.6 Power pack CAN communication

With the CAN (Controller Area Network) bus data can be exchanged between the power pack and the other modules. The higher-level software protocol is SABUS (**S**ensor and **A**ctuator **BUS**).

The power pack has a CAN 2.0 B compatible interface. The interface transfers data and status information in both directions.

The power pack sends its data periodically, every 500 ms, to the GUI.

The power pack CAN bus transfers the following data:

- Power pack version
- Power pack hours. Total time in operation of power pack.
- Battery hours. Power pack operating time in battery mode. The figure is given in Ah (Ampere hours).
- Time remaining: Indicates the time remaining in seconds until the power pack will shut off.
- Battery type: Indication of battery type.
- Power pack details: e.g. self-test errors.
- Date: To determine how long the unit was switched off.
- Switch power pack off. The power pack shuts when the remaining time expires. The shut-off is aborted as soon as the value “0” (->switch off power pack = no) is received by the power pack.

8.7 Power failure warning

The power pack hooter sounds under the following conditions:

- About 1 second after power-up for about 1 second.
- If the “Hooter on” error is delivered over the CAN bus. For as long as the CAN controller is in “Reset” mode.
- When the power switch is set to “On” and the batteries are flat or have been removed.
- If no CAN messages are received for the power pack during operation for more than 15 seconds after receipt of the first CAN message.
- In case of power failure.

The hooter sounds for as long as the error condition persists, up to a maximum of 30 seconds +-5 seconds.

The function description relating to the operating modes follows.

9 Operating modes

This section details the individual operating modes of the Primus.

9.1 Cold start

When the Primus is switched on, the unit starts up with a so-called cold start.

During the cold start the user checks and confirms the checklist on the display. Then the user is prompted to connect the Y-piece to the patient unit and set the APL valve to 30 mbar (MAN setting).

In the self-test which follows the unit checks its system components. Any errors detected are indicated on the display. If no errors occurred, the Primus switches to “ready”.

The self-test can be interrupted for an emergency start.

9.2 Standby mode

When the self-test is completed, standby mode is automatically activated. In this operating mode no CS gas is consumed. No fresh gas supply is possible (except for fresh gas through the safety O2 adjuster “VSFC”). The user can select all ventilation parameters, the fresh gas flow setting and the ventilation mode.

Alarms and messages are indicated on the display.

9.3 Shutdown

All Primus components are switched off from the central power switch. Only the charging circuit for the UPS batteries is permanently in operation.

When the Primus is off, the following alarms are inactive:

- Mains power failure
- CS pressure failure

9.4 Safety mode

If the software detects a serious error during fresh gas supply or ventilation, individual components (such as the mixer) or the entire Primus unit switch to safety mode.

In safety mode it is possible to provide the patient with manual ventilation or spontaneous breathing. The fresh gas is then supplied by the adjustable safety O2 flow control valve “VSFC”.

9.4.1 Safety O2 flow

The safety O2 flow is usually set by the user with the safety O2 adjuster and routed through the vaporizer.

The patient is supplied with O2 (4 L/min to 12 L/min) by the “VSFC”. As a result, anaesthetic gas metering is possible. This operating mode is usually activated by the user under the following conditions:

- In case of a total system failure. Primus switches to Safety mode.
- Power failure or UPS batteries flat.

In this case the control range of the O2 flow is 4 L/min to 12 L/min. If the safety O2 flow is activated in normal mode, a warning appears on the display. The mixer electronics additionally limit the fresh gas flow to 3 L/min. The fresh gas settings are then greyed on the display (from software release 1.n).

9.5 Alarm system

The Primus has a common alarm system for visual and acoustic indication of ventilator and monitoring alarms. Error messages are indicated on the display.

There are three categories of alert:

– Alarm (category **I**)
– Warning (category **II**)
– Notification (category **III**

The function description relating to the cylinder pressure reducers follows.

10 Cylinder pressure reducer

This section describes the pressure reducer for the high-pressure cylinders (option).

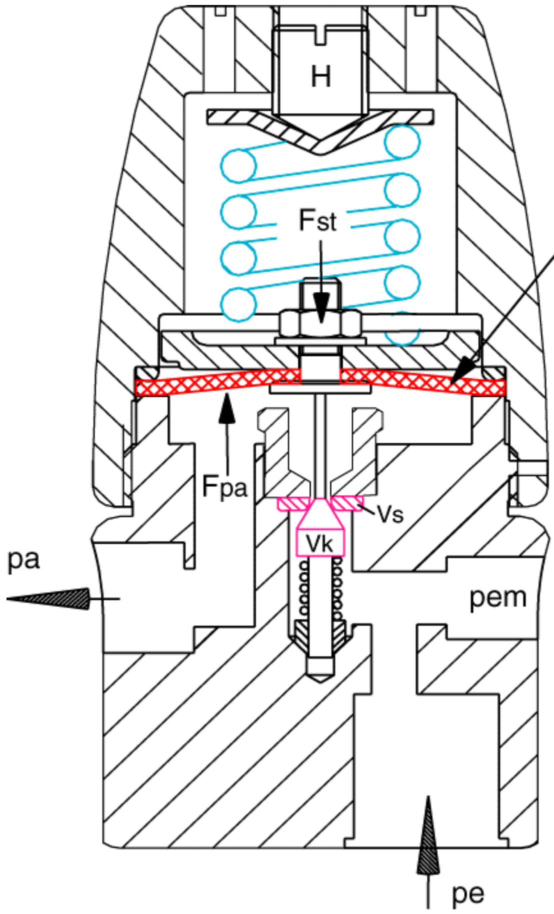

Figure 60 Sectional drawing of cylinder pressure reducer; for legend see Table 26

Table 26 Legend to Figure 60

Abbreviation	Function
H	Adjusting screw
Fst	Adjusting spring force
M	Diaphragm
Fpa	Press force
pem	Sensor/pressure gauge connection
pe	Input pressure
pa	Low pressure
Vs	Valve seat
Vk	Valve cone

The abbreviations occurring in the following text relate to Figure 60 .

The following pressure reducer types exist:

– AIR, from 200 bar to 5 bar
– O2, from 200 bar to 5 bar
– N2O, from 60 bar to 5 bar

The diaphragm (M) regulates the pressure.

When the adjusting screw “H” is at the anti-clockwise stop limit the adjusting spring force “Fst” is at its lowest. The valve cone “Vk” is pressed into the valve seat by the spring underneath it and interrupts the gas flow.“pa” rises.

When the adjusting screw (H) is turned clockwise the adjusting spring force (Fst) increases. The valve cone is pressed down by the diaphragm, the valve opens and the low pressure “pa” rises.

A constant low pressure “pa” results from the equilibrium of forces (Fpa = Fst).

The low pressure is preset to between 5 and 6 bar (USA = 2.7 bar and 3.5 bar).

If the low pressure drops, the force “Fpa” decreases and the adjusting spring force “Fst” opens the valve.

If the low pressure rises, the force “Fst” increases and compresses the adjusting spring. The valve is closed accordingly.

The pre-tension of the spring is set by the manufacturer, and can be adjusted by the DrägerService technician.

If the valve cone does not close, the internal blow-off valve “Sv” limits the low pressure (see Figure 61). The opening pressure is between 6.6 bar and 8.5 bar.

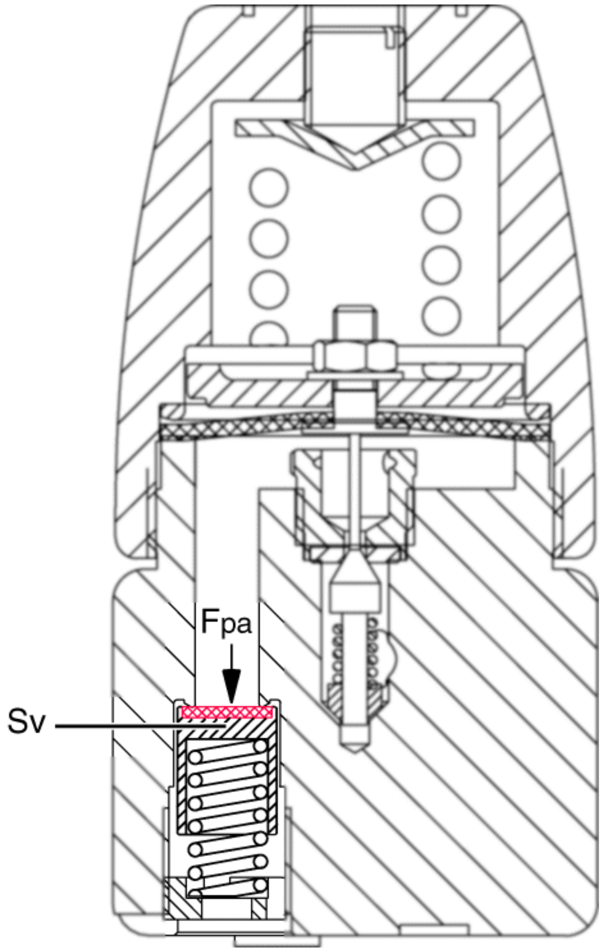

Figure 61 Sectional drawing of blow-off valve

The function description relating to the vaporizer follows.

11 Vaporizer

The interlock system prevents two vaporizers from operating simultaneously.

The active vaporizer enriches the mixed gas with anaesthetic.

For a detailed description refer to the relevant Instructions for Use of the vaporizers used.

12 Bronchial aspirator

12.1 Intended use

The bronchial aspirator is intended for use with the Primus and Zeus anesthetic workstations. The driving gas is AIR, O2, or VAC (vacuum), depending on the type of bronchial aspirator.

12.2 Device types

The device types are designed as stand-alone devices.

The following device types are currently available:

– Bronchial aspirator with ejector
– Bronchial aspirator with vacuum

12.2.1 Variants

The following variants are available:

– NIST variant. Can be installed on rail system or on devices with appropriate mounting option.
– Pipeline connector variant. The bronchial aspirator is plugged directly into the pipeline terminal unit.

12.3 Bronchial aspirator with ejector

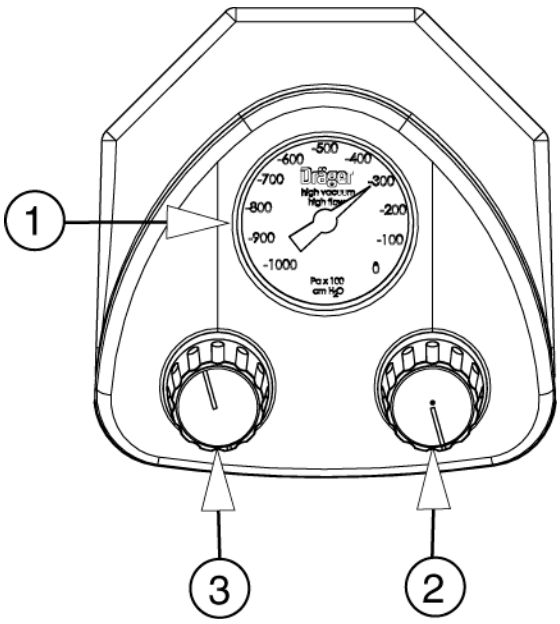

Figure 62 Front view of the bronchial aspirator with ejector

The front panel has the following parts:

– Pressure gauge (Figure 62/1)
– Rotary knob for setting aspiration flow (Figure 62/2)
– Rotary knob for fine adjustment of regulated aspiration flow (Figure 62/3)

The system vacuum is indicated on the control element (pressure gauge).

12.3.1 Pneumatics (ejector)

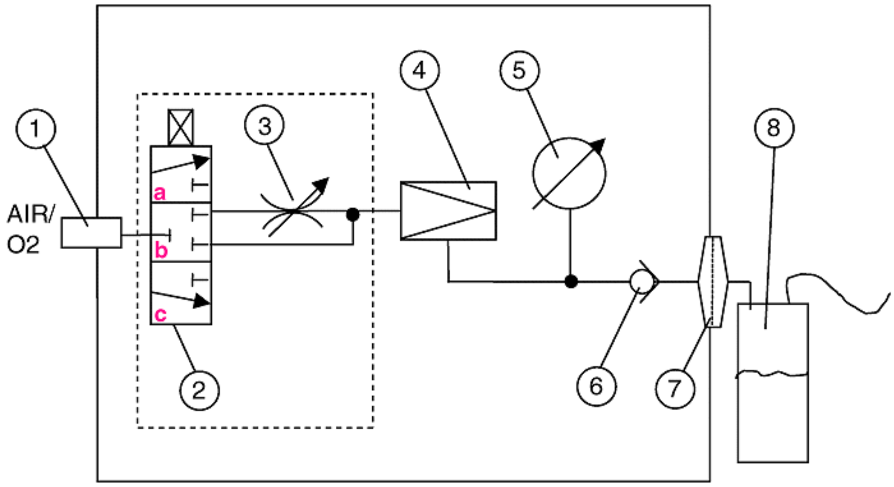

Figure 63 Pneumatics of the bronchial aspirator with ejector

Table 27 **Legend to Figure 63**

Pos.	Meaning
1	Supply pressure connector (O2/AIR-NIST or AIR-NIST or O2/AIR pipeline connector)
2	Operating mode selector
3	Control valve
4	Ejector
5	Pressure gauge
6	Non-return valve (bacterial filter mount)
7	bacterial filter
8	Collector

The position numbers and valve positions mentioned in this chapter refer to Figure 63.

The driving gas (AIR or O2) enters into the bronchial aspirator through the supply pressure connector.

The operating mode selector (2) is used to select the following operating modes:

– **OFF** (valve position “b”). The bronchial aspirator is switched off.
– **Regulated flow** (valve position “a”). The driving gas passes through the control valve (3). The control valve adjusts the ejector driving gas thus generating the required vacuum.
– **Maximum flow** (valve position “c”). The supply pressure is fed directly to the ejector. This generates a maximum vacuum in the suction system.

The non-return valve (6) is used as a mount for the bacterial filter. In the event of malfunctions, the non-return valve makes sure no positive pressure is present in the vacuum system.

The bacterial filter (7) makes sure that no particles or bacteria from the collector (8) enter the suction system. The filter material can block fluids up to a vacuum pressure of 920 mbar.

The pneumatic circuit has the following advantages:

– In the “regulated flow” position only as much driving gas is used as required to generate the vacuum.
– Fast toggling between regulated flow and maximum flow.
– Less noise by reduced gas consumption.
– No suction flow loss by bypass openings.

12.4 Bronchial aspirator with vacuum

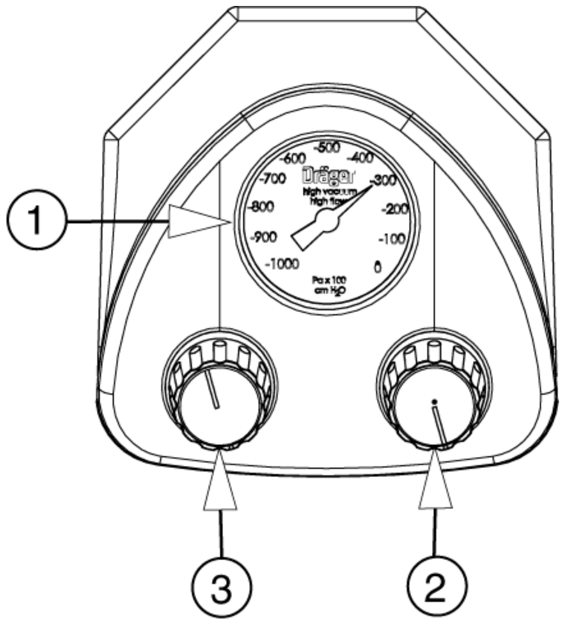

Figure 64 Front view of the bronchial aspirator with vacuum

The front panel has the following parts:

– Pressure gauge (Figure 64/1)
– Vacuum regulator (Figure 64/2)
– Operating mode selector (Figure 64/3)

The system vacuum is indicated on the control element (pressure gauge).

12.4.1 Pneumatics (vacuum)

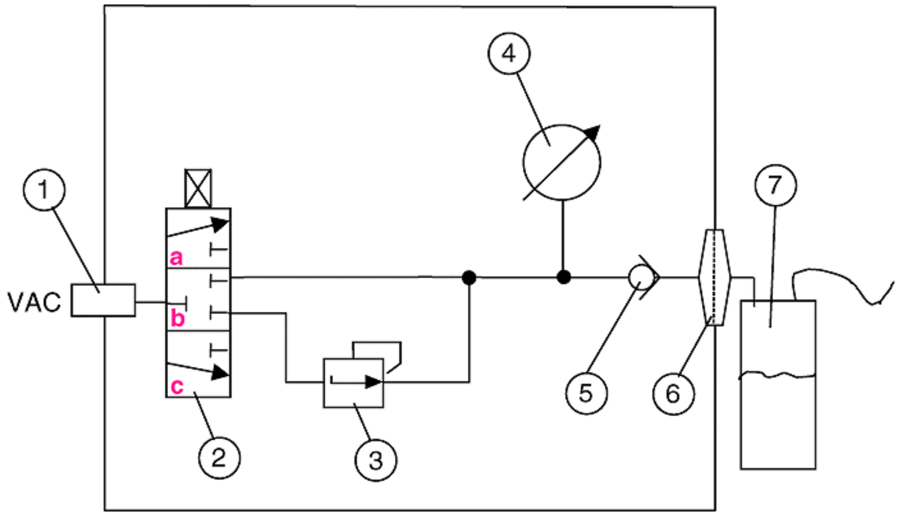

Figure 65 Pneumatics of the bronchial aspirator with vacuum

Table 28 Legend to Figure 65

Pos.	Meaning
1	VAC connector (VAC-NIST or VAC pipeline connector)
2	Operating mode selector
3	Vacuum regulator
4	Pressure gauge
5	Non-return valve (bacterial filter mount)
6	bacterial filter
7	Collector

The position numbers and valve positions mentioned in this chapter refer to Figure 65.

The vacuum enters into the bronchial aspirator through the VAC connector (1).

The operating mode selector (2) is used to select the following operating modes:

– **OFF** (valve position “b”). The bronchial aspirator is switched off.
– **Regulated flow** (valve position “a”). The generated vacuum depends on the position of the vacuum regulator (3). The vacuum is indicated by the pressure gauge (4).
– **Maximum flow** (valve position “c”). The vacuum is fed directly to the non-return valve (5). This generates a maximum vacuum in the suction system.

The non-return valve (5) is used as a mount for the bacterial filter.

The bacterial filter (6) makes sure that no particles or bacteria from the collector (7) enter the suction system. The filter material can block fluids up to a vacuum pressure of 920 mbar.

The pneumatic circuit has the following advantages:

– Fast toggling between regulated flow and maximum flow.
– High-quality vacuum control.
– No suction flow loss by bypass openings.

13 Block diagrams and pneumatic components layout

13.1 Introduction

The following block diagrams and the pneumatic components layout are component elements of the function description of the Primus.

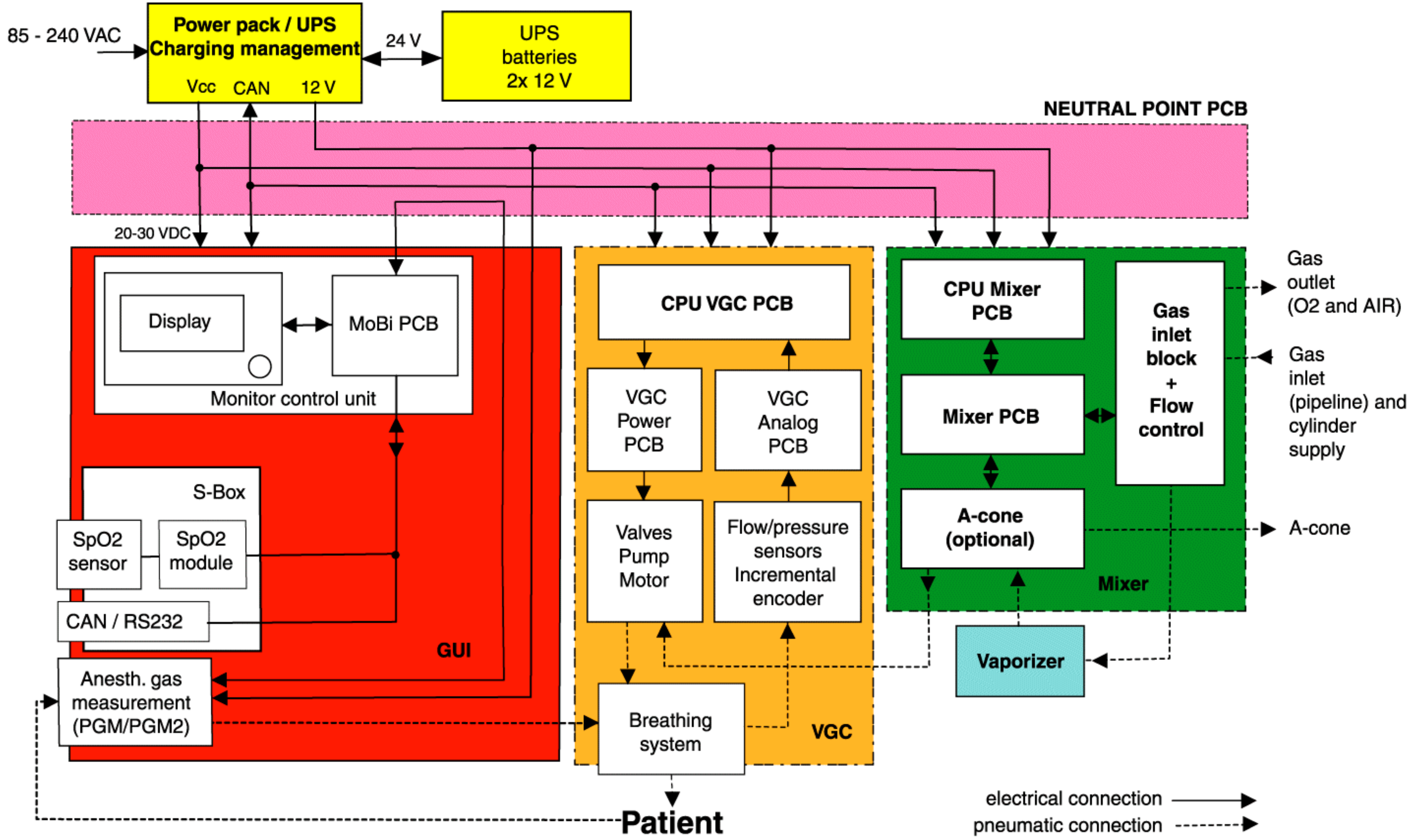

Figure 66 Primus block diagram, detailed

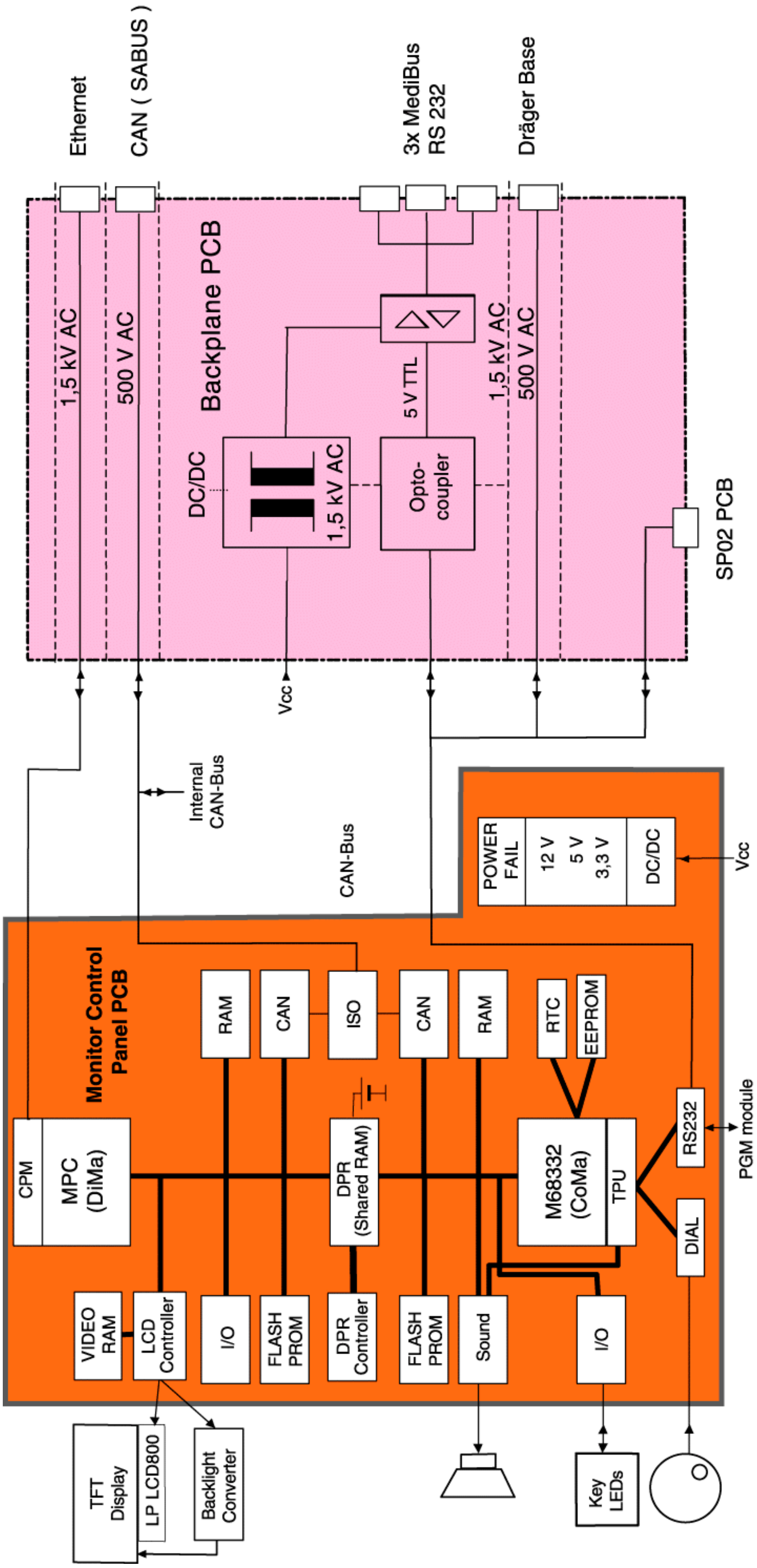

Figure 67 MoBi block diagram

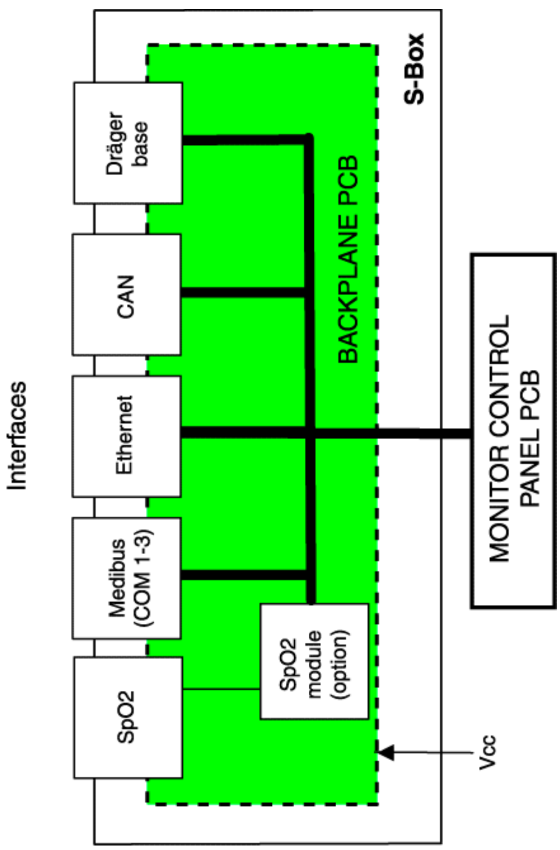

Figure 68 S-Box, block diagram, detailed

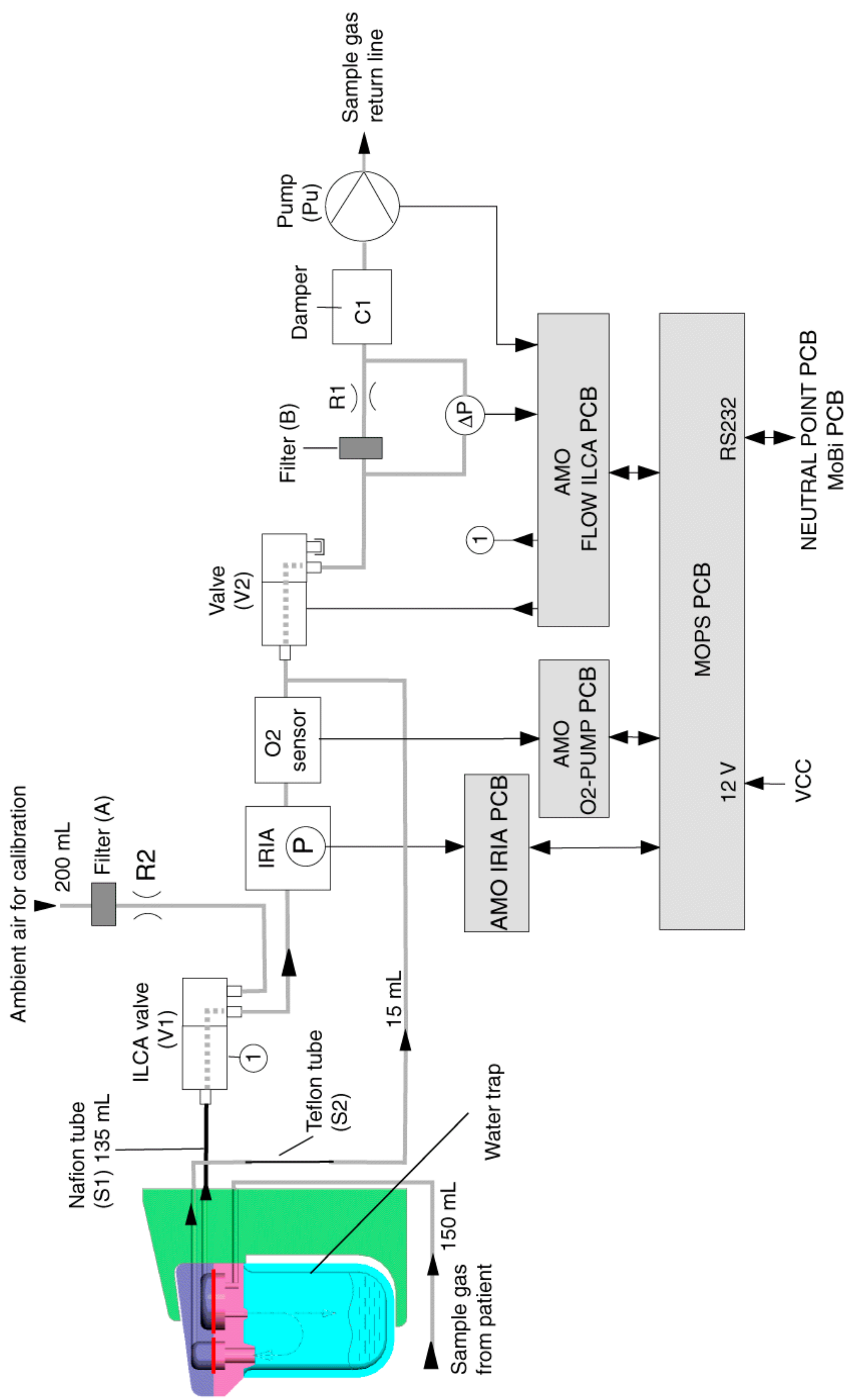

Figure 69 PGM pneumatics diagram, detailed

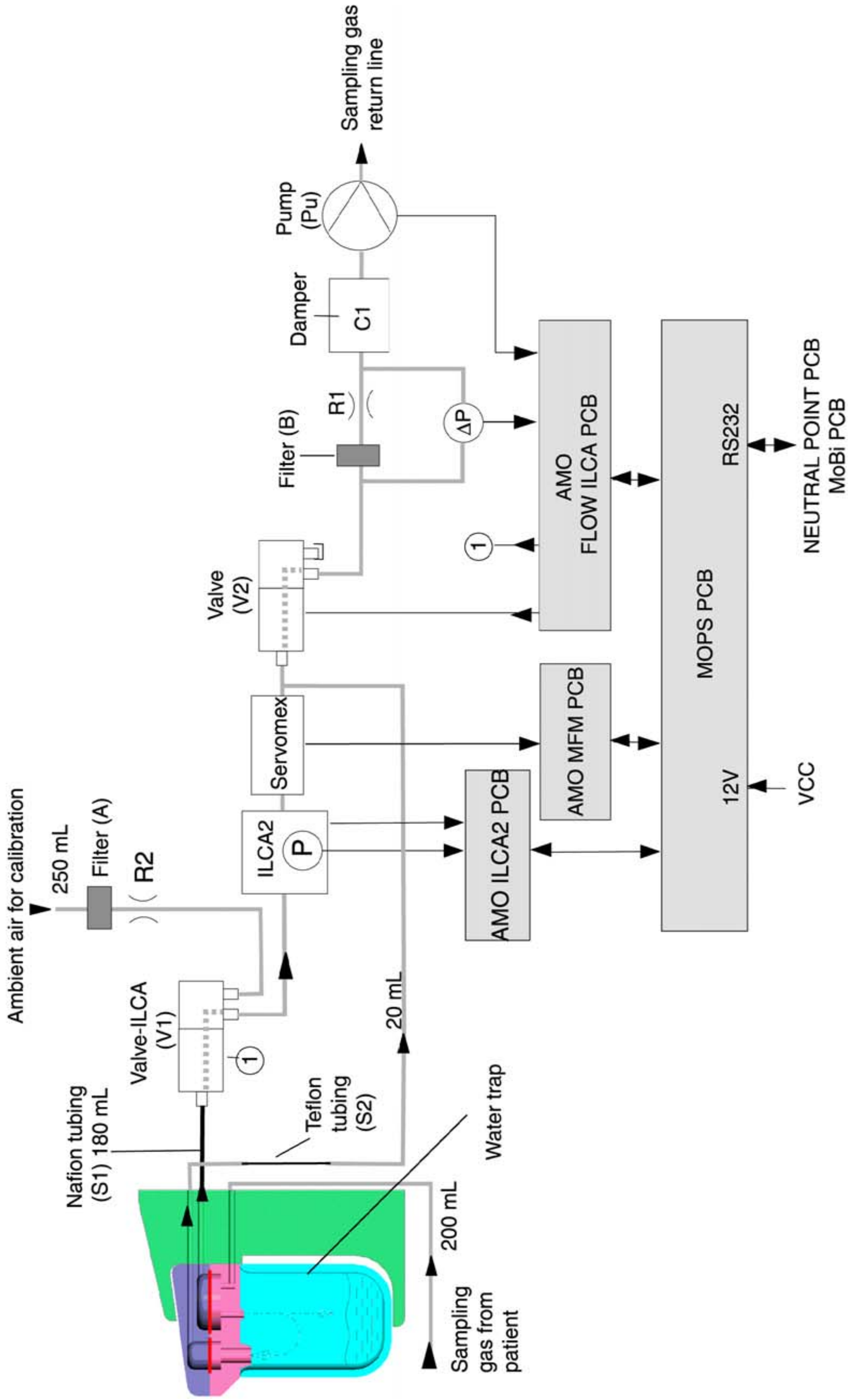

Figure 70 PGM2 pneumatics diagram, detailed

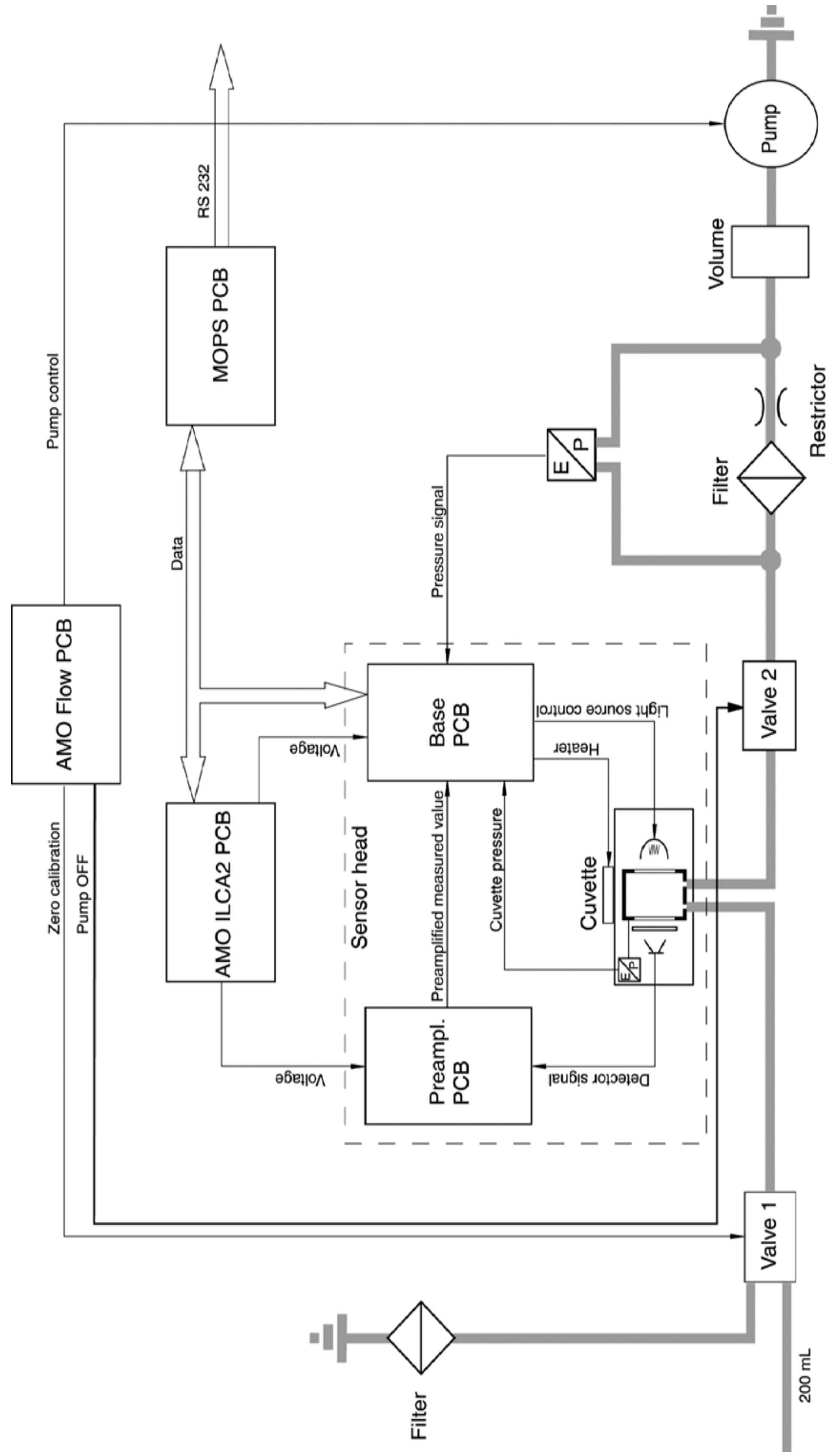

Figure 71 PGM2 block diagram

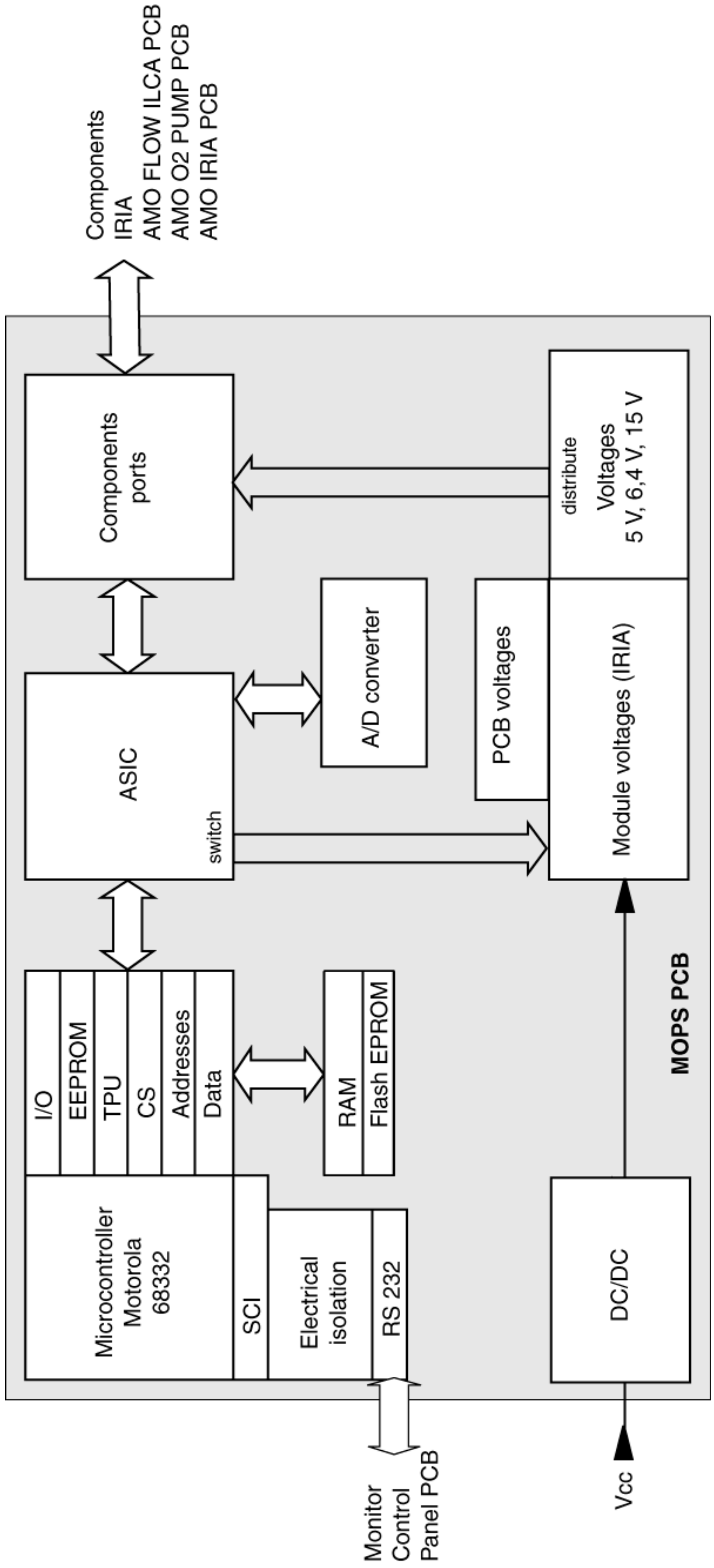

Figure 72 MOPS PCB block diagram

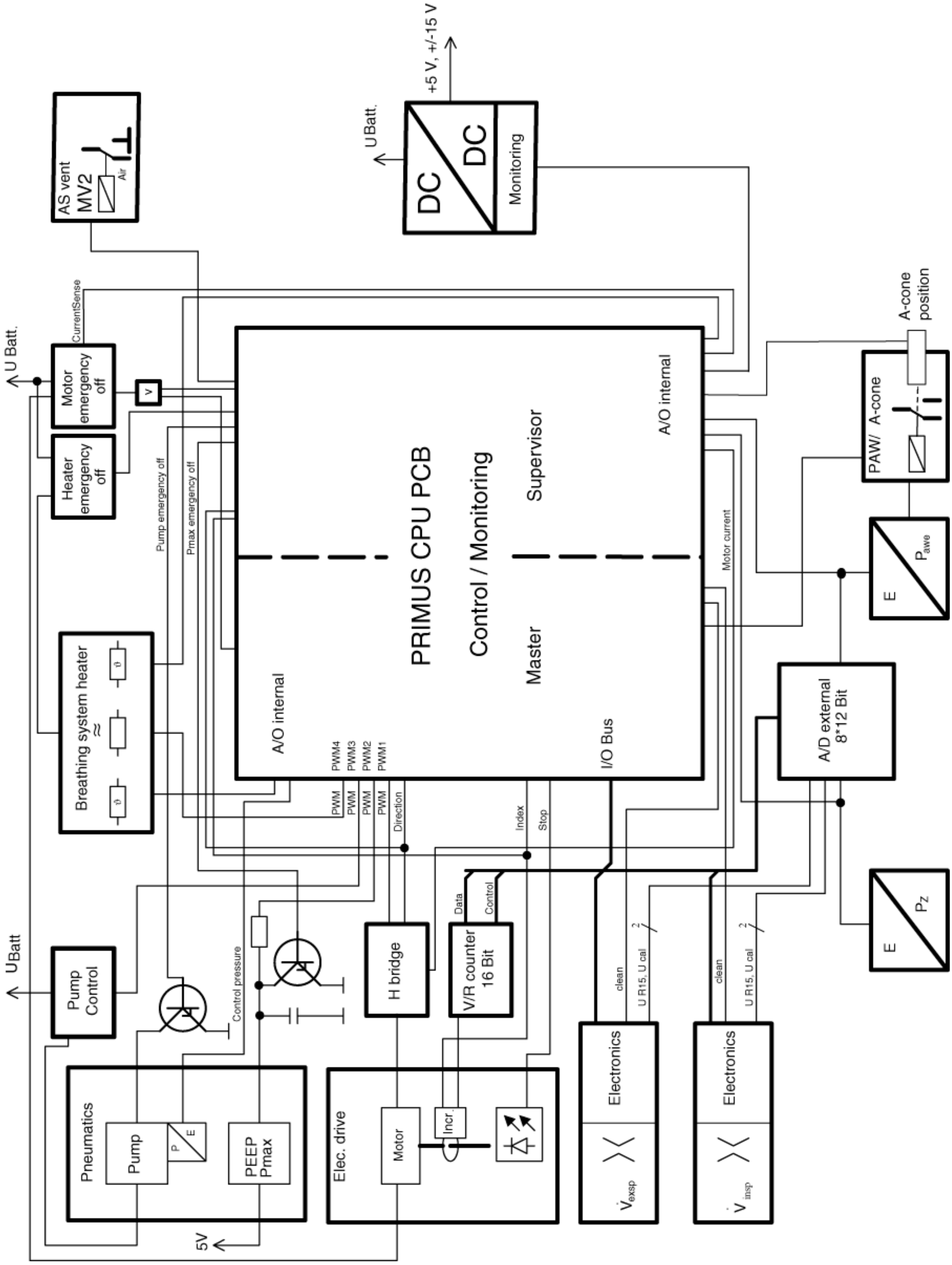

Figure 73 VGC block diagram

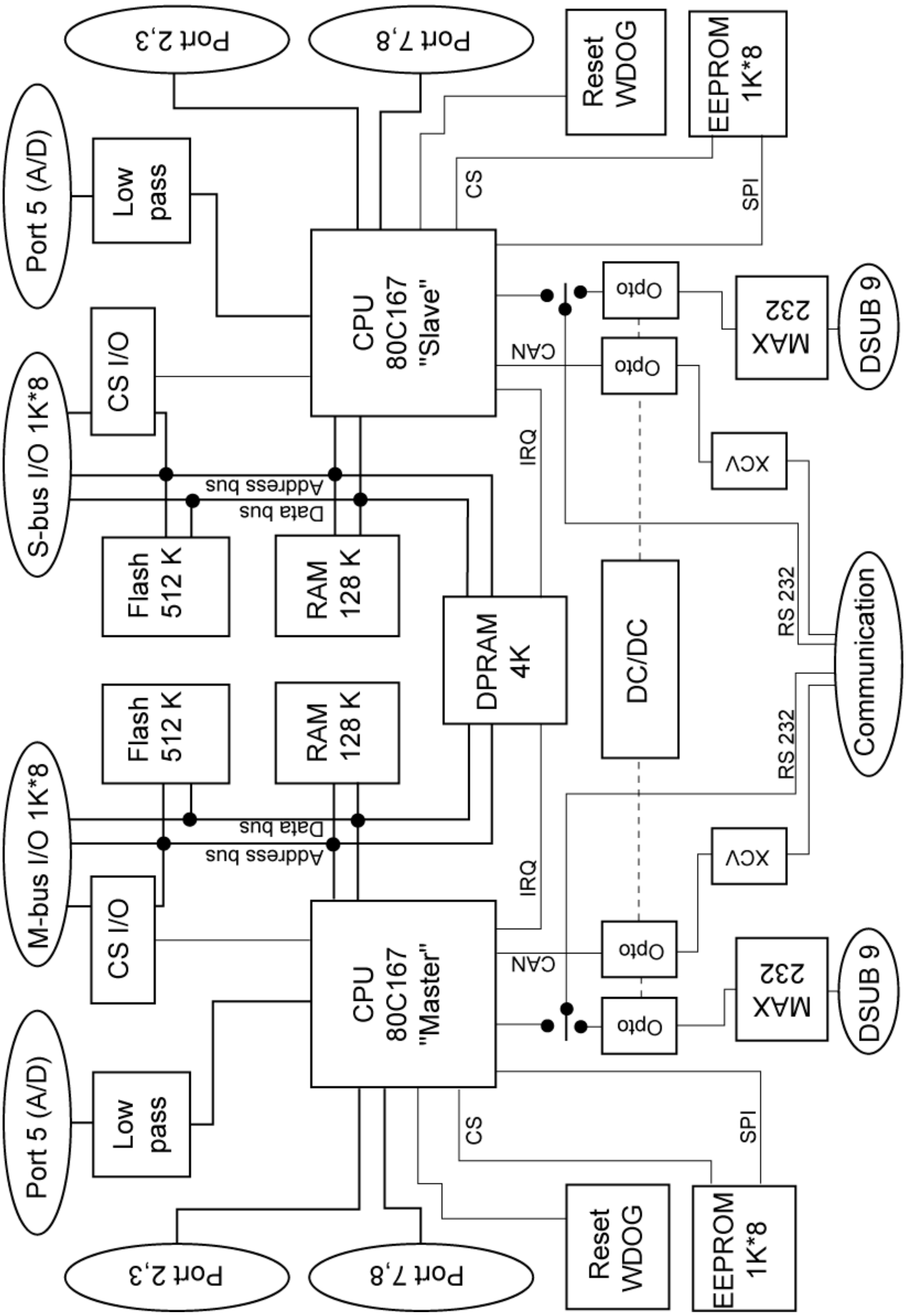

Figure 74 CPU PRIMUS PCB block diagram, installed in mixer and VGC

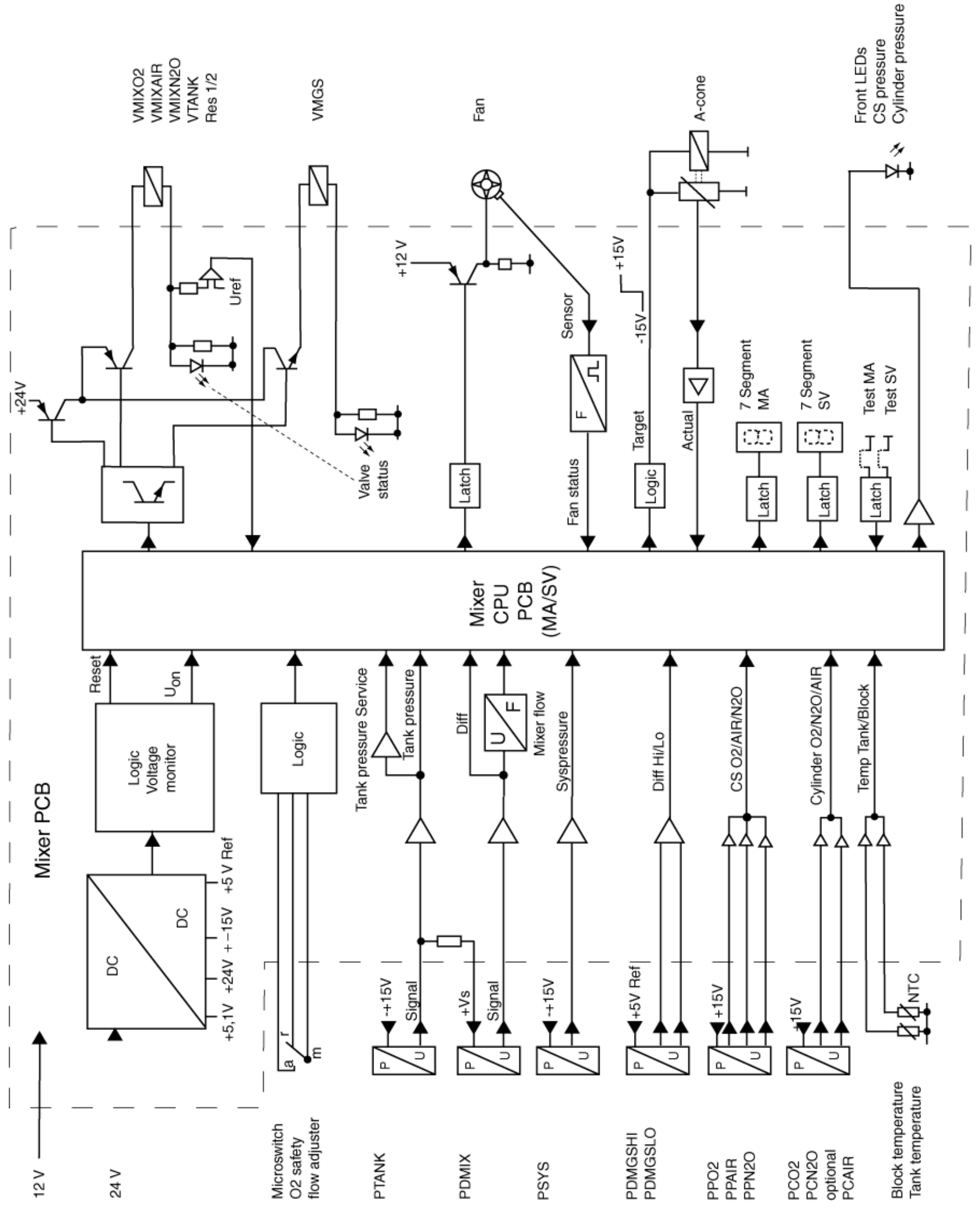

Figure 75 Mixer PCB block diagram

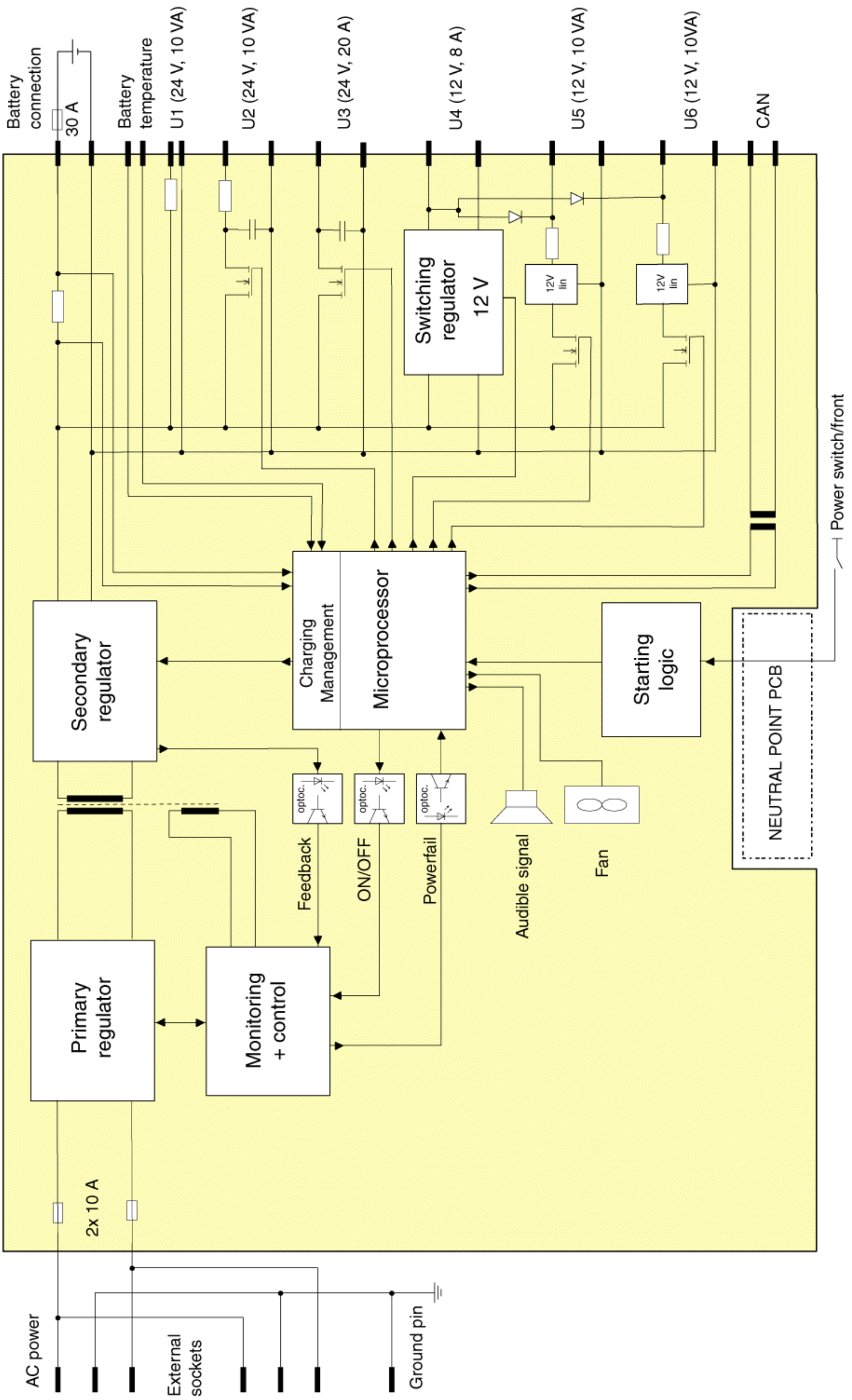

Figure 76 Power pack/UPS block diagram

Maintenance Procedures

1 Safety precautions

WARNING

Risk of explosion!
Always make sure parts which come into contact with oxygen are free of grease and oil prior to fitting.

WARNING

Hazardous voltage!
Do not touch live conductors/parts when Primus' power plug is plugged into the AC outlet.
Switch off the Primus at the power switch (main switch).
Unplug the power plug from the non-heating apparatus socket on the power pack. To do so, turn the mechanical guard aside.

CAUTION
Electrostatic discharge!
Electrostatic discharge may damage electrostatic sensitive devices.
When handling electrostatic sensitive devices always use an anti-static mat and a wrist strap.

WARNING

Function and safety tests after servicing!
After carrying out servicing work, perform a function test and a test of electrical safety.

2 Rear panel

2.1 Rear panel removal

1. Follow the safety instructions (see Safety precautions).
2. Remove the five rear panel fixing screws (see Figure 1).

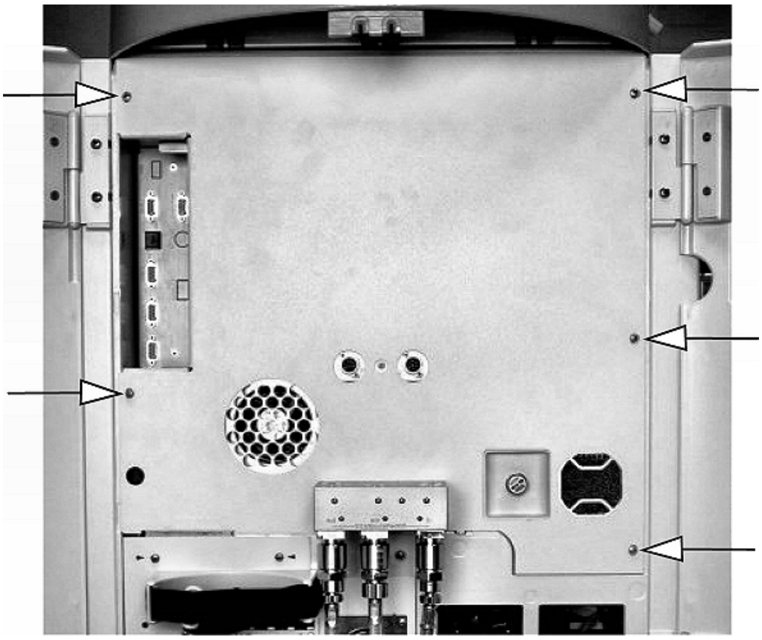

Figure 1 Rear panel fixing screws

3. Withdraw the rear panel from the unit and place it down safely.

2.2 Rear panel fitting

1. Re-assemble using the reverse (logical) sequence of that used for disassembly.

2.2.1 Rear panel final check

1. Are all screws fixed?
2. Is the rear panel fitted in place without mechanical strain?
3. Electrical safety test.

3 Replacing bronchial suction device bacterial filter

1. Remove the old bacterial filter from the underside of the bronchial suction device and replace it (see Figure 2/1).

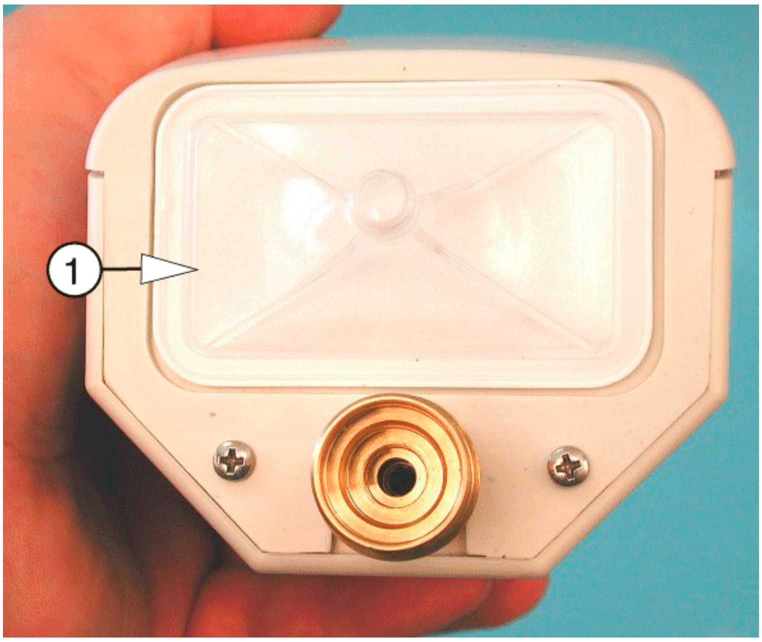

Figure 2 Bacterial filter position

2. Carry out a functional test.

4 Replacing filter mat on PGM fan

1. Take out the filter on the rear of the PGM (see Figure 3) and replace it with a new one.

Figure 3 PGM, filter

5 Replacing bacterial filter and Nafion tube in PGM

5.1 Removing the PGM

5.1.1 Removing the PGM housing

1. Remove the three fixing screws (see Figure 4).

Figure 4 Fixing screws

2. Remove the four side panel fixing screws (see Figure 5).

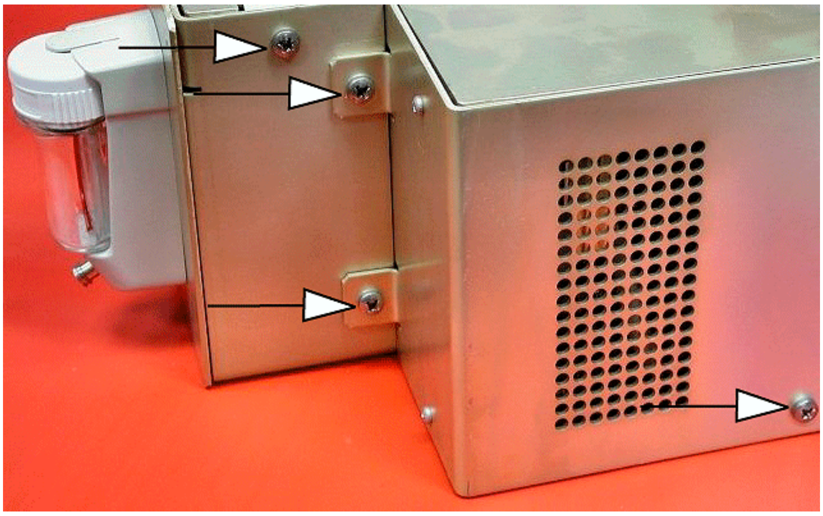

Figure 5 Side panel fixing screws

3. Slide the top cover aside (see Figure 6).

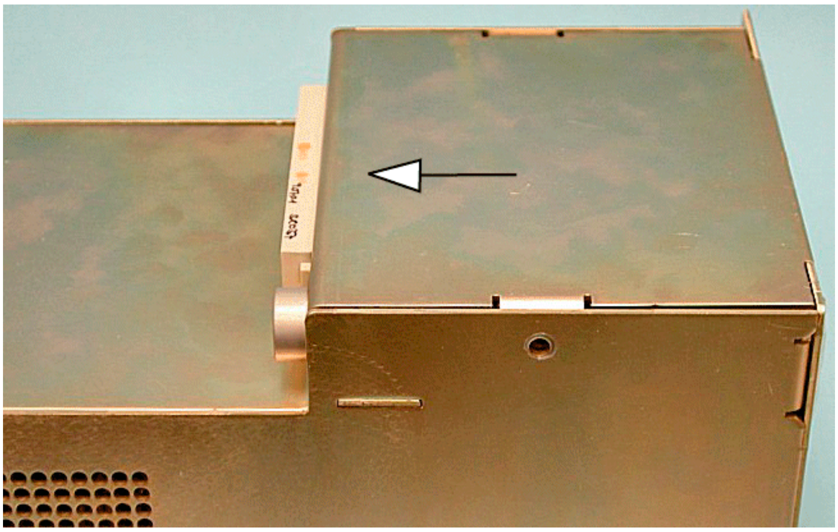

Figure 6 Top cover

4. Place the top cover next to the housing. Tilt the side panel slightly (Figure 7/1) and place the adapter board (Figure 7/2) next to the housing.

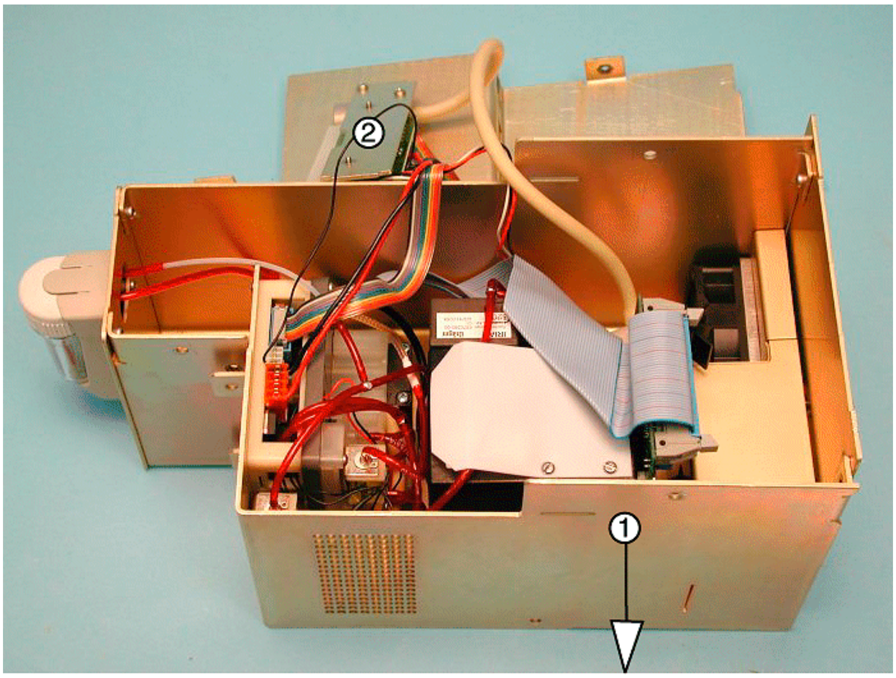

Figure 7 Opened PGM housing

5.2 Replacing the bacterial filter

1. Remove the old bacterial filter (Figure 8/1) and replace it with the new one.

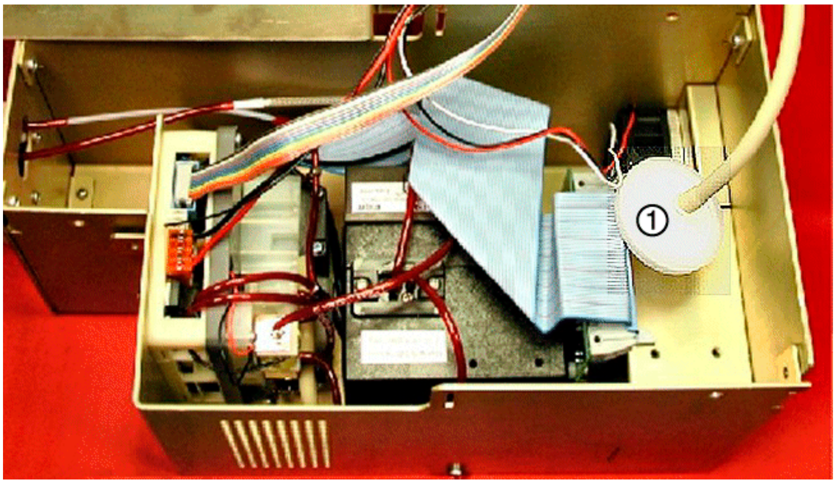

Figure 8 Bacterial filter

5.3 Replacing the Nafion tube

NOTE
Always use gloves when replacing the Nafion tube.

1. Remove the old Nafion tube (Figure 9) and replace it with the new one.

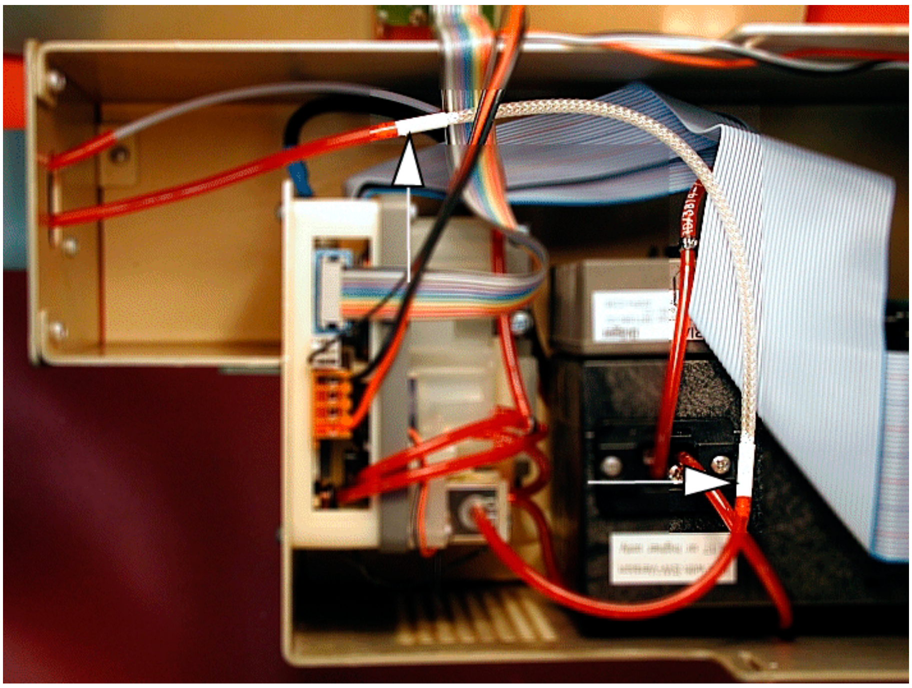

Figure 9 Nafion tube connections

5.4 Fitting the PGM housing (new)

1. Refit the PGM housing in the reverse order of its removal, as described in section 5.1.1 Removing the PGM housing.

Check the following points during the various operations:

2. Are all electrical connections plugged in? Are all tubes connected and without kinks? Are all components firmly screwed down inside the PGM module? Do all housing interlocks fit together (see Figure 10/1)? Is the Teflon plate fitted over the IRIA (see Figure 10/2)?

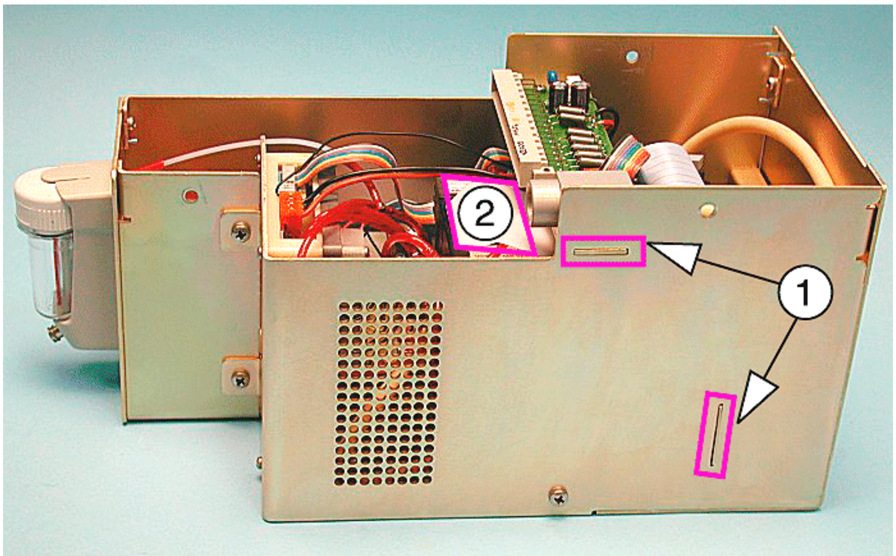

Figure 10 Housing interlocks and insulating foil

3. Mount the top cover, lift slightly at the rear (see Figure 11), and slide it completely over the housing.

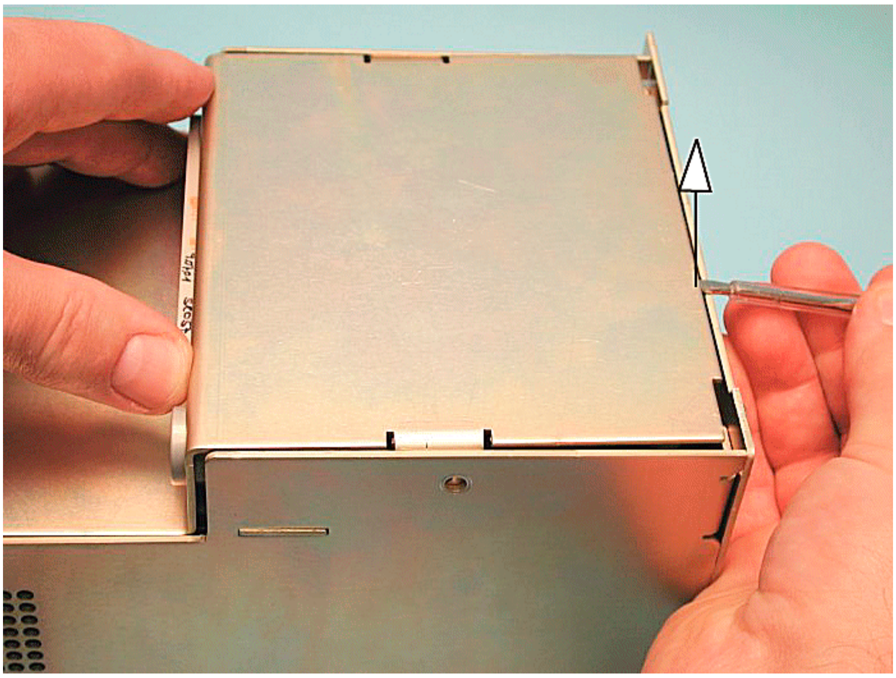

Figure 11 Fitting the cover

4. Carry out function and electrical safety tests.

6 Cleaning or replacing filter mat in housing cover

6.1 Filter mat removal

1. Remove the four housing cover fixing screws (see Figure 12).

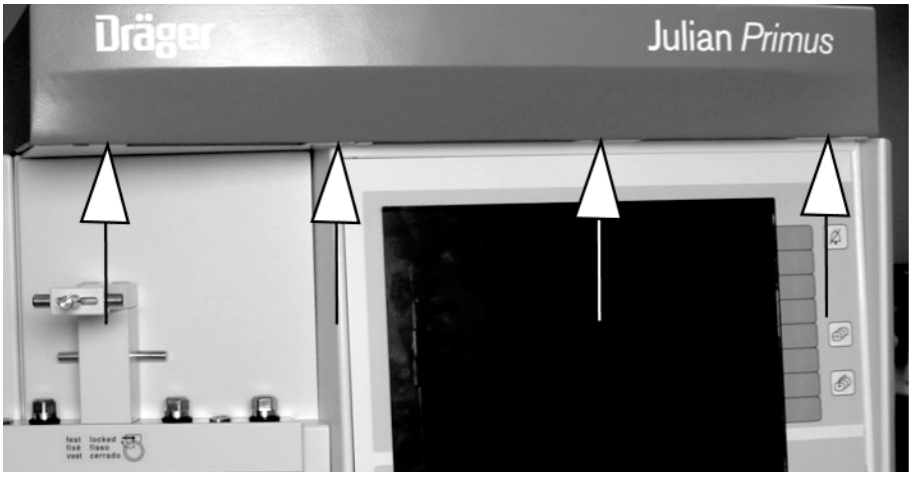

Figure 12 Housing cover fixing screws

2. On the rear of the unit slacken the three fixing screws about four turns (see Figure 13).

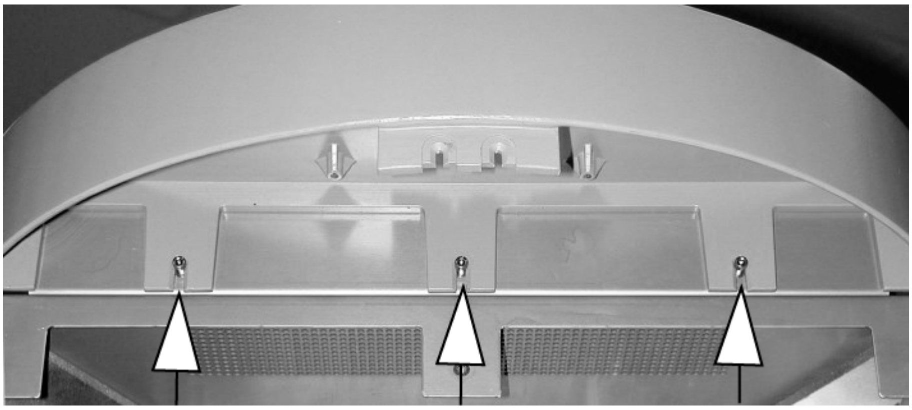

Figure 13 Unit rear fixing screws

3. Raise the housing cover at the rear just enough to push it forward away from the unit (see Figure 14).

Figure 14 Remove housing cover

4. Place the housing cover on a suitable surface.
5. Clean (yearly) or replace (every three years) the filter mat (see Figure 15).

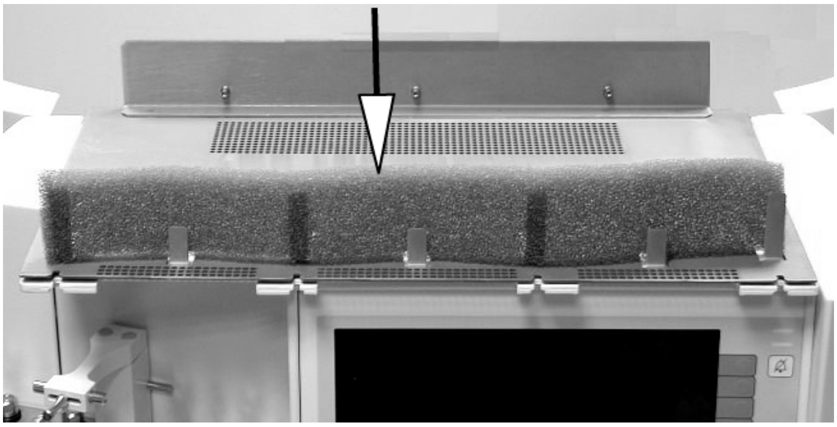

Figure 15 Filter mat position

6.1.1 Filter mat fitting

1. Mount the filter mat in the bracket.
2. Refit the housing cover in the reverse order of its removal.
3. Check that the housing cover is mounted horizontally on the housing.
4. Check that all fixing screws are fitted tight.

7 Replacing filter mat in power pack

1. Remove the two filter cover fixing screws from the rear of the power pack (see Figure 16)
2. Take out the filter mat and replace it with a new one.

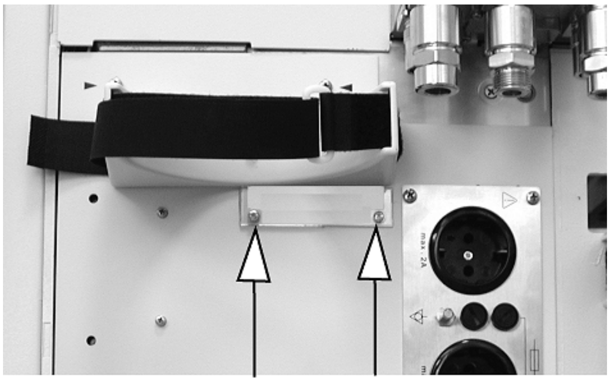

Figure 16 Filter cover fixing screws

3. Refit the filter cover in the reverse order of its removal.

8 Replacing UPS batteries

8.1 Power pack removal

1. Follow the safety instructions (see Safety precautions).
2. Remove the compressed gas supply tubing as necessary - see
3. Remove the fixing screws from the power pack (see Figure 17).

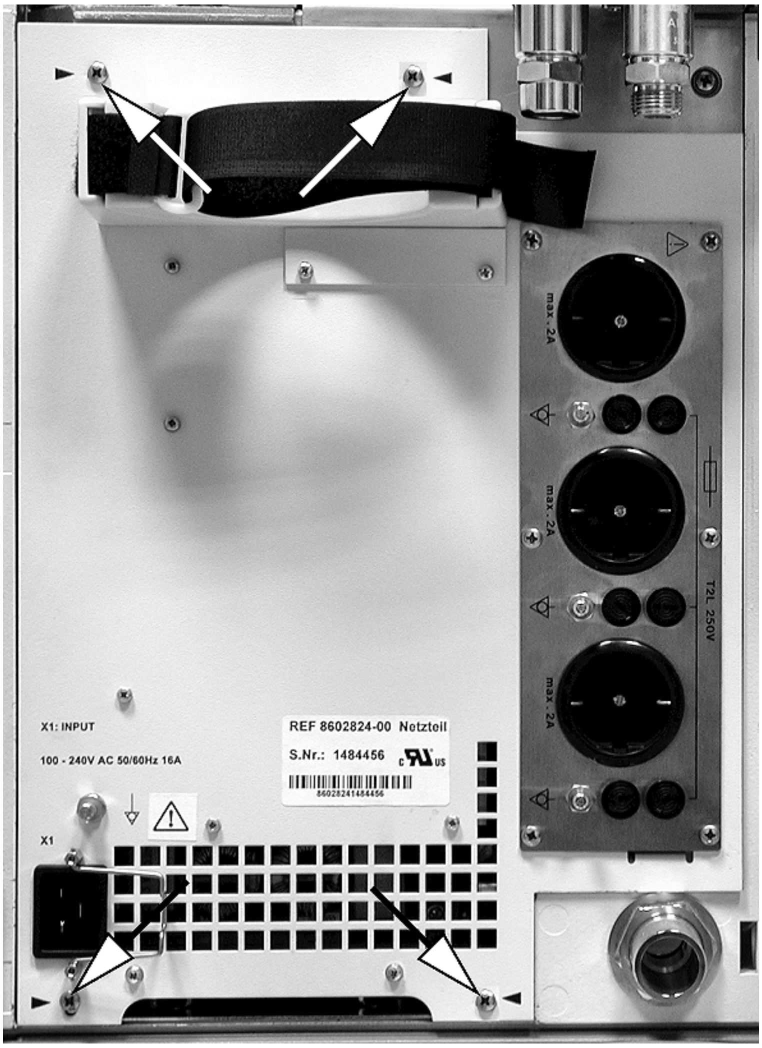

Figure 17 Power pack fixing screws

4. Open up the top of the power pack.

5. Unplug the four connectors (temperature sensor (Figure 18/1), supply voltages (Figure 18/2), UPS batteries (Figure 18/3), protective conductor (Figure 18/4)).

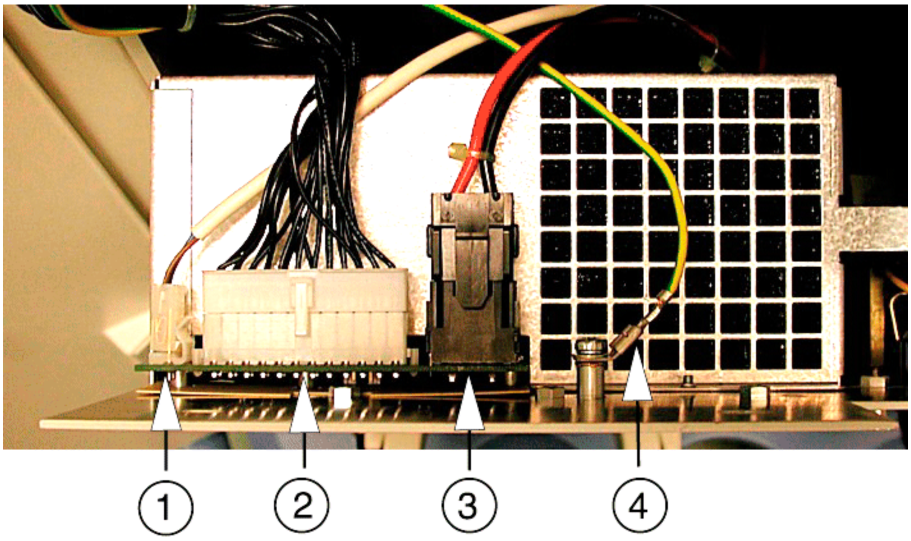

Figure 18 Power pack connectors

6. Lift out the power pack and place it on a suitable surface.

8.2 Removing UPS batteries

The retaining strap for the UPS batteries is attached by a Velcro strip (see Figure 19).

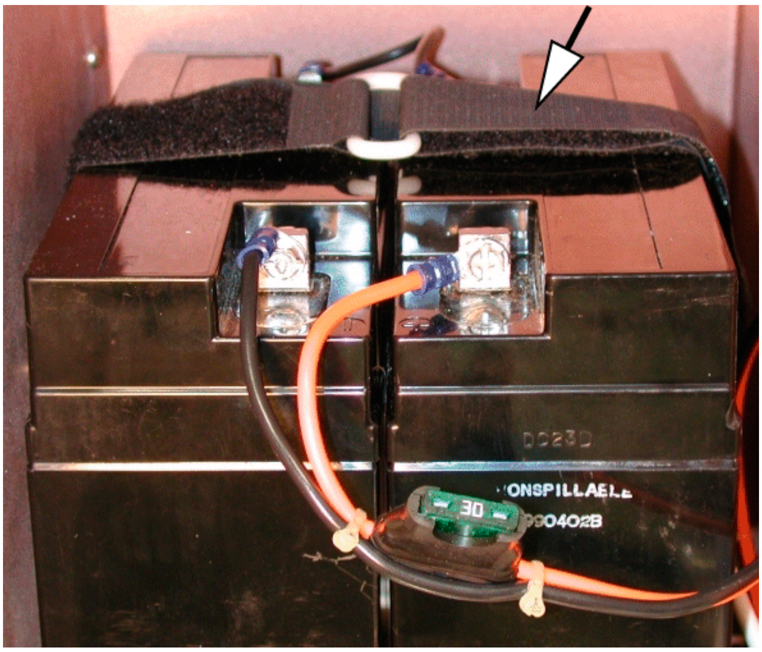

Figure 19 Velcro strip on retaining strap

The following illustrations show a removed holder containing UPS batteries.

1. Do not fully detach the retaining strap (see Figure 20).

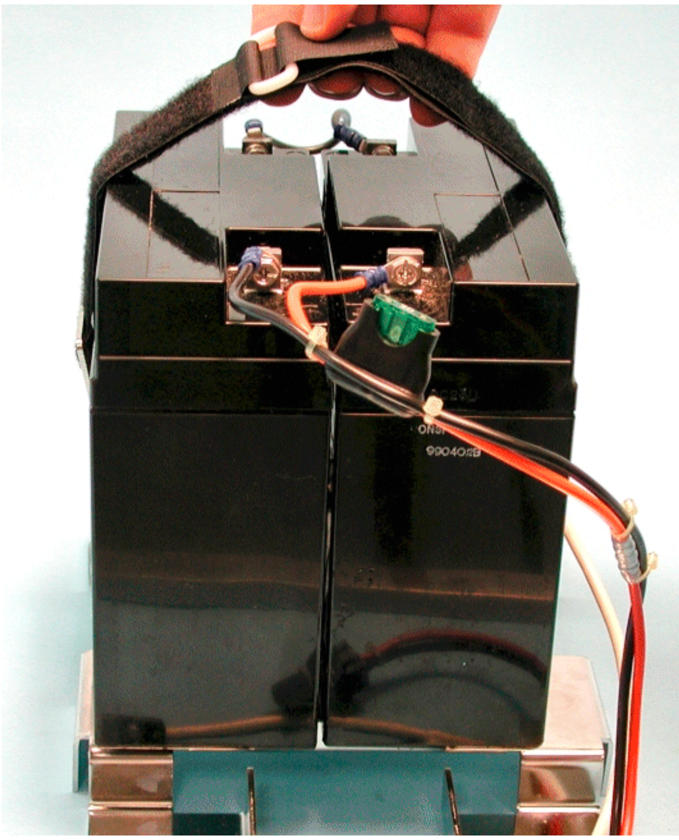

Figure 20 Retaining strap partially detached

CAUTION
Risk of injury resulting from incorrect removal of the UPS batteries!
The two UPS batteries weigh about 13 kg. The UPS batteries may slip out of place and knock into each other.
When removing, lift both batteries simultaneously and take them out together.

2. Take out the two UPS batteries.
3. Dispose of the used UPS batteries in accordance with local regulations.

8.3 Fitting UPS batteries

1. Connect the electrical connectors of the two new UPS batteries (see Figure 21).

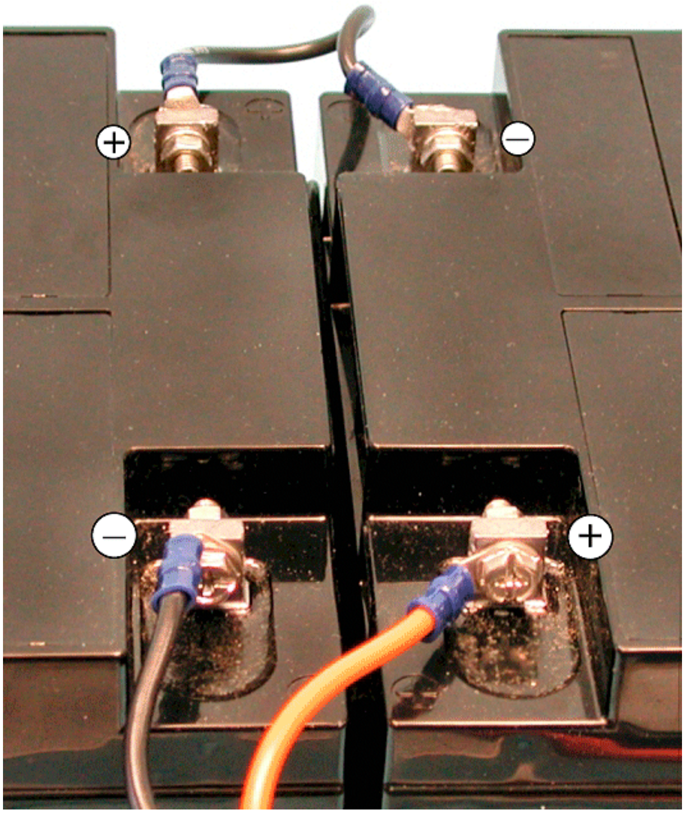

Figure 21 Positive and negative poles of the UPS batteries

2. Position the UPS batteries so they are half-way into the holder.

3. Hold the retaining strap upwards (see Figure 22). Push the UPS batteries all the way into the holder.

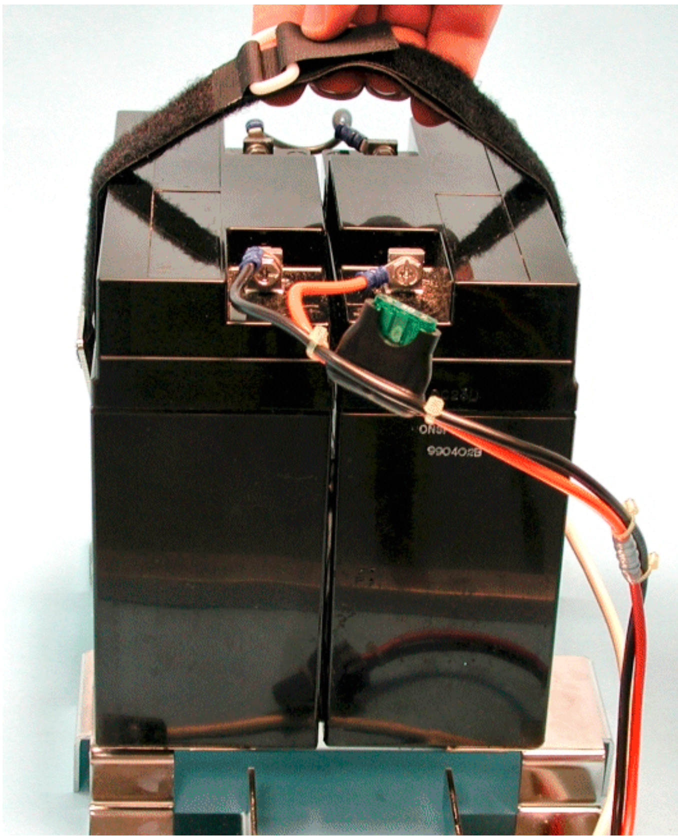

Figure 22 Lifting retaining strap

4. Tighten the retaining strap around the batteries and secure it with the Velcro strip (see Figure 23).

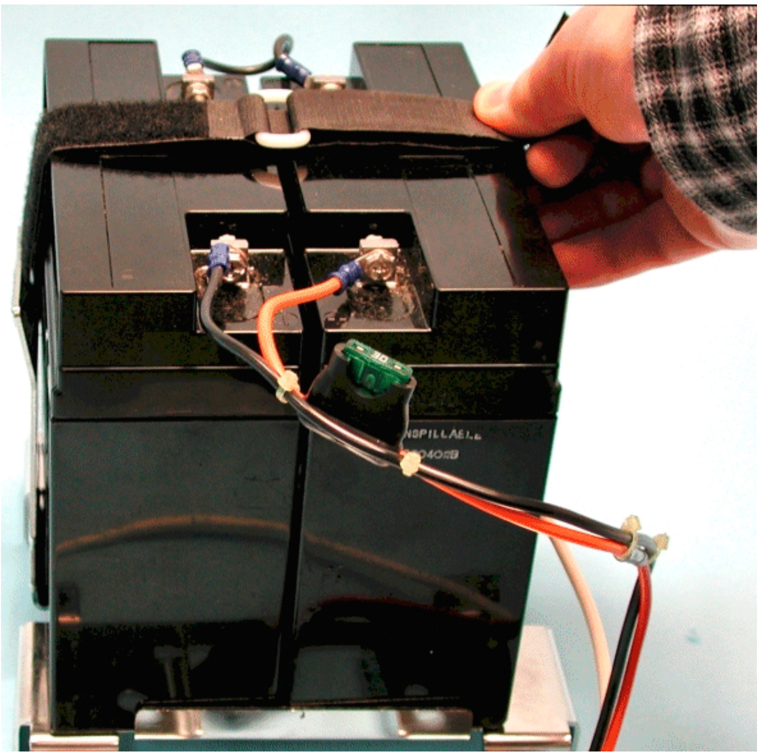

Figure 23 Tightening and securing the retaining strap

8.4 Fitting the power pack

1. Refit the power pack in the reverse order of its removal.

CAUTION
Cables will be damaged if the power pack is not fitted correctly!
Do not allow any cables to become trapped when fitting the power pack.

2. Carry out functional and electrical safety tests.
3. Fully charge the UPS batteries.

9 Cleaning or replacing large and small filter mats in VGC

9.1 Removal of large filter mat

1. Withdraw the VGC as far as possible out of the unit.

NOTE
The large filter mat is held in place at five points (see Figure 24). The filter bracket is located underneath the VGC housing.

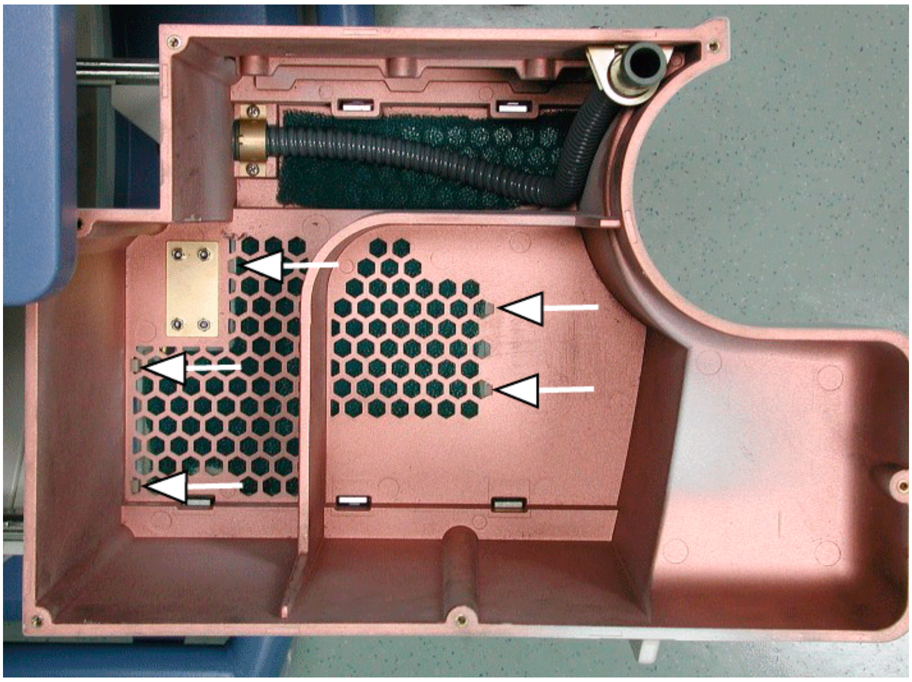

Figure 24 VGC, filter housing attachment points

2. Press on one corner of the filter housing to release it (see Figure 25).

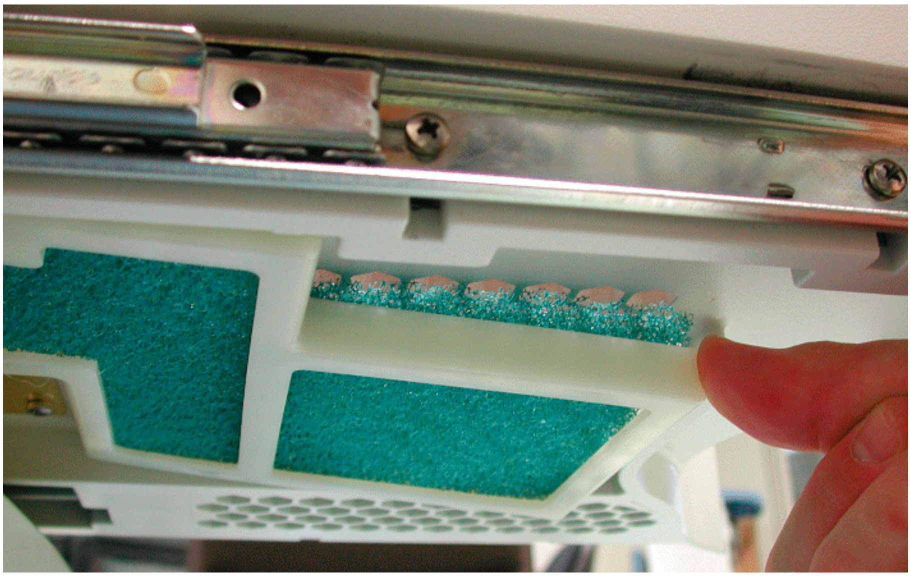

Figure 25 VGC, filter housing fitting position

CAUTION
When performing the following action note that the plastic retaining lugs of the filter housing may snap off.

3. Carefully detach the entire filter housing (see Figure 26).

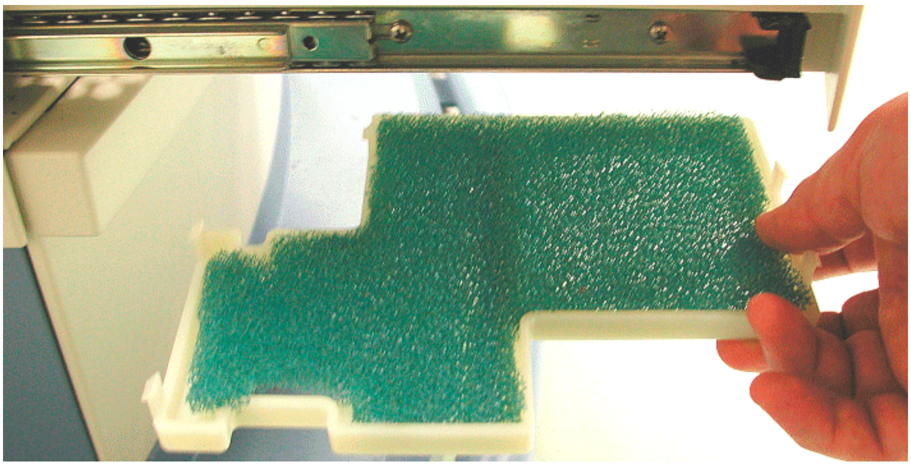

Figure 26 VGC, filter housing fitting position

9.1.1 Fitting of large filter mat

1. After cleaning (yearly) or replacement (every 3 years), refit the filter mat in its bracket fixture.
2. First clip the filter housing in towards the unit body.
3. Refit the filter housing in the reverse order of its removal.
4. After fitting, check that the filter housing is fully contacting the housing.
5. DO not yet slot the VGC back into the unit (see section 9.2 Removal of small filter mat).

9.2 Removal of small filter mat

1. Remove the four fixing screws for the cover panel on the side of the VGC housing (see Figure 27).

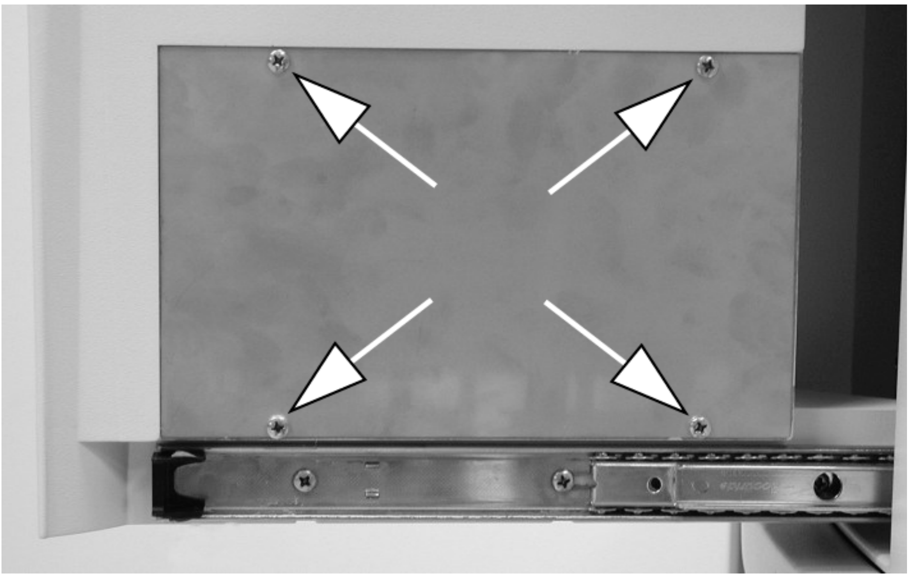

Figure 27 VGC, cover panel fixing screws

The small filter mat is accessible through the resultant opening in the housing.

2. Remove the small filter mat and replace it with the new one (see Figure 28).

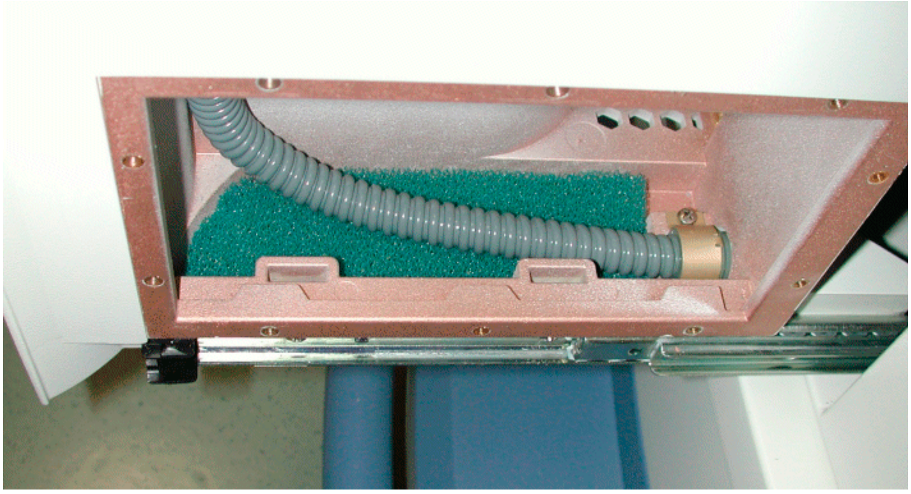

Figure 28 VGC, small filter mat

9.2.1 Fitting of small filter mat

1. After cleaning (yearly) or replacement (every 3 years), refit the filter mat in the housing.
2. Refit the cover panel in the reverse order of its removal.
3. After fitting, check that the cover panel is fully contacting the housing.
4. Check that the VGC can be slotted back into the housing without problem.

10 Replacing bag upper roller diaphragm

1. Withdraw the VGC from the Primus.
2. Release the three catches for the compact breathing system and remove the breathing system from the VGC.
3. If the piston is at the upper position, the bag upper roller diaphragm cannot be inserted. In this case carefully push the piston down by hand. As far as possible, apply force to the middle of the piston (see Figure 29).

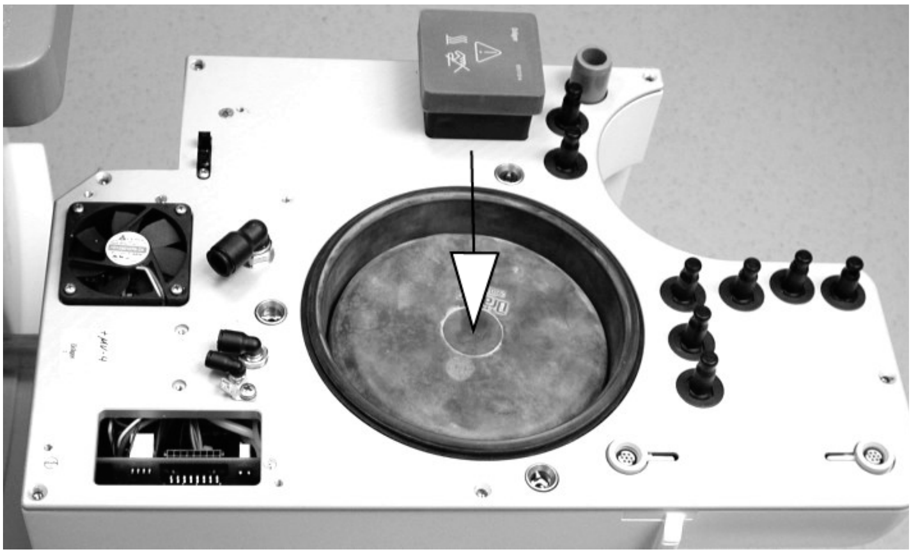

Figure 29 Upper piston position

4. Take the old bag upper roller diaphragm out of the VGC and replace it with the new one.
5. Refit the VGC in the reverse order of its removal.
6. Carry out the functional test.

11 Replacing the lower rolling seal (VGC)

11.1 Removing the VGC

1. Disconnect the Primus from the mains power supply.
2. Disconnect the Primus from the three central supply system gases.
3. Withdraw the VGC as far as possible out of the Primus.
4. Slacken the three fixing screws for the breathing system and remove the breathing system from the VGC.
5. If the piston of the piston cylinder unit is still at the upper position, carefully push it down to the lower position by hand (see Figure 30). This will help to fit the upper bag rolling seal later.
6. Take the upper bag rolling seal out of the VGC (see Figure 30).

CAUTION
Risk of blocking the motor spindle!
Do apply too much force on the piston when performing the next step. This is to avoid that the motor spindle gets stuck in the lower limit position.
As of software version 2.01 the piston is moved to the bottom position. Therefore, it is no longer necessary to push down the piston when opening the VGC.

7. The piston of the VGC is located under the upper bag rolling seal. Carefully push the piston down to the lower working position.

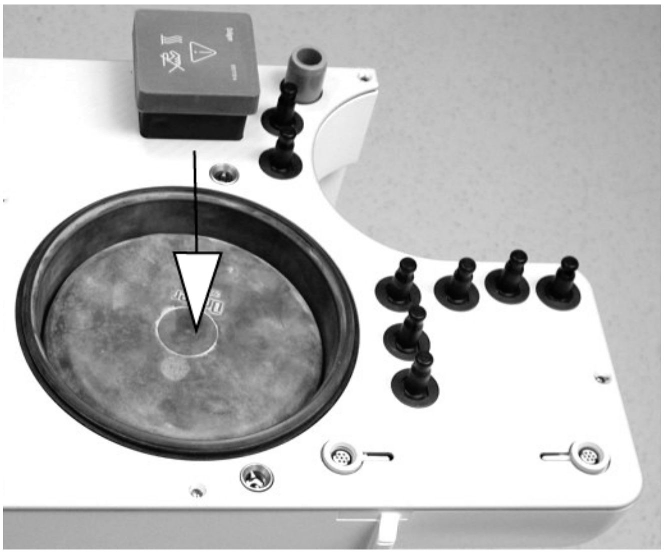

Figure 30 Location of the upper bag rolling seal

8. Remove the four chain box cover fixing screws (see Figure 31).

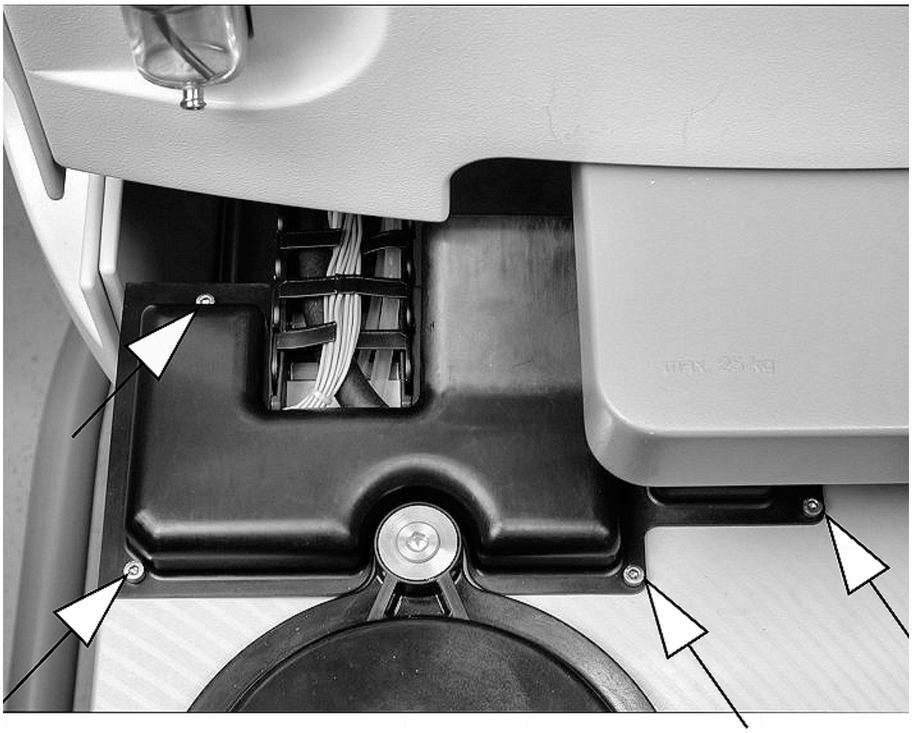

Figure 31 Chain box cover, fixing screws

9. Unplug the three pneumatic connectors and the two electrical connectors (see Figure 32).

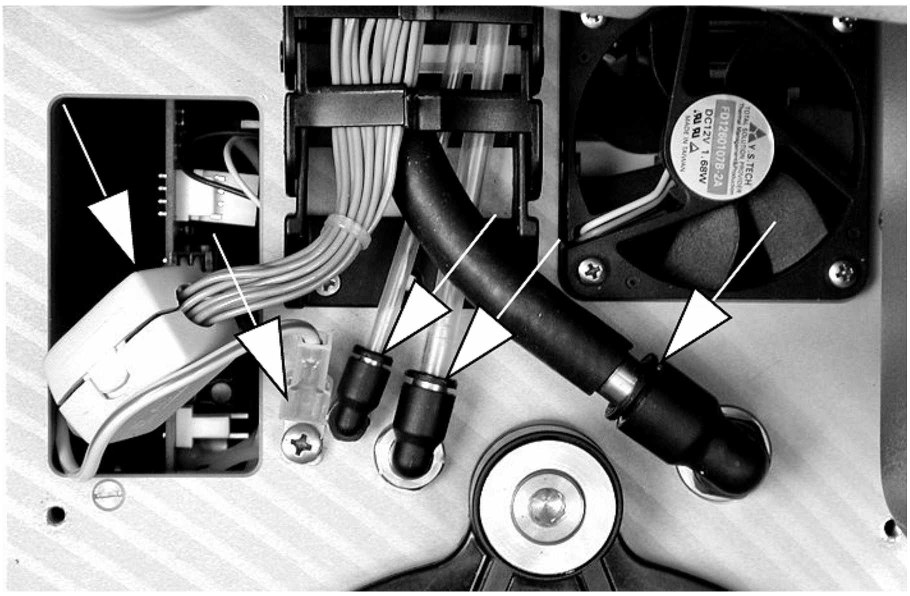

Figure 32 Chain box cover, unplugging connections

10. Slacken the two chain box fixing screws just enough so that the washers do not fall down (see Figure 33 and Figure 34)

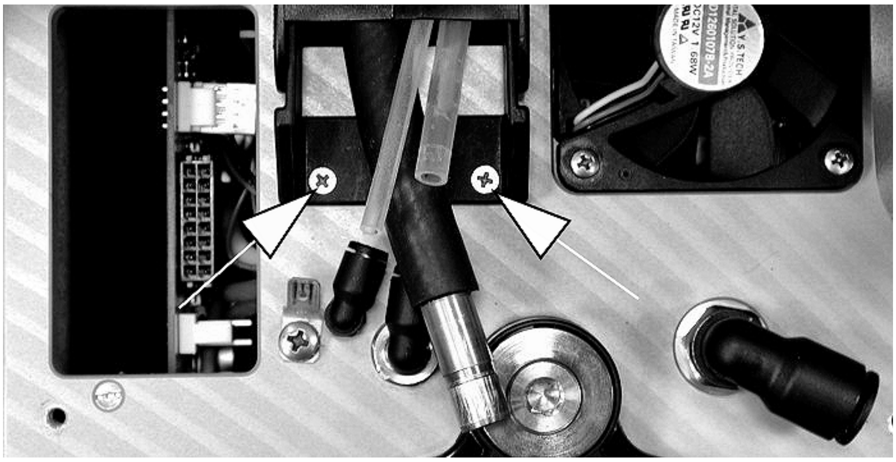

Figure 33 Chain box, fixing screws

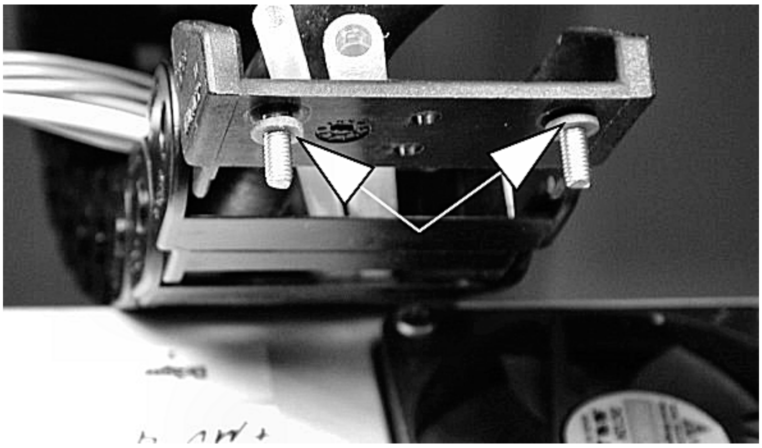

Figure 34 Chain box, lock washers

CAUTION
Possible damage to chain box!
Remove the chain box before the running rails of the VGC are detached.

11. Slacken the fixing screw (A) on the right side running rail of the VGC one quarter turn (otherwise it will scrape on the rail). Remove the two fixing screws (B) (see Figure 35).

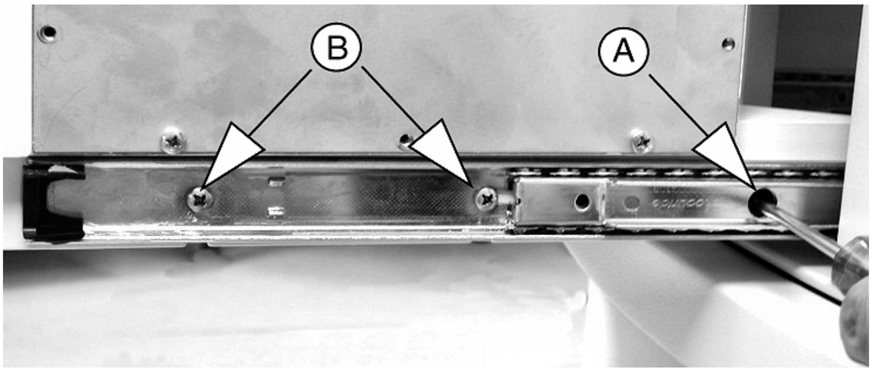

Figure 35 VGC, removing right side running rail

12. Slacken the fixing screw (A) on the left side running rail of the VGC one quarter turn (otherwise it will scrape on the rail). Remove the two fixing screws (B) (see Figure 36).

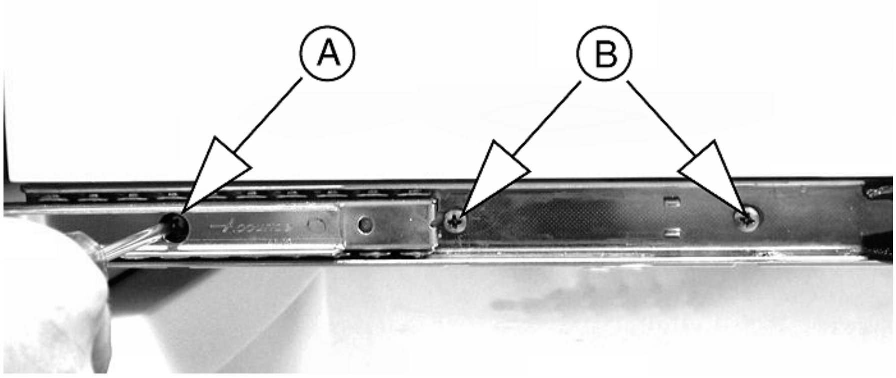

Figure 36 VGC, removing left side running rail

13. Withdraw the VGC from the housing such that it can be lifted out subsequently. The VGC housing is secured by four screws to prevent it from falling down.

14. Remove the six VGC fixing screws (see Figure 37).

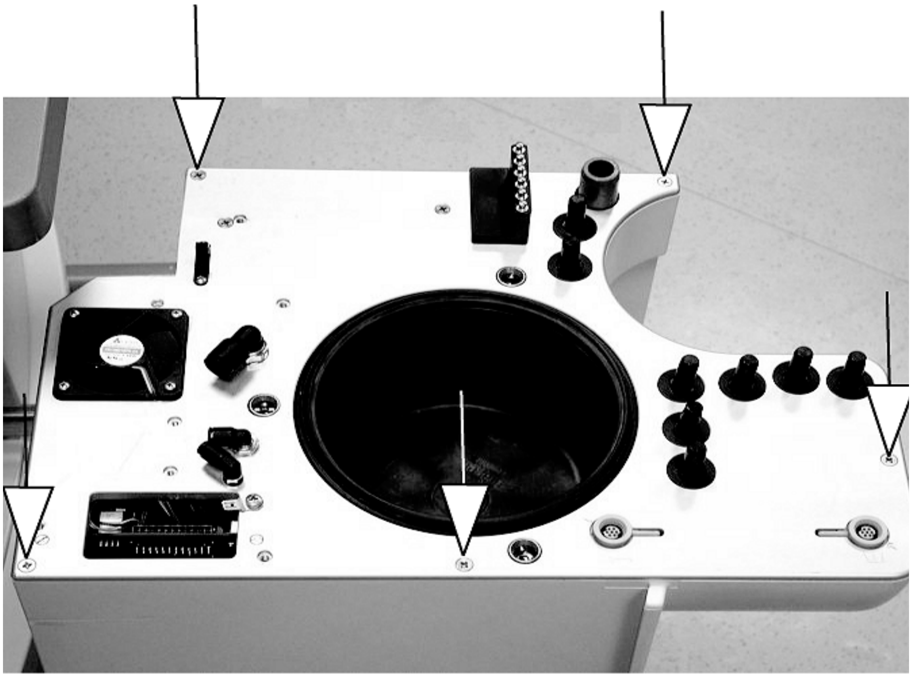

Figure 37 VGC, removing fixing screws

15. Refit the breathing system on the VGC and secure it with the three fixing screws.

16. Lift the VGC together with the breathing system (total weight approx. 15 kg) vertically out of the VGC housing (see Figure 38).

Figure 38 Taking VGC out of housing

17. Place the VGC on a static-dissipative mat.

CAUTION
Electrostatic discharge!
Electrostatic discharge may damage electrostatic sensitive devices. When handling electrostatic sensitive devices use a static-dissipative mat and a wrist strap.

18. Slacken the three fixing screws for the breathing system and remove the breathing system from the VGC.

11.2 Removing the piston-cylinder unit

CAUTION
Possible damage to the perforated disk of the incremental encoder (piston-cylinder unit)!
The perforated disk of the incremental encoder is deformed even by slight mechanical pressure (for location see Figure 39).
Exercise great care when reaching into the opening above the perforated disk.

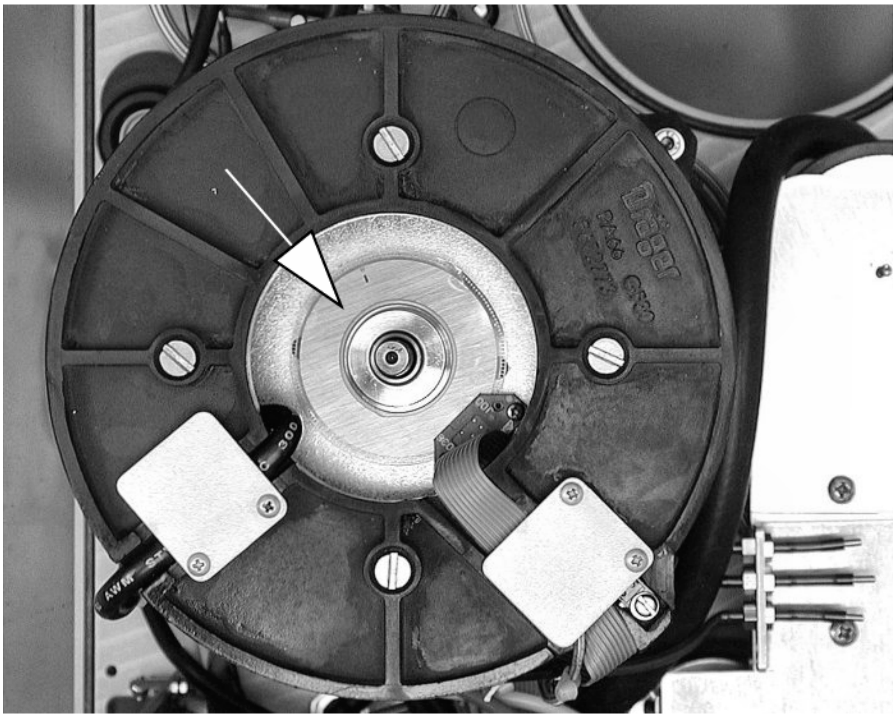

Figure 39 VGC, position of incremental encoder perforated disk

1. Place the VGC upside down on the static-dissipative mat.
2. Remove the fixing screw of the PCB unit (see Figure 40).

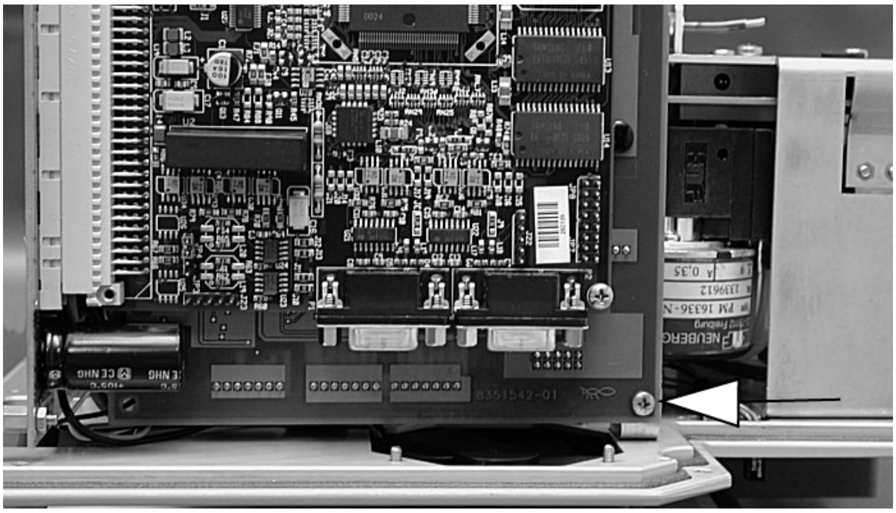

Figure 40 VGC, PCB unit fixing screw

3. Swivel the PCB unit aside to the left.

4. Unplug the three electrical connectors of the piston-cylinder unit (see Figure 41).

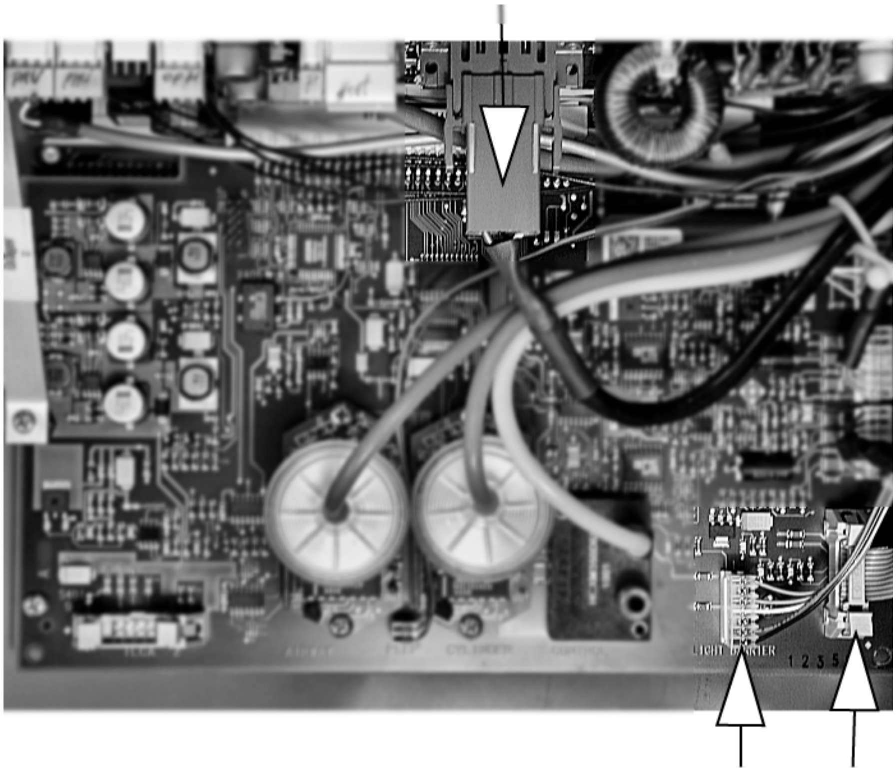

Figure 41 ANALOG PRIMUS PCB, connections to the piston-cylinder unit

5. Remove the four piston-cylinder unit fixing screws (see Figure 42 and Figure 43).

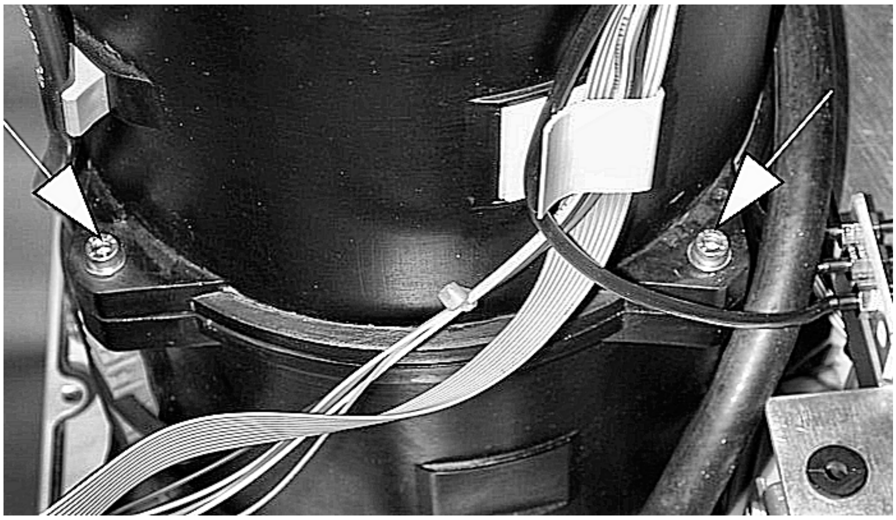

Figure 42 Piston-cylinder unit, fixing screws (1)

Figure 43 Piston-cylinder unit, fixing screws (2)

6. Place the motor section of the piston-cylinder unit upside down on a suitable surface.

11.2.1 Removing/Fitting the lower rolling seal

1. Remove the three fixing screws from the cylinder of the rolling seal (see Figure 44).

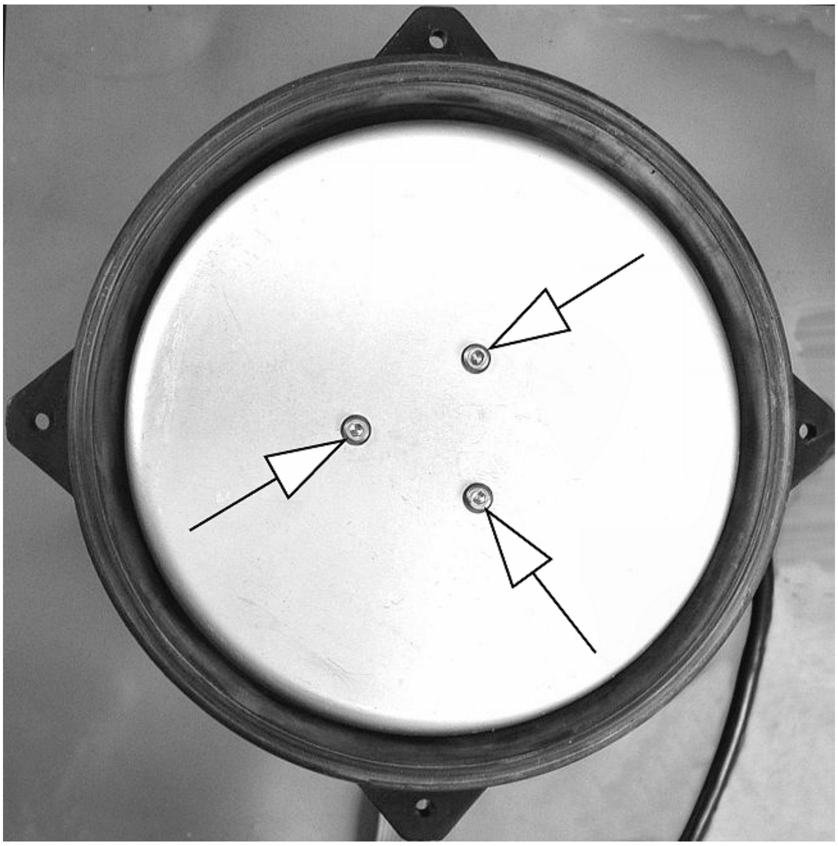

Figure 44 Piston-cylinder unit, cylinder fixing screws

2. Lift the cylinder upwards out of the piston-cylinder unit (see Figure 45).

Figure 45 Piston-cylinder unit, removing cylinder

The lower rolling seal (subsequently referred to as the rolling seal for short) is attached to the cylinder by the snap ring (A) and the O-ring (B) (see Figure 46).

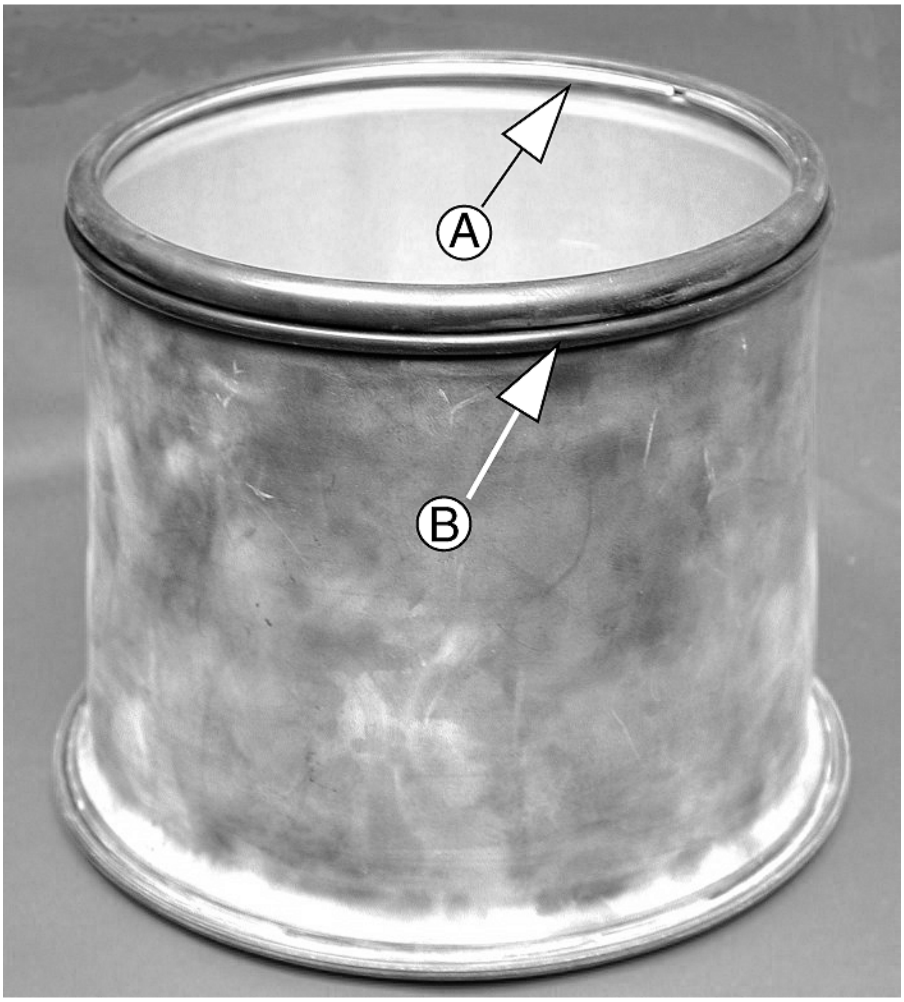

Figure 46 Piston-cylinder unit, snap ring (A) and O-ring (B)

3. Remove the snap ring and the O-ring (see Figure 47 and Figure 48).

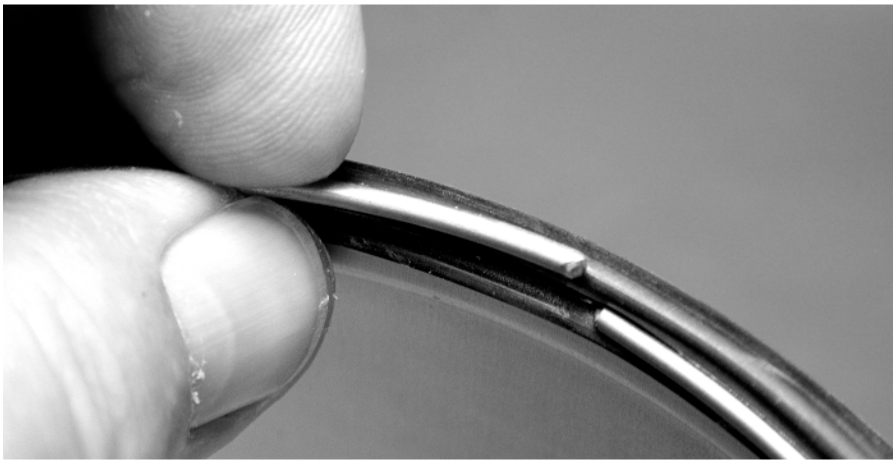

Figure 47 Piston-cylinder unit, removing the snap ring

Figure 48 Piston-cylinder unit, removing the O-ring

CAUTION
Faulty rolling seal due to incorrect installation!
The rolling seal can be fitted the wrong way round. If it is, however, a wide bulge occurs under the snap ring (see Figure 49).
To avoid errors, follow the instructions below precisely and compare the illustrations against the result achieved.

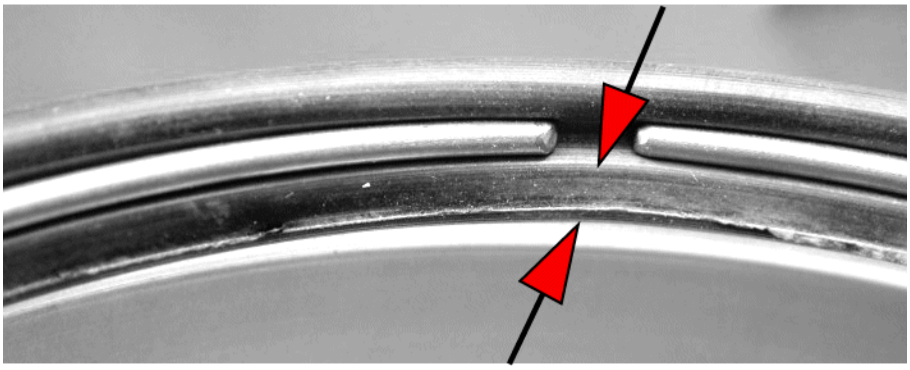

Figure 49 Piston-cylinder unit, incorrect installation of the rolling seal

4. Fold the rolling seal over the cylinder such that a narrow bulge is created under the snap ring groove (see Figure 50).

Figure 50 Piston-cylinder unit, folding rolling seal correctly

5. Insert the snap ring into the groove of the rolling seal (see Figure 51).

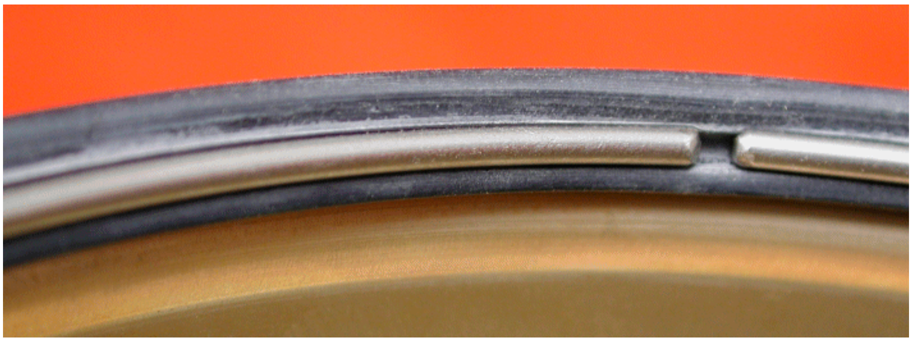

Figure 51 Piston-cylinder unit, mounting rolling seal snap ring

NOTE
The O-ring (P/N G603379) for fixing the lower rolling seal can become porous due to UV radiation.
Fit the new O-ring (P/N 8604831). This O-ring is insensitive to UV radiation.

6. Fit the rolling seal O-ring (see Figure 52) The O-ring must be seated firmly in the groove.

Figure 52 Piston-cylinder unit, fitting rolling seal O-ring

11.3 Mounting piston-cylinder unit

1. Place the cylinder in the piston-cylinder unit.
2. Tighten the three fixing screws on the rolling seal cylinder.
3. Check that the end of the rolling seal is correctly seated in the guide groove (see Figure 53).

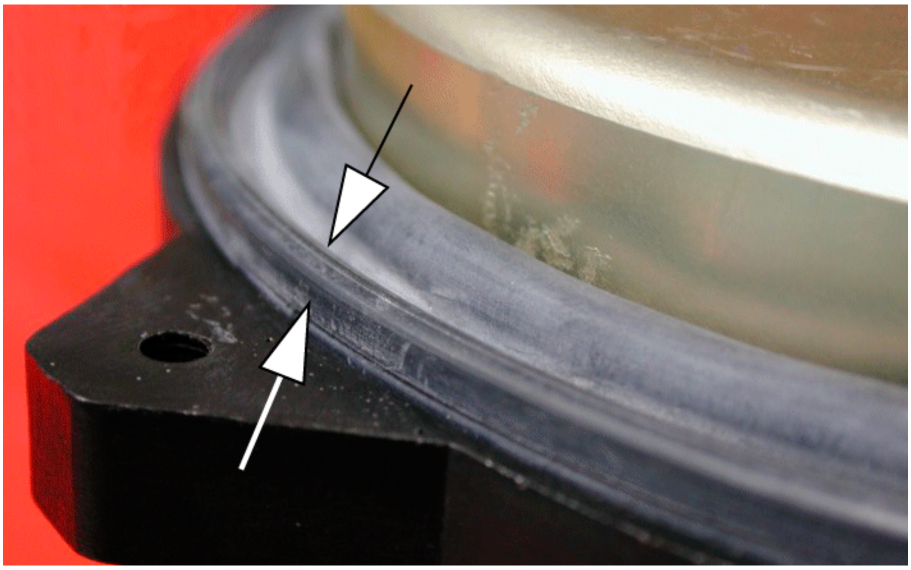

Figure 53 Piston-cylinder unit, rolling seal end

4. Place the motor section of the piston-cylinder unit upside down on the lower piston-cylinder unit section (see Figure 54).

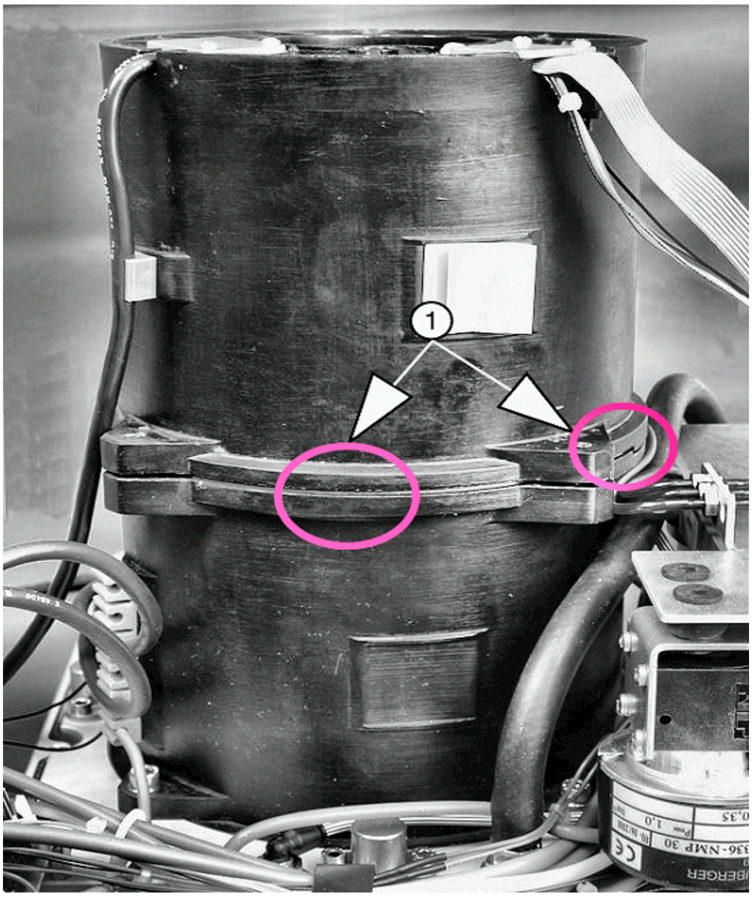

Figure 54 Piston-cylinder unit, mounting piston-cylinder unit motor section

5. The gap between the motor section of the KZE and the lower section must be uniform. If it is not, carefully check where the rolling seal is unevenly seated in the guide groove (see Figure 55). Correct as necessary (see Figure 53).

Figure 55 Piston-cylinder unit, checking the rolling seal position

6. Screw in the four piston-cylinder unit fixing screws.
7. Insert the piston-cylinder unit cables and the pneumatic system tube in the cable holders (see Figure 56).

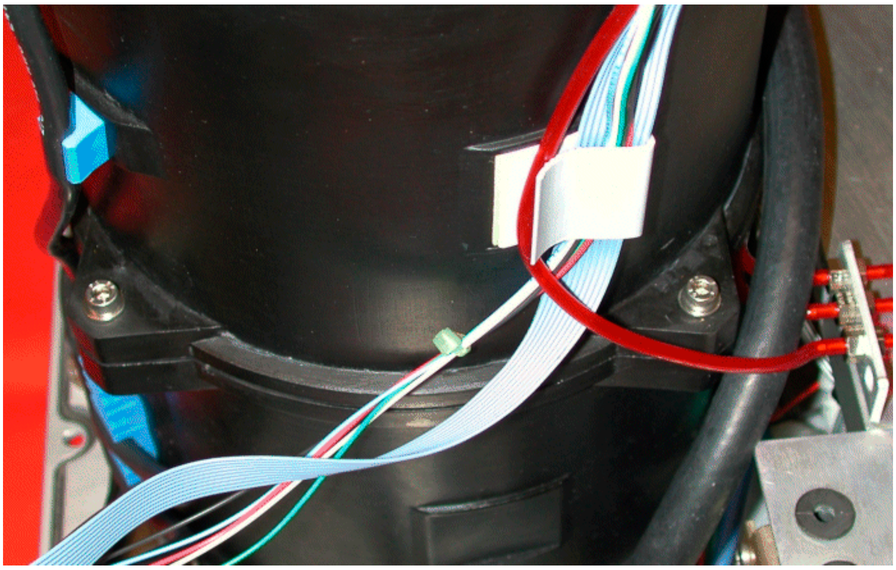

Figure 56 VGC, cable routing 1

8. Connect the three piston-cylinder unit cables with the ANALOG PRIMUS PCB (see Figure 57).

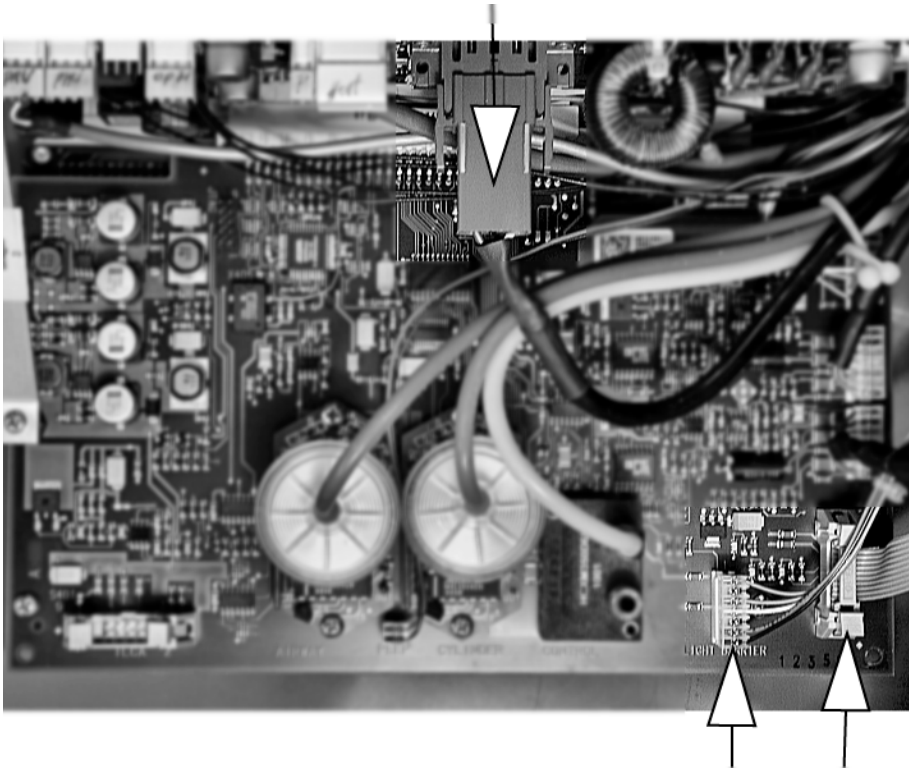

Figure 57 ANALOG PRIMUS PCB, connections to the piston-cylinder unit

9. Lift the PCB unit. Make sure no tubes are bent or cables trapped as you do so.
10. Tighten the PCB unit fixing screw (see Figure 58).

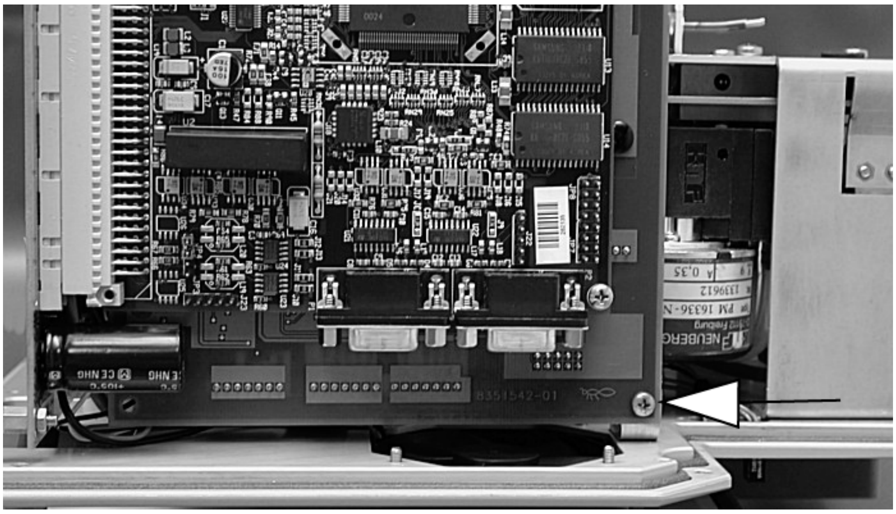

Figure 58 VGC, PCB unit fixing screw

11. Push the piston-cylinder unit cables into the holders according to the labelling on the cylinder (see Figure 59).

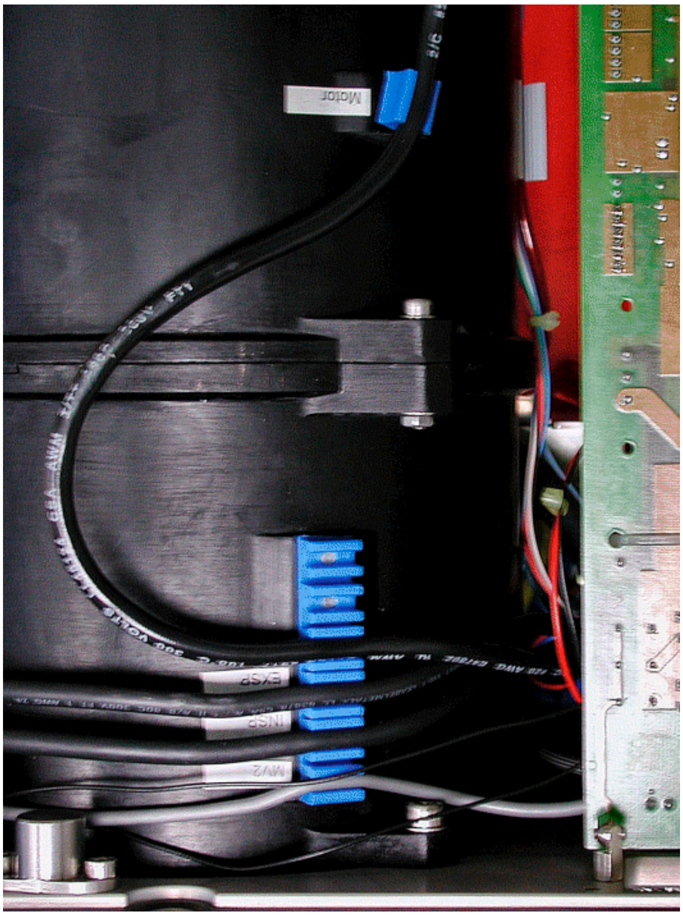

Figure 59 VGC, cable routing 2

12. Refit the VGC in the reverse order of its removal (see 11.1 Removing the VGC).

NOTE
Possible leakages during the RV2 leak test!

To avoid leakages, secure the three fixing screws (cylinder of rolling seal, see Figure 44) with silicone glue at the at the screw seats.

13. Carry out functional and electrical safety tests.

12 Replacing pressure regulators PRPN2O, PRPAIR, PRPO2

12.1 Removing gas inlet block pressure regulators

The following steps can be carried out with the mixer fitted.

1. Follow the safety instructions (see Safety precautions document).
2. Remove the compressed gas supply tubing.
3. Take off the housing cover as necessary (see document: Removing housing cover).
4. Remove the mixer cover.

Looking from above into the mixer, you will see the three pressure regulators (for assignment of gases see Figure 60).

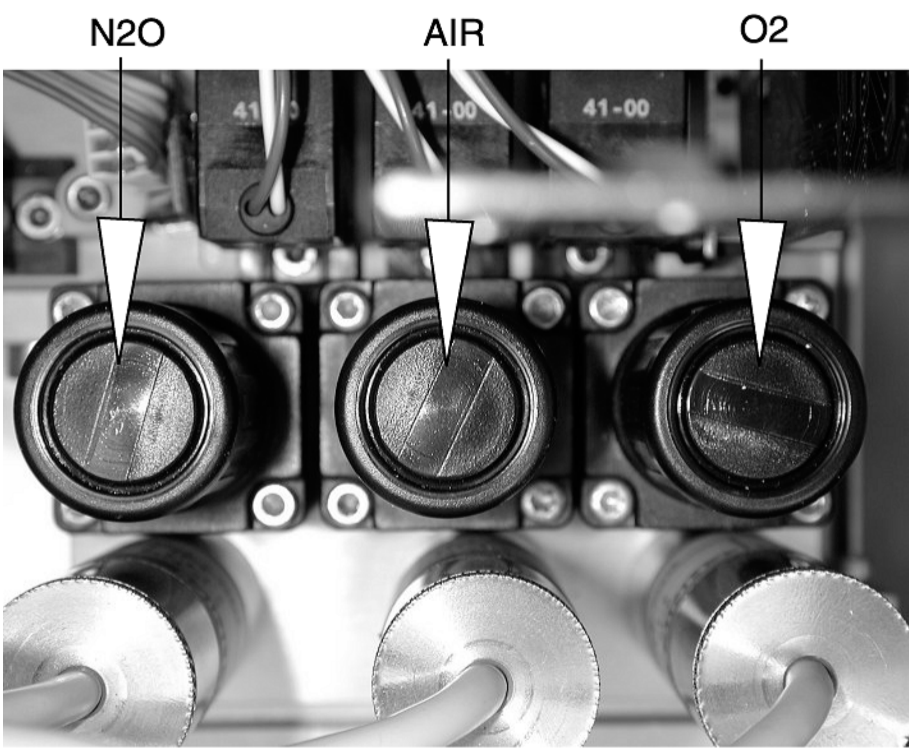

Figure 60 Pressure regulator positions

5. Remove the hexagon socket fixing screws of the relevant pressure regulator (for position see Figure 61).

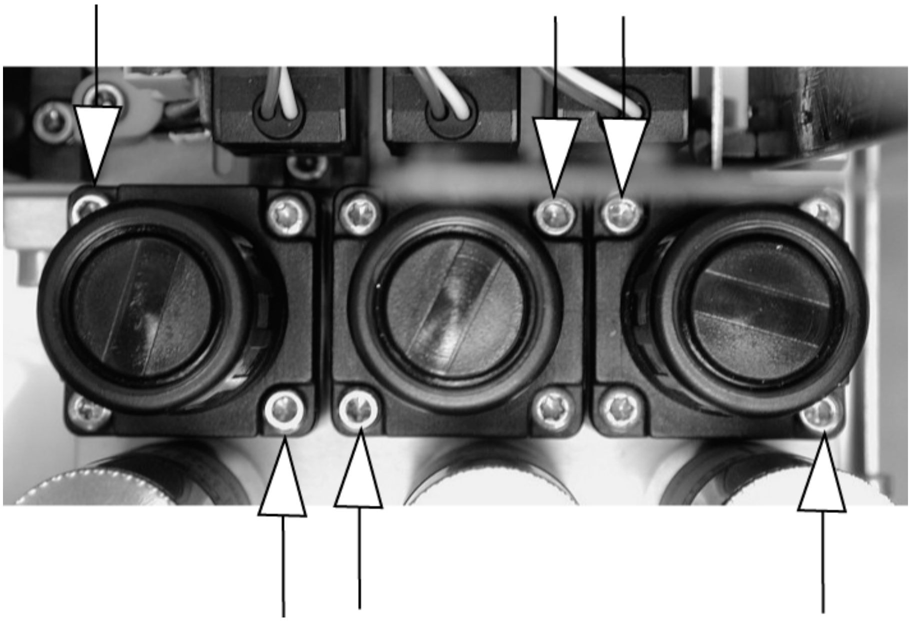

Figure 61 Pressure regulator fixing screws

12.2 Fitting pressure regulators

CAUTION
Malfunction resulting from fitting error!
On each pressure regulator is a label indicating the direction of flow (for example of pressure regulator for N2O see Figure 62). If the label is missing, the direction of flow is indicated on the underside of the pressure regulator (see Figure 63).
The preferential direction of the individual pressure regulators is embossed into the gas inlet block.
When fitting, pay attention to the preferential direction of the pressure regulators.

In the following, fitting of the PRPN2O pressure regulator is shown as an example. The steps also apply correspondingly to the PRPAIR and PRPO2 pressure regulators.

Figure 62 Preferential direction of N2O pressure regulator 'PRPN2O“ with label

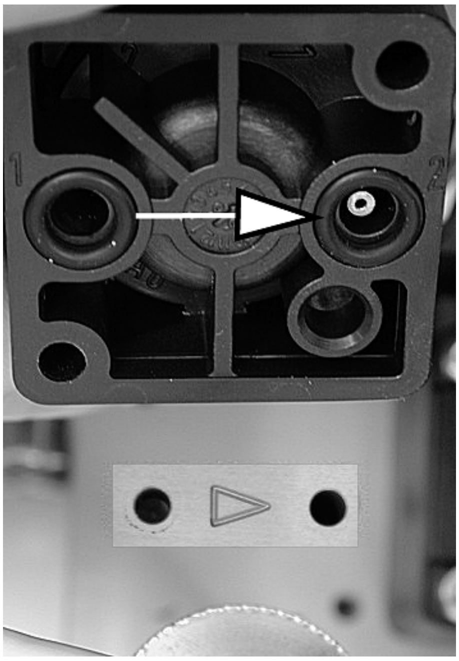

Figure 63 Preferential direction of N2O pressure regulator 'PRPN2O“ without label

NOTE
The locking caps of the new pressure regulators are fixed in place (see Figure 64). Unlock the caps prior to fitting.

Figure 64 Fixed locking cap

1. Pull locking cap upwards and unlock (A). This creates a gap (B) between the housing and the locking cap (see Figure 65). The pressure regulator can now be adjusted.

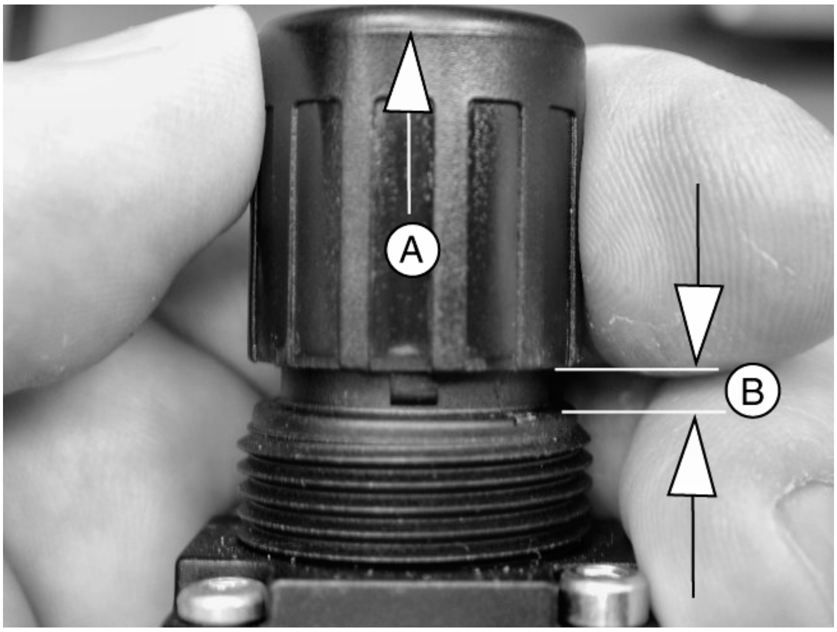

Figure 65 Unlocked locking cap

2. Check that the two O-rings are fitted on the pressure regulator (see Figure 66).

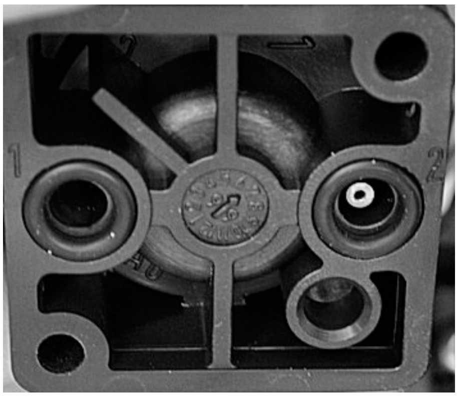

Figure 66 O-rings on pressure regulator 'PRPN2O“

3. Fit the pressure regulators in their respective preferential directions (see Figure 67).

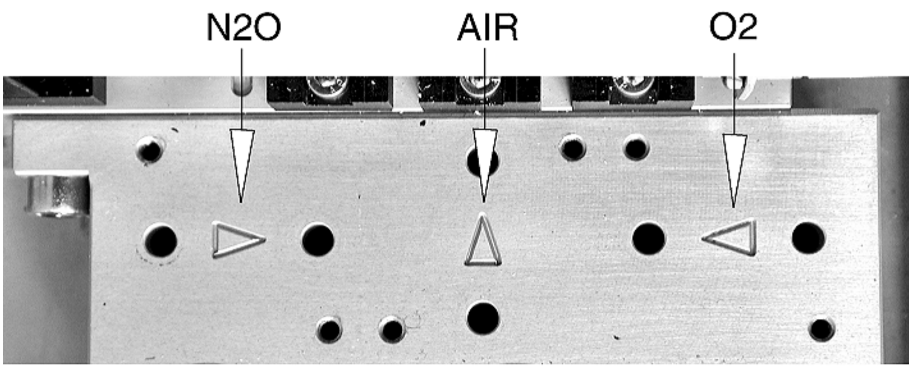

Figure 67 Preferential directions of pressure regulators

13 Replacing CPU PRIMUS PCB lithium battery

NOTE
Before you replace the CPU PRIMUS PCB lithium battery, please note:
Replacement as a maintenance procedure is only required up to software version 1.01.
The lithium battery is no longer needed in software versions 1.05 or higher (and must always be removed).

NOTE
Batteries are special waste.
Dispose of the batteries in accordance with local waste disposal regulations.

13.1 Removing mixer

1. Follow the safety instructions (see document: Safety Precautions).
2. Remove the rear panel (see document: Removing rear panel).
3. Remove the compressed gas supply tubing as necessary.
4. Remove the three central gas supply tubes (see Figure 68).

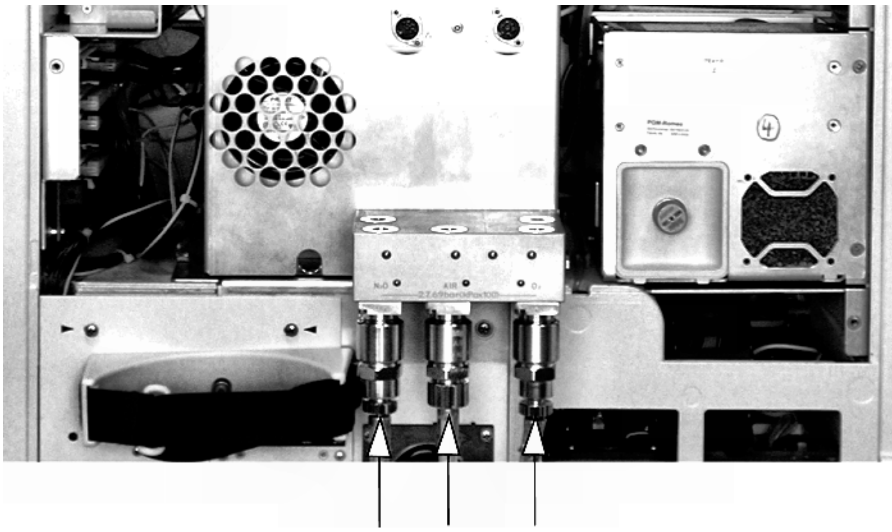

Figure 68 Central gas supply hoses

5. Remove the fixing screw from the gas inlet block using an Allen key (see Figure 69).

Figure 69 Fixing screw on gas inlet block

6. Remove the central fixing screw on the mixer (see Figure 70).

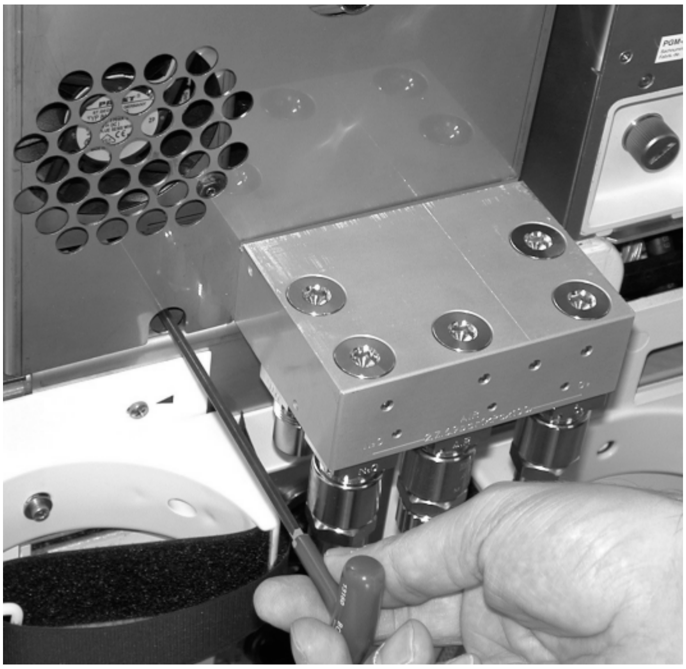

Figure 70 Central fixing screw

7. Withdraw the mixer about half-way out of the housing and unplug the electrical connection to the mixer (see Figure 71).

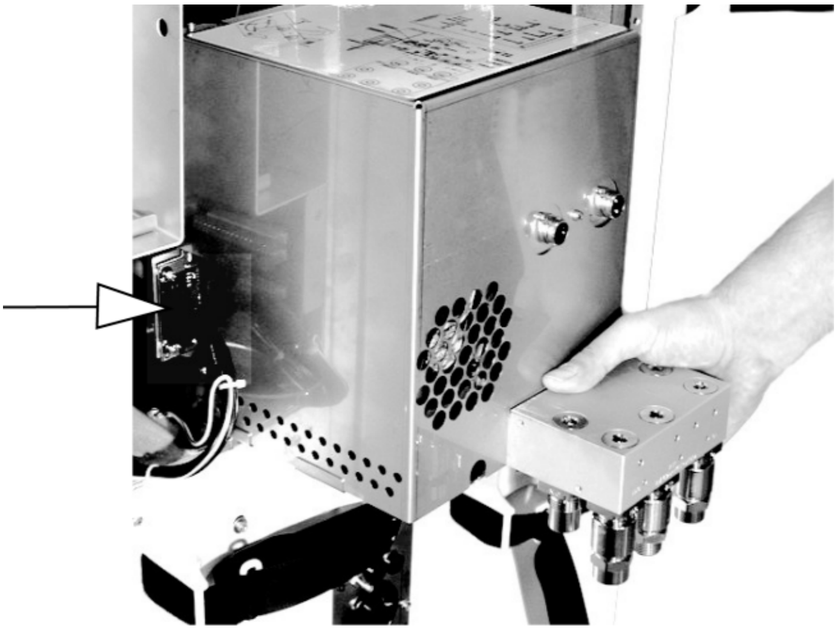

Figure 71 Disconnecting electrical connections

8. Take the mixer fully out of the housing and place it on a suitable surface.

13.2 Removing mixer cover

1. Follow the safety instructions (see document: Safety Precautions).
2. Remove the compressed gas supply tubing as necessary.
3. Remove the three mixer cover fixing screws (see Figure 72).

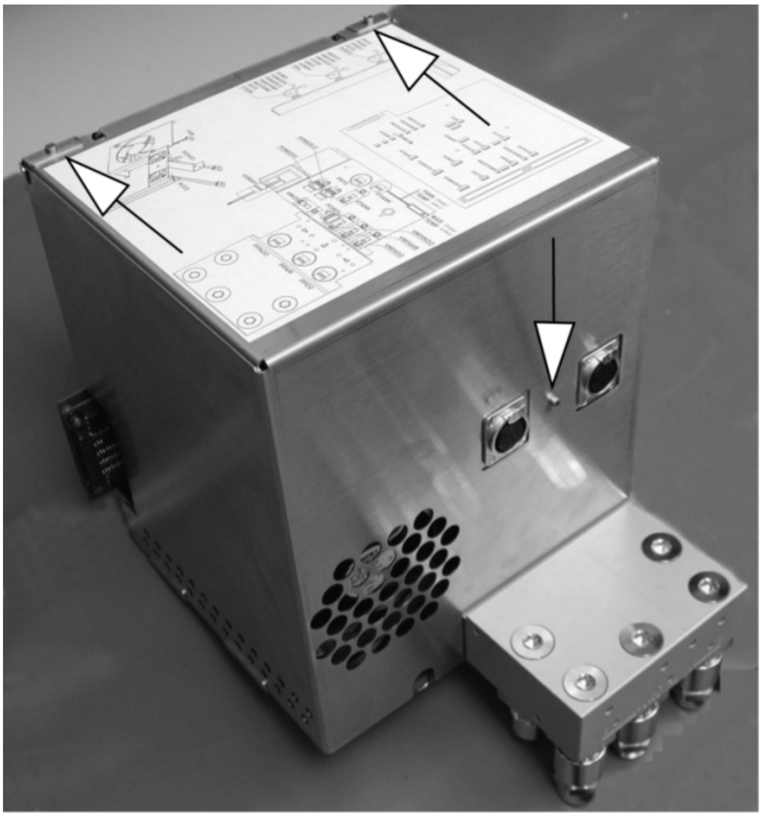

Figure 72 Mixer cover fixing screws

4. Remove the mixer cover.

13.3 Replacing the lithium battery

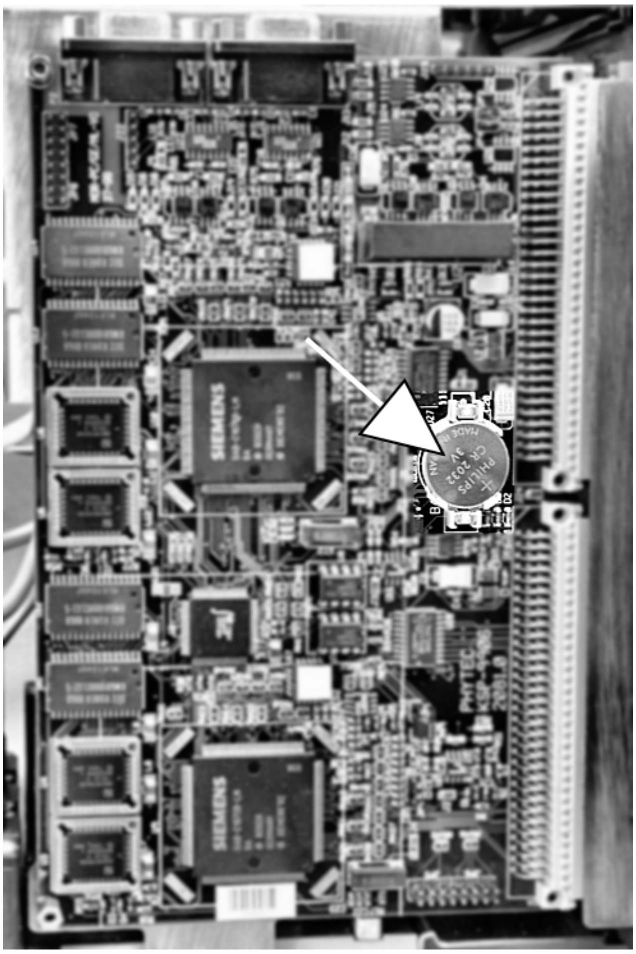

Figure 73 Location of the lithium battery on the CPU PRIMUS PCB

1. Pry the lithium battery off the holder using an appropriate tool (see Figure 74).

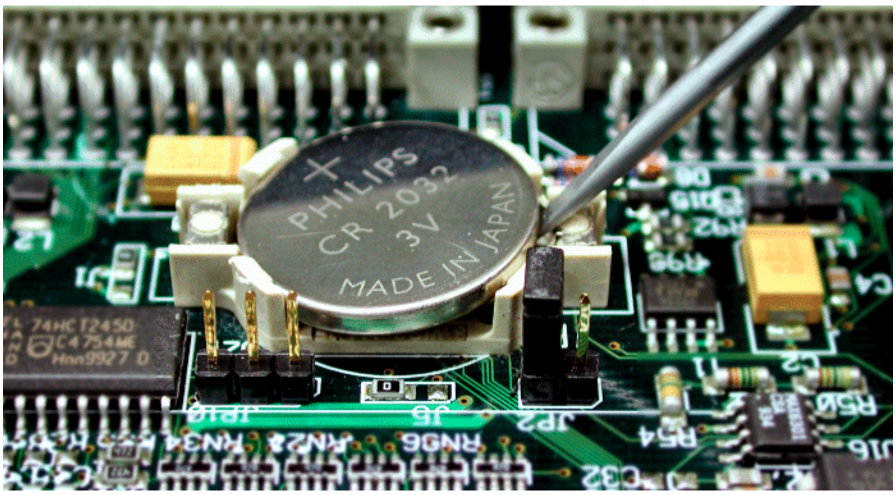

Figure 74 Removing the lithium battery

NOTE
Batteries are special waste.
Dispose of the batteries in accordance with local waste disposal regulations.

2. Place the new lithium battery into the holder (positive terminal up) and click into the clamps without using too much force.

13.4 Fitting mixer cover

CAUTION
Damage to cables by trapping!
Make sure no cables are trapped when refitting the mixer cover.

1. Refit the mixer cover in the reverse order of its removal.
2. Fit the mixer (see section 13.5 Mixer fitting).

13.5 Mixer fitting

1. Before fitting the mixer, check that the six terminal block O-rings are fitted in the housing (see Figure 75).

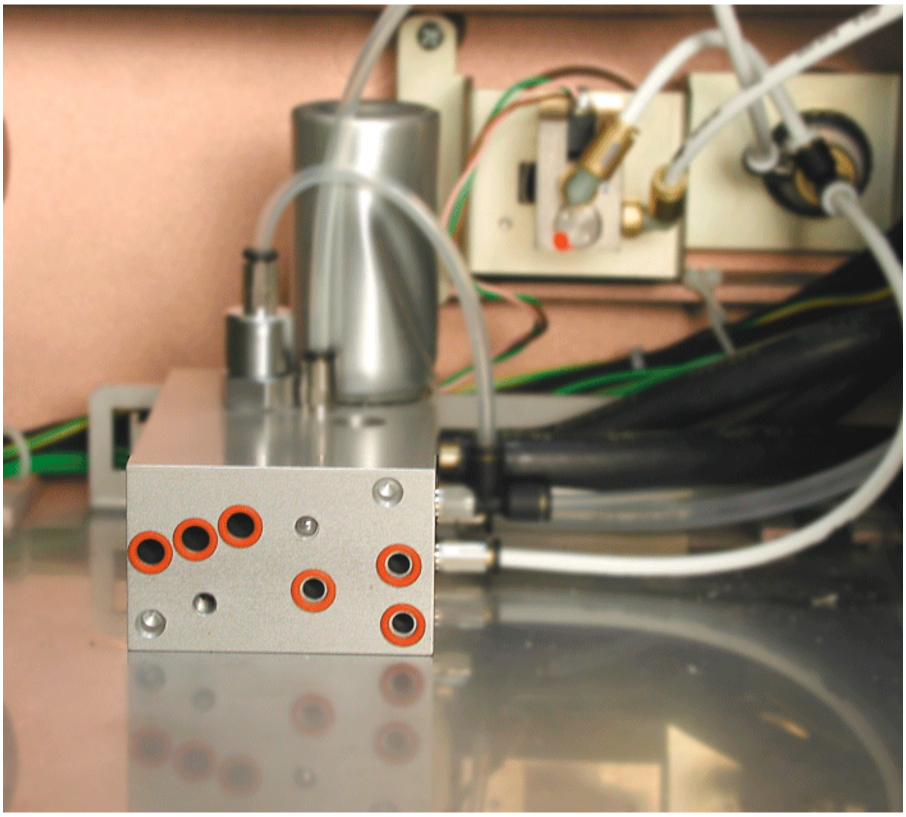

Figure 75 Six O-rings on connector block

2. Refit the mixer in the reverse order of its removal (see 13.1 Removing mixer).
3. Carry out functional and electrical safety tests.

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14 Replacing PEEP diaphragm and MAN/SPONT diaphragm

1. Follow the safety instructions (see document: Safety precautions).
2. Remove the absorber cup.
3. Slacken the five screws on the compact breathing system cover (see Figure 76).

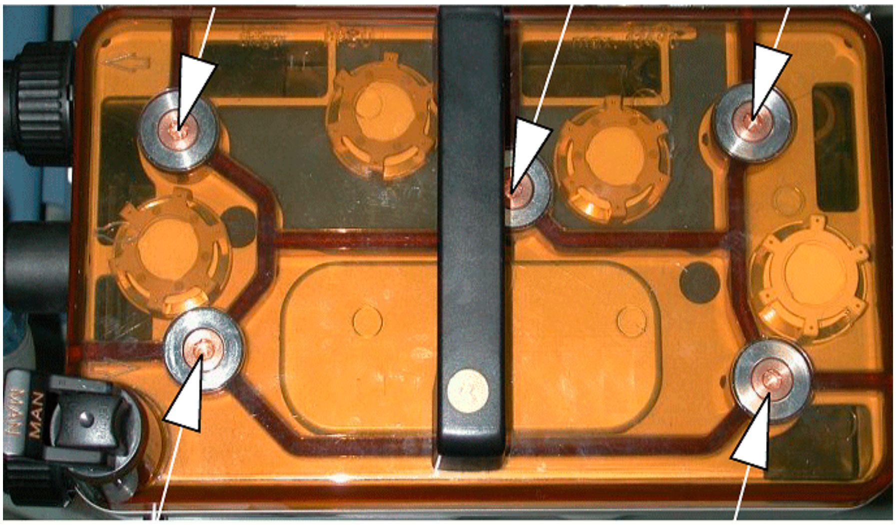


Figure 76 Compact breathing system cover

4. Lift the compact breathing system cover and place it on a suitable surface.

Underneath the valve block (Figure 77/1) are the diaphragm sets of the PEEP valve V1 (Figure 77/2) and the MAN/SPONT switching valve V2 (Figure 77/3).

Figure 77 Valve block (1)

5. Turn the valve plate round and remove the four valve block fixing screws (see Figure 78).

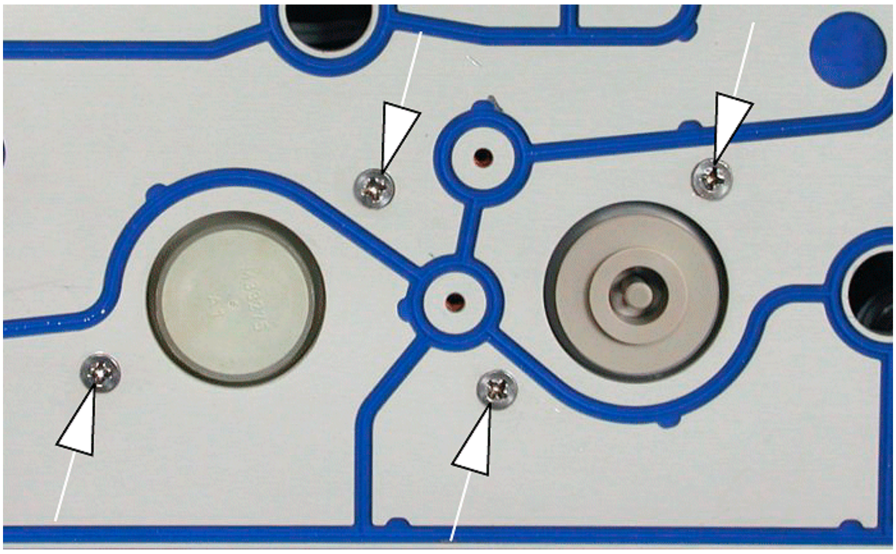


Figure 78 Valve block fixing screws

6. Replace the following components: the diaphragm connector of the PEEP valve V1 (Figure 79/1), the O-rings (Figure 79/2) and the diaphragm set of the MAN/SPONT switching valve V2 (Figure 79/3) (see Figure 79). When assembling, make sure the metal ring of valve V1 and the springs of valve V2 are in place!

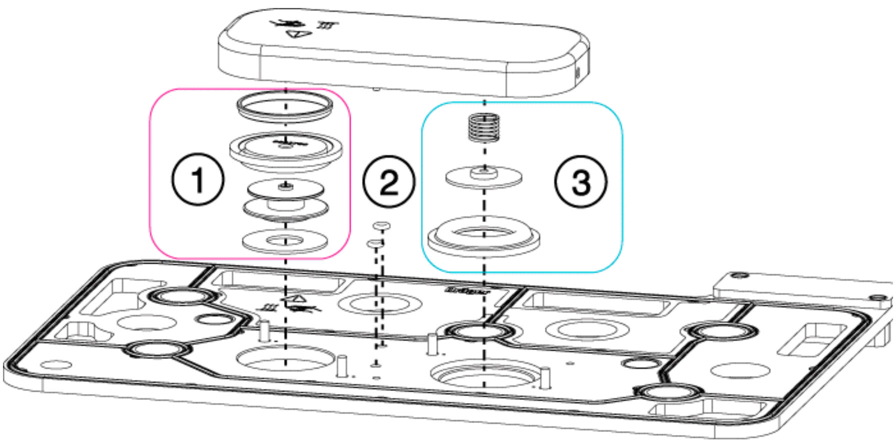


Figure 79 Positions of V1, V2 and O-rings

7. Screw in the four Phillips screws.
8. Refit the valve block in the reverse order of its removal. Observe the following points: After fitting the valve block, valves V1 and V2 must be moveable by fingers. The spring effect of V2 must be perceptible.

The following test steps are carried out with a ventilation dummy:

9. Carry out the Primus power-on test.
10. Carry out a MAN/SPONT ventilation.
11. Carry out an IPPV ventilation with pre-set “PEEP” of 10 hPa.
12. Check the flow and pressure parameters.

15 Pressure regulator major overhaul

15.1 Safety precautions

WARNING

Explosion and fire hazard!
Always make sure parts which come into contact with oxygen are free of grease and oil prior to fitting.

CAUTION
Risk of damage to Primus if pressure regulator and blow-off valve are adjusted incorrectly.
The pressure regulator and its blow-off valve must be readjusted after a major overhaul. For safety reasons, it is recommended to have the adjustment done by DrägerService.

15.2 Required spare parts

Name	Part number
General overhaul spare parts set	MX08047
Set of gas type labels	MX08060

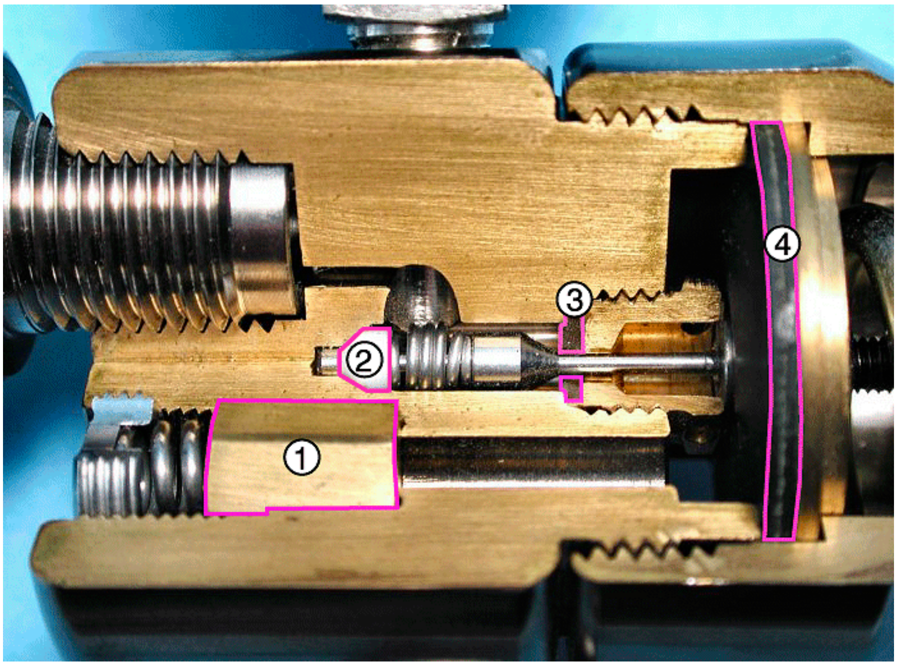


Figure 80 Major overhaul spare parts set, see legend

Table 1 **Legend to Figure 80**

Item	Designation
1	Closing plunger (blow-off valve)
2	Friction (valve tappet)
3	Sealing (valve tappet)
4	Diaphram on diaphragm carrier

15.3 Service Equipment Required

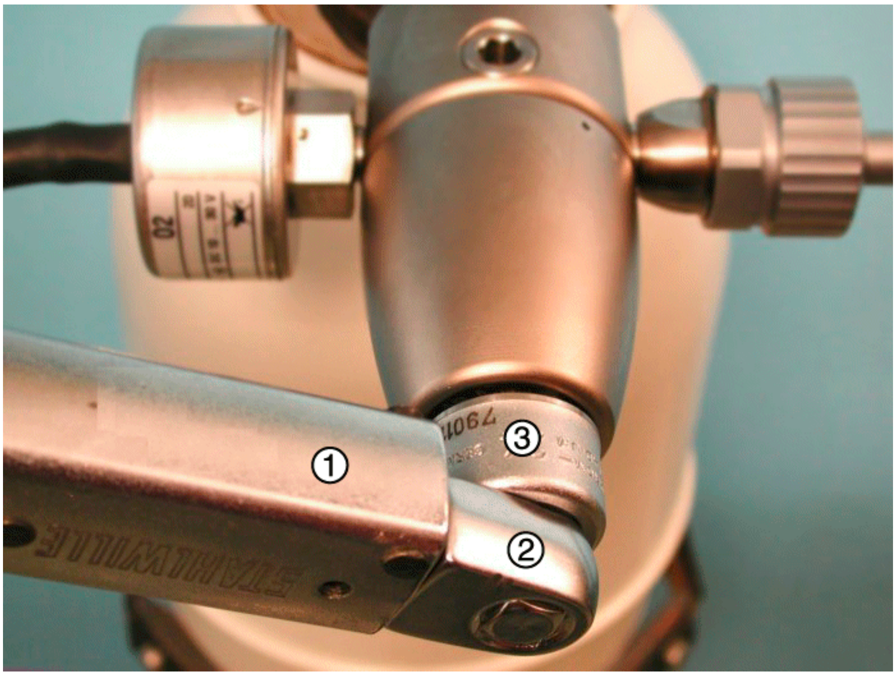


Figure 81 Tools; for legend, see the following table

Table 2 Legend to Figure 81

Item	Name	Part no.
1	Torque spanner	7910132
2	Square bit, 1/2 inch.	7901864
3	Pin insert (**Note:** Tool was modified mid-2004. The pins have now a length of 5 mm instead of 3 mm. Perform the general overhaul using the new tool only!).	7901129
4	Loctite 221 (not shown).	7901966
6	Loctite 271 (not shown).	1198165

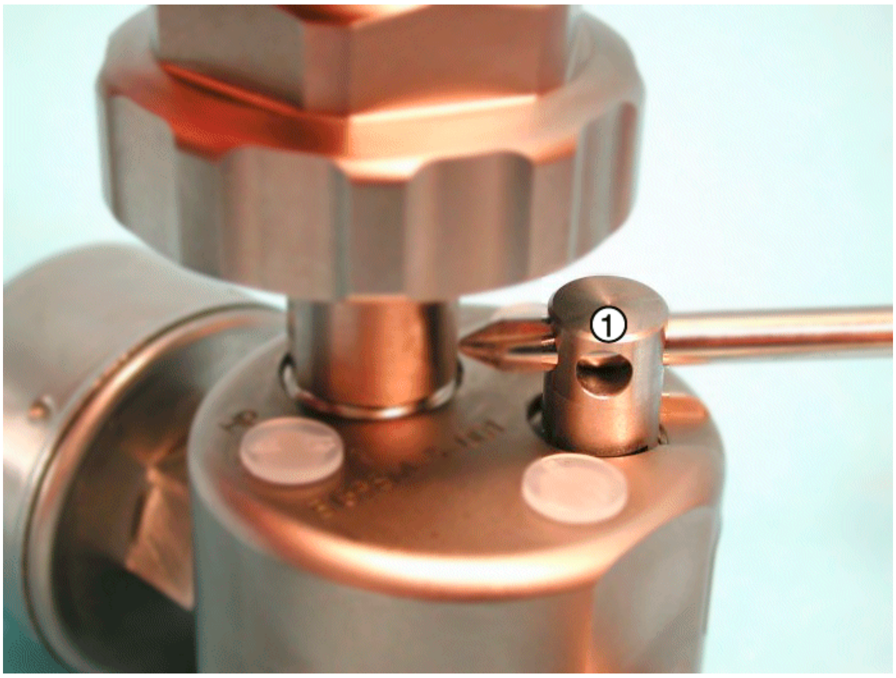


Figure 82 Wrench; for legend, see the following table

Table 3 **Legend to Figure 82**

Item	Name	Part no.
1	Wrench (blow-off valve)	7911318

15.4 Removing the pressure regulator

In the following section an O2 pressure regulator is used as an example for a major overhaul.

WARNING
Risk of personal injury due to improper setting up of high-pressure cylinders!
The high-pressure cylinders used shall be set up securely (to prevent them from being knocked over) in accordance with applicable safety regulations.

WARNING
Risk of personal injury due to improper disassembly of the pressure regulator!
If the high-pressure regulator is fitted on a high-pressure cylinder, always vent the high-pressure of the high-pressure cylinder first before performing the following work steps.
During the entire major overhaul procedure, protect the high-pressure cylinder valve from being opened unintentionally.

1. Leave the pressure regulator fitted on the high-pressure cylinder or place it flat on an appropriate surface.
2. Remove the gas-type label (Figure 83/1).

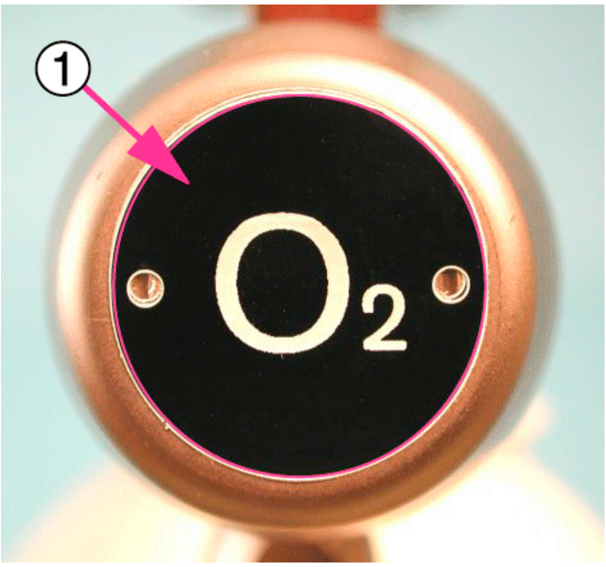


Figure 83 Gas-type label

3. Remove the front housing part of the pressure regulator (Figure 84/1). While doing so, the pressure regulator should be fitted on the high-pressure cylinder or on an assembly aid, or should be placed flat on an appropriate surface.

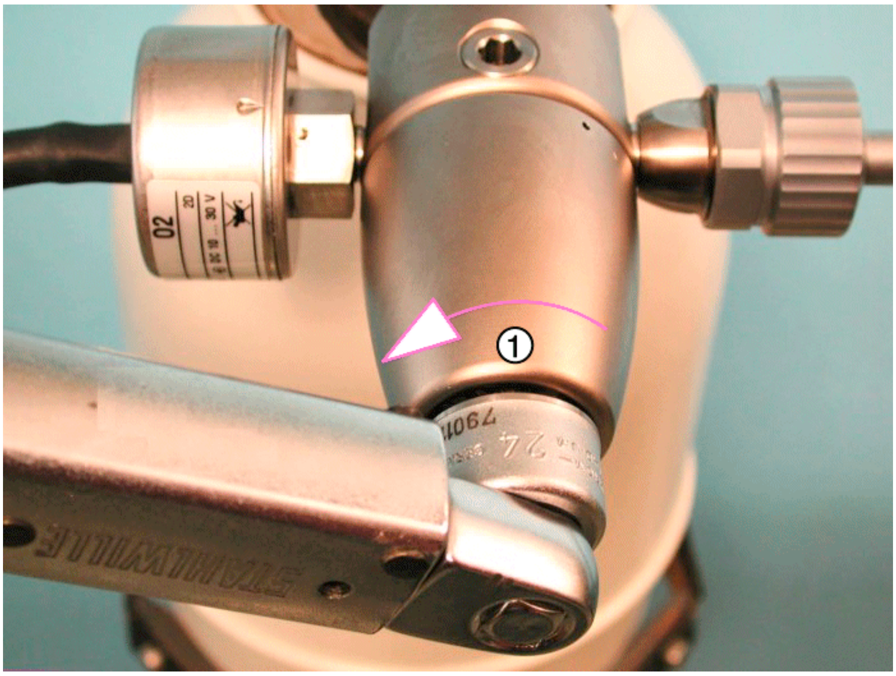


Figure 84 Removing the front housing part

15.5 Replacing the "Major Overhaul" spare parts set

WARNING
Explosion and fire hazard!
Always make sure parts which come into contact with oxygen are free of grease and oil prior to fitting.

1. Remove the diaphragm carrier (Figure 85/1).

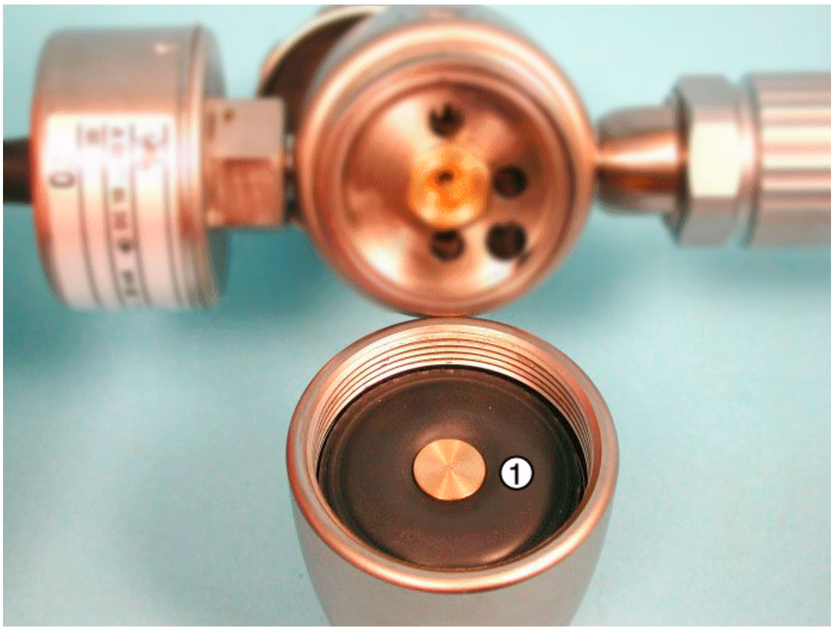


Figure 85 Housing (open)

2. Remove the fixing nut (Figure 86/1) from the diaphragm carrier.

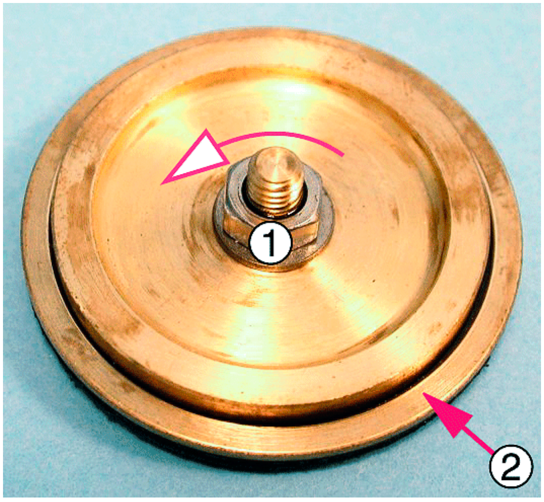


Figure 86 Diaphragm carrier with fixing nut

3. Fit the new diaphragm and secure the nut with Loctite 221. Tighten the nut (Figure 86/1) only such that the diaphragm is not deformed. Fit the ring (Figure 87/1) with its radius side facing the diaphragm.

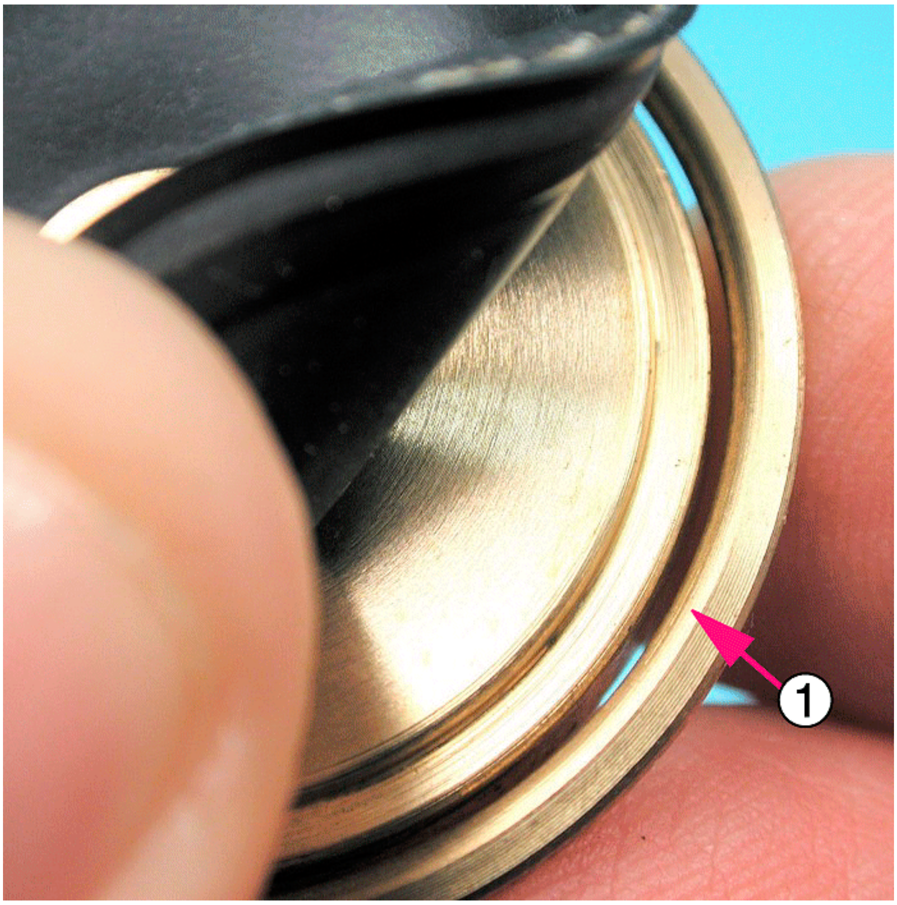


Figure 87 Fitting position of the ring

4. Place the diaphragm carrier into the housing. Make sure that the components under the diaphragm are fitted in the correct order (see Figure 88).

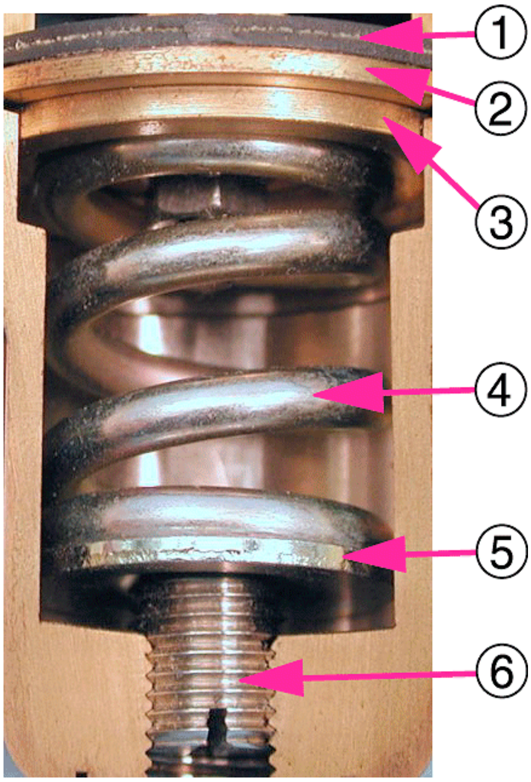


Figure 88 Components under the diaphragm

Table 4 **Legend to Figure 88**

Item	Designation
1	Diaphragm
2	Ring
3	Diaphragm carrier
4	Control spring
5	Pressure plate
6	Adjusting screw

5. Using an appropriate tool (bit with 11 mm WAF), unscrew the brass valve seat (Figure 89/1).

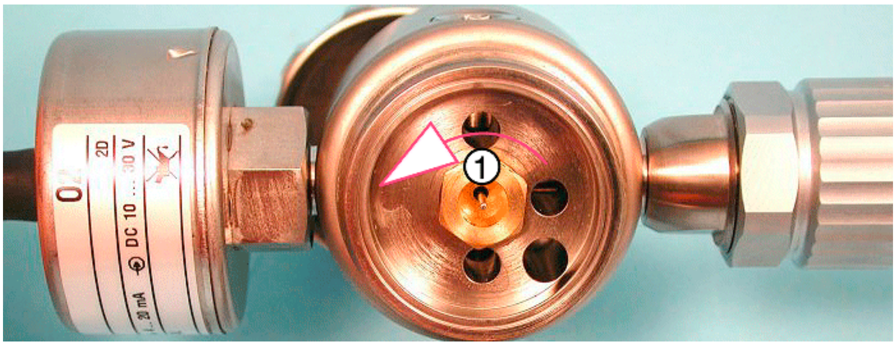


Figure 89 Valve seat

NOTE
Avoid any contamination during the next work steps.

6. Remove the friction (Figure 90/1) from the valve plunger (Figure 90/2) and replace it with a new one.
7. Remove the sealing (Figure 90/3) from the valve seat and replace it with a new one.

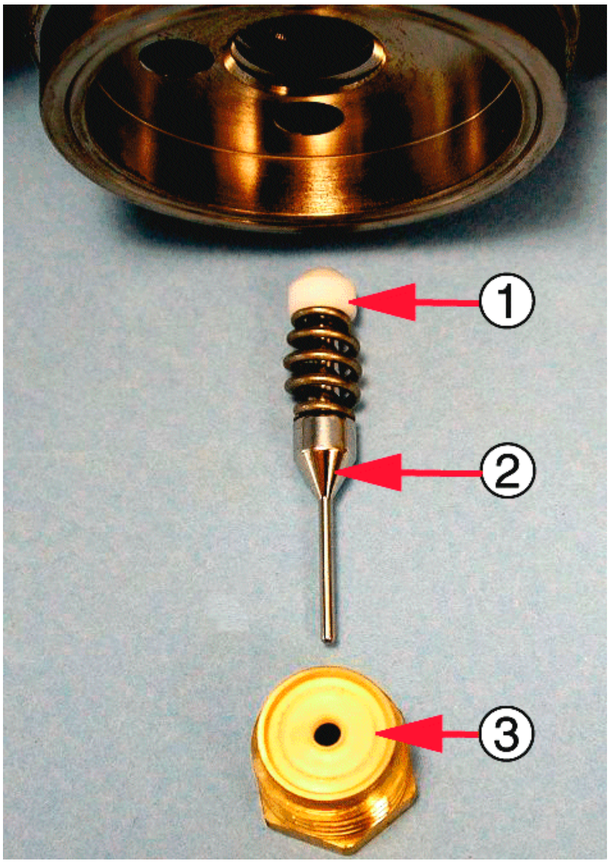


Figure 90 Valve components

8. Fit the valve components. Place the new sealing such that the internal chamfer (Figure 90/3) points toward the valve plunger. Tighten the valve seat (to a torque of 5 Nm).
9. Refit the housing in the reverse order of its removal.

10. Secure the thread of the housing. To do so, fill a small amount of Loctite 270 (1198165) into the small housing borehole (Figure 91/1).

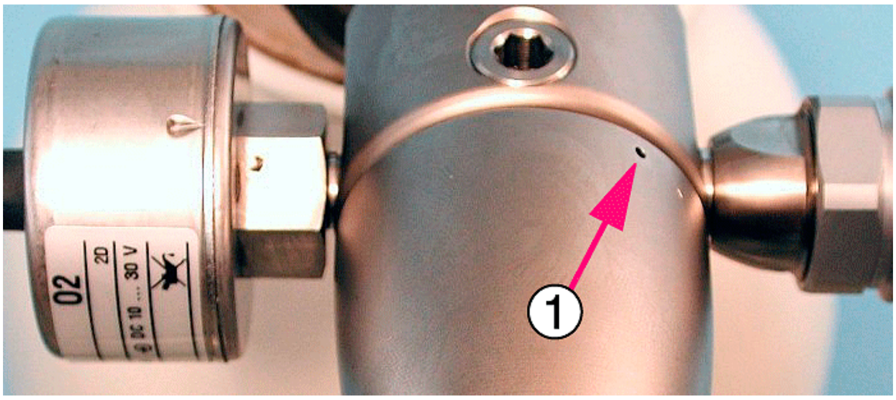


Figure 91 Small housing borehole

11. Remove the blow-off valve using the wrench (Figure 92/1).

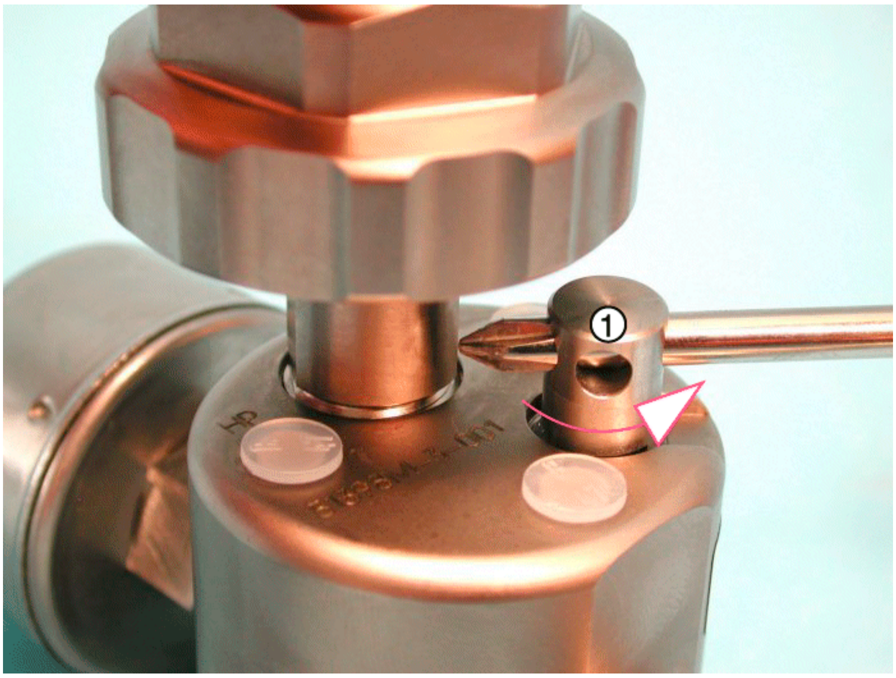


Figure 92 Removing the blow-off valve

12. Remove the blow-off valve's components and replace the closing plunger (Figure 93/3).

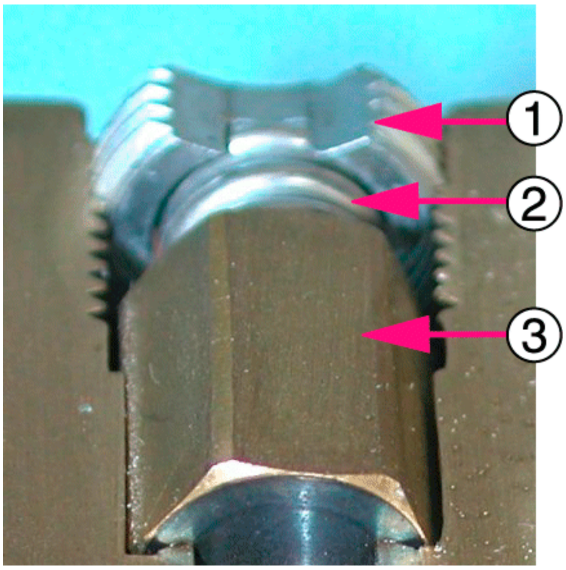


Figure 93 Blow-off valve components

Table 5 **Legend to Figure 88**

Item	Designation
1	Adjusting screw
2	Control spring
3	Closing plunger

13. Refit the blow-off valve in the reverse order of its removal. Screw in the adjusting screw without using excessive force.
14. For safety reasons, it is recommended to have the downstream pressure and the blow-off valve adjusted by DrägerService.

Schematics and Diagrams

1 Primus pneumatic components diagram

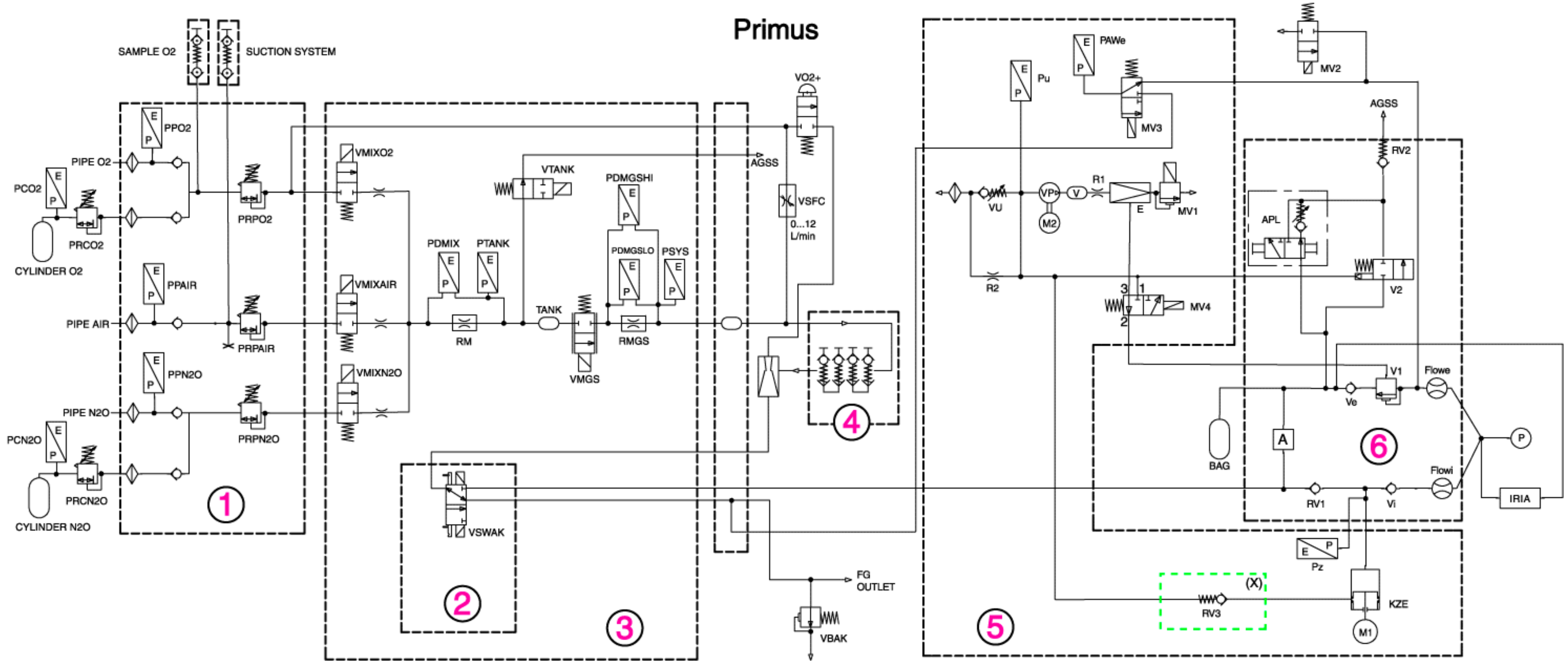


Figure 1 Primus pneumatic components diagram as of software 2.n, see legend Table 1 (changes see (X))

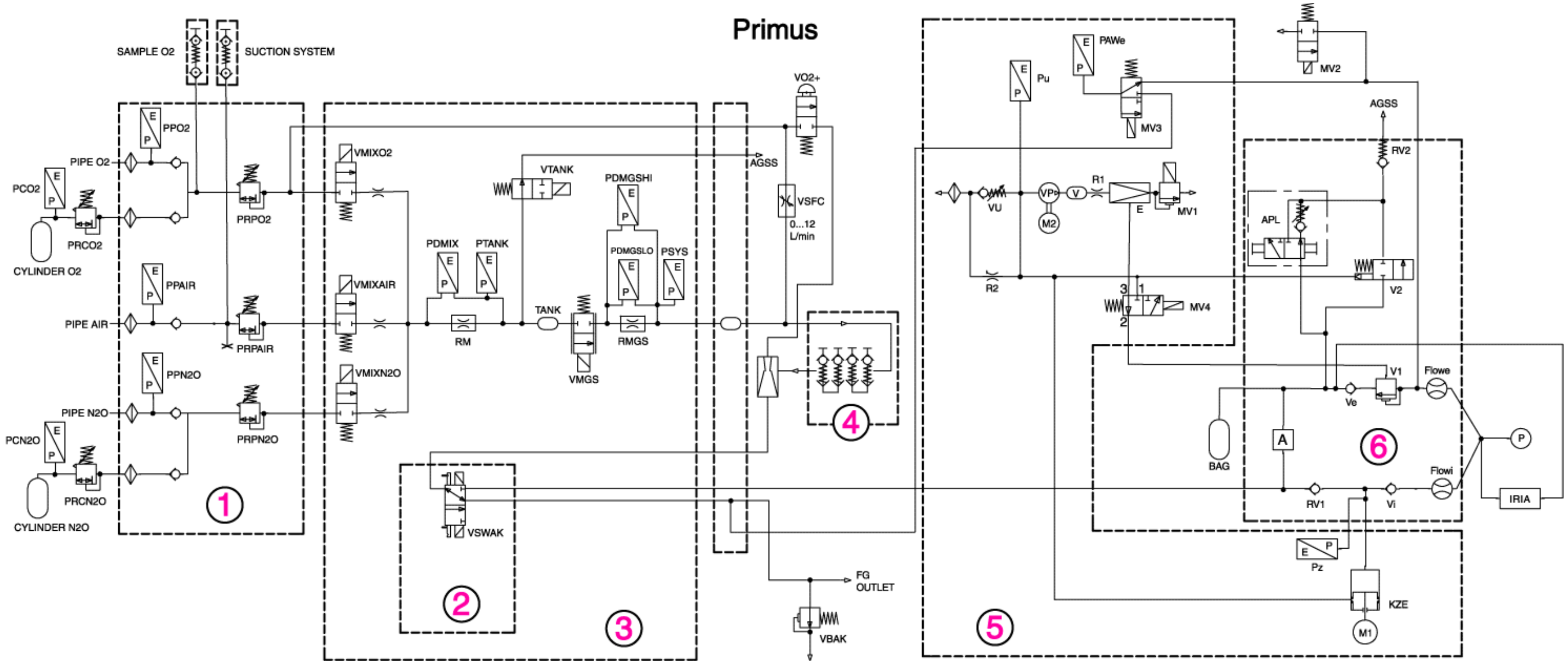


Figure 2 Primus pneumatic components diagram up to software 1.6n, see legend Table 1

Table 1 **Legend to Figure 1 and Figure 2**

Item short name	Component name
1	Gas inlet block.
2	A-cone valve (option).
3	Mixer.
4	Vaporizer plug-in system.
5	Ventilator.
6	Breathing system.
A	Absorber.

Item short name	Component name
AGSS	Anesthetic gas scavenging system.
APL	APL valve.
BAG	Breathing bag.
CYLINDER N2O	N2O compressed-gas cylinder.
CYLINDER O2	O2 compressed-gas cylinder.
E	Ejector.
FG OUTLET	Fresh gas outlet
Flowe	Expiratory flow sensor
Flowi	Inspiratory flow sensor.
IRIA	IRIA (anesthetic gas measurement).
KZE	Piston-cylinder unit.
M1	Piston-cylinder unit motor.
M2	Motor PEEP pressure.
MV1	PEEP/Pmax valve.
MV2	Calibration valve.
MV3	Breathing system/fresh-gas outlet switching valve.
MV4	PEEP valve/control valve.
P	Patient.
PAWe	Expiratory airway pressure sensor.
PCN2O	N2O compressed-gas cylinder pressure.
PCO2	O2 compressed-gas cylinder pressure.
PDMGSHI	Differential pressure (high range).
PDMGSLO	Differential pressure (low range).
PDMIX	Differential pressure mixer.
PDTANK	Pressure in the “TANK”.
PIPE AIR	AIR central supply.
PIPE N2O	N2O central supply.

Item short name	Component name
PIPE O2	O2 central supply.
PPAIR	AIR central supply pressure.
PPN2O	N2O central supply pressure.
PPO2	O2 central supply pressure.
PRCN2O	N2O compressed-gas cylinder pressure regulator.
PRPAIR	AIR central supply pressure regulator.
PRPN2O	N2O central supply pressure regulator.
PRPO2	O2 central supply pressure regulator.
PSYS	System pressure.
Pu	Vacuum pressure sensor, current vacuum.
Pz	Inspiratory airway pressure sensor.
R 1	Restrictor to smooth pressure peaks.
R 2	Resistor to reduce vacuum (pump off).
RM	Fresh-gas measuring path (upstream of the TANK).
RMGS	Fresh-gas measuring path.
RV1	Non-return valve of fresh-gas decoupling.
RV2	AGSS non-return valve.
RV3	KZE vacuum non-return valve (as from software 2.n).
SAMPLE O2	O2 connection for external O2 flowmeter (option).
SUCTION SYSTEM	Connection for external bronchial suction device (option).
TANK	Fresh-gas tank.
V	Volume.
V1	PEEP valve diaphragm.
V2	Auto-man/spont ON/OFF valve.
VBAK	A-cone safety valve.
Ve	Expiratory valve.
Vi	Inspiratory valve.

Item short name	Component name
VMGS	Fresh-gas flow valve (proportional valve).
VMIXO2	O2 mixer valve.
VMIXAIR	AIR mixer valve.
VMIXN2O	N2O mixer valve.
VO2+	O2 flush valve.
VP	Vacuum pump.
VSFC	Safety O2 control.
VSWAK	A-cone valve.
VTANK	TANK valve (safety valve).
VU	Vacuum valve -200 mbar.

2 Schematics and Diagrams

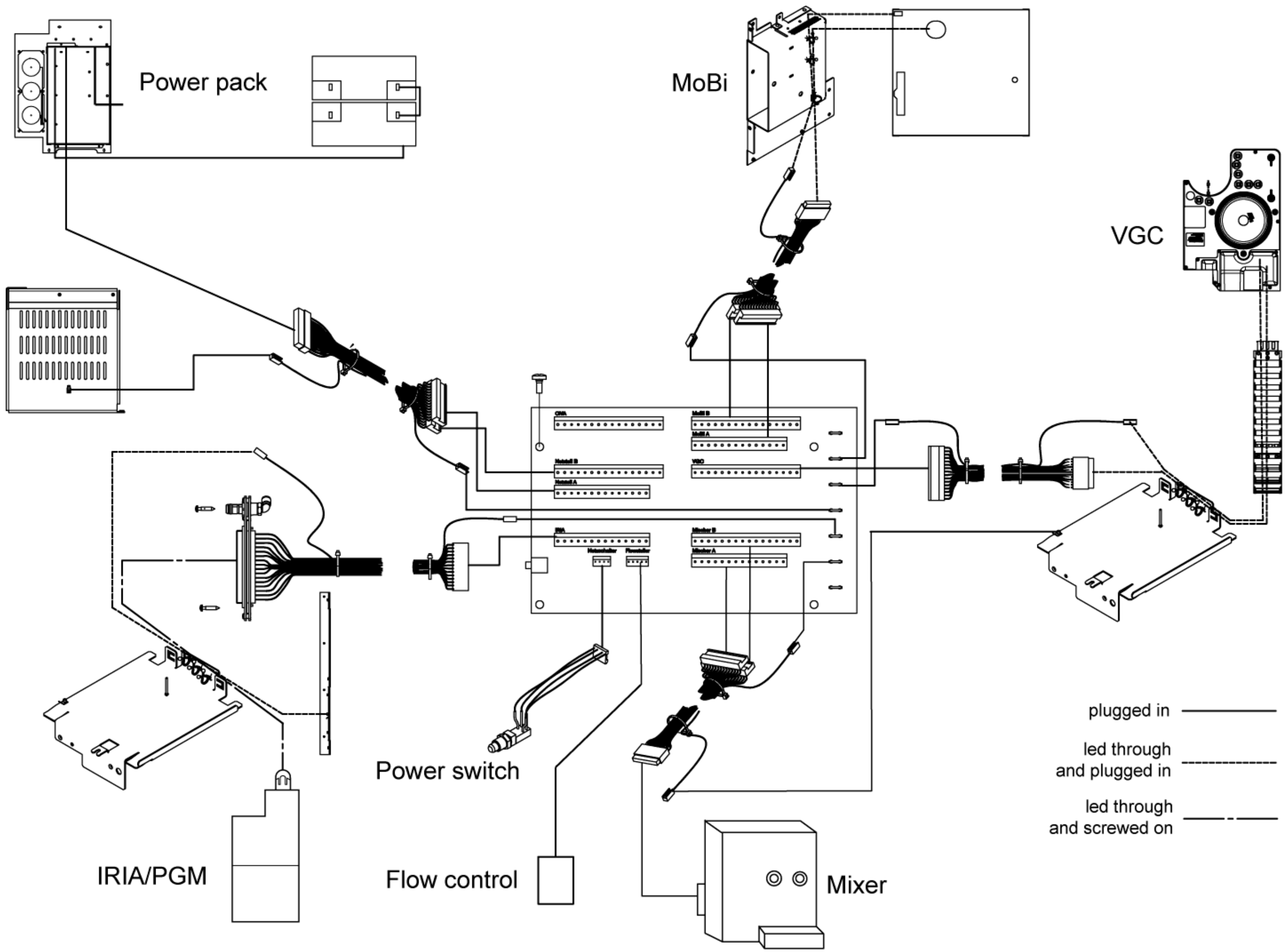


Figure 3 Primus block diagram

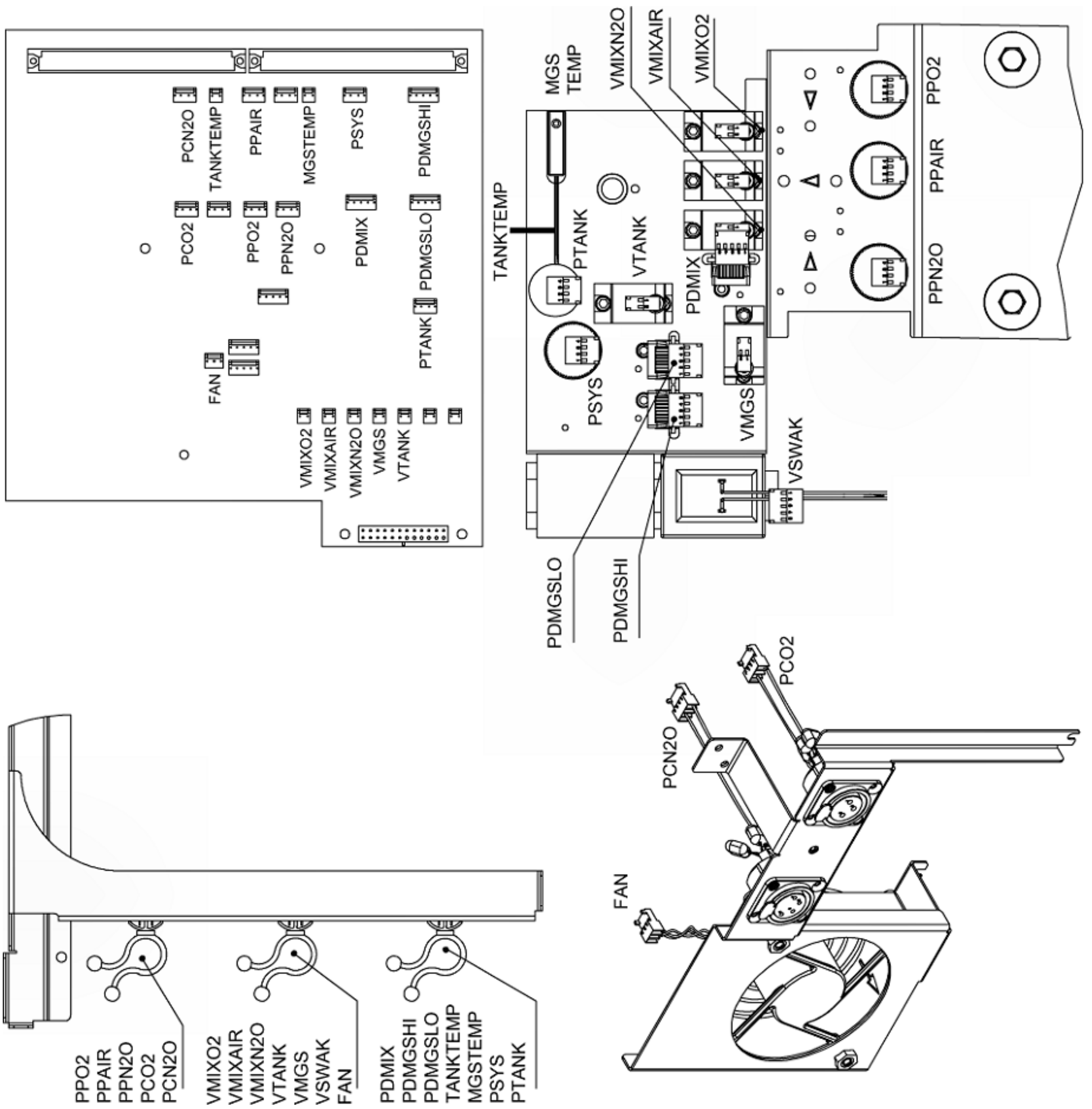


Figure 4 Mixer connection diagram

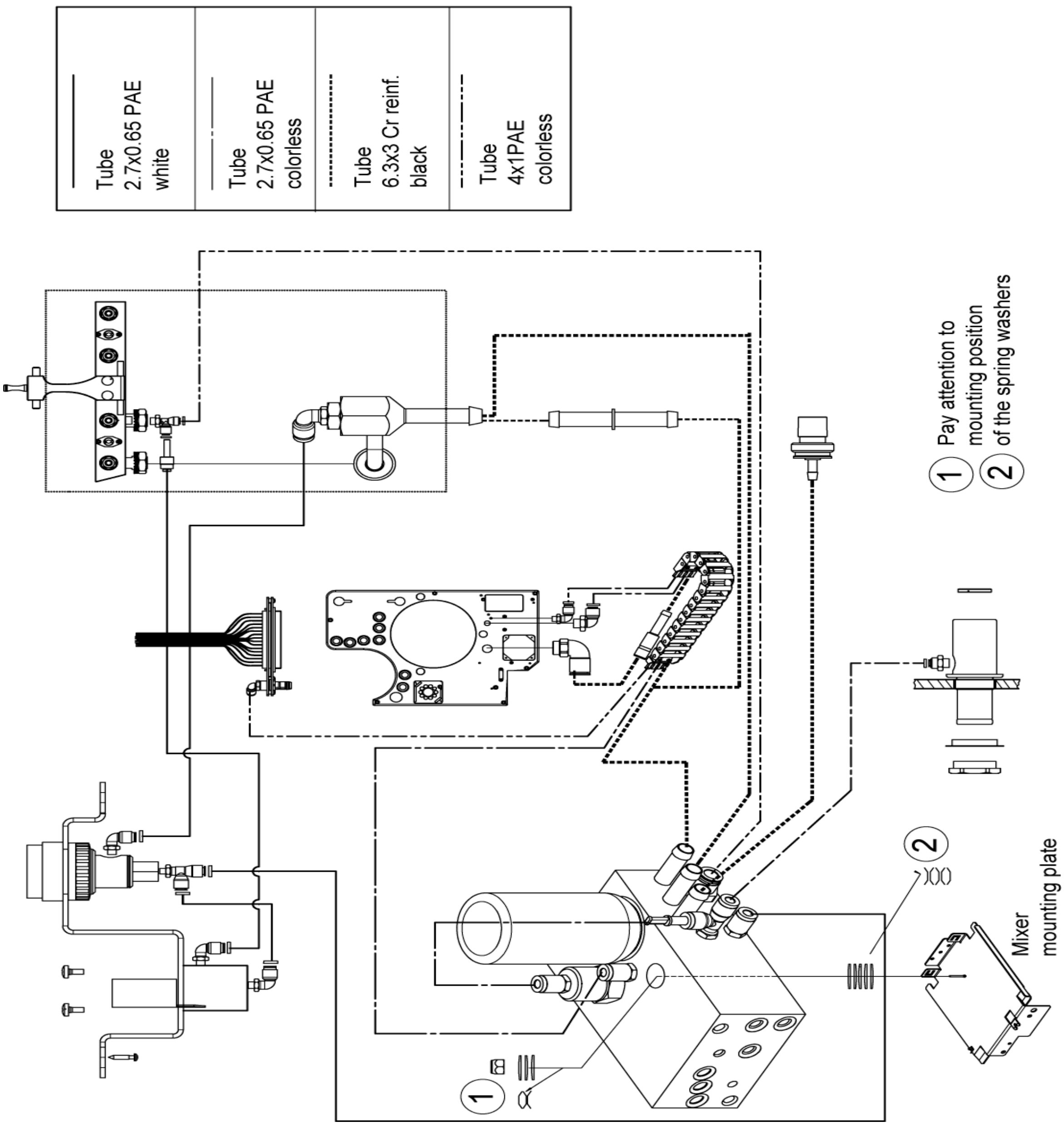


Figure 5 Primus tubing diagram

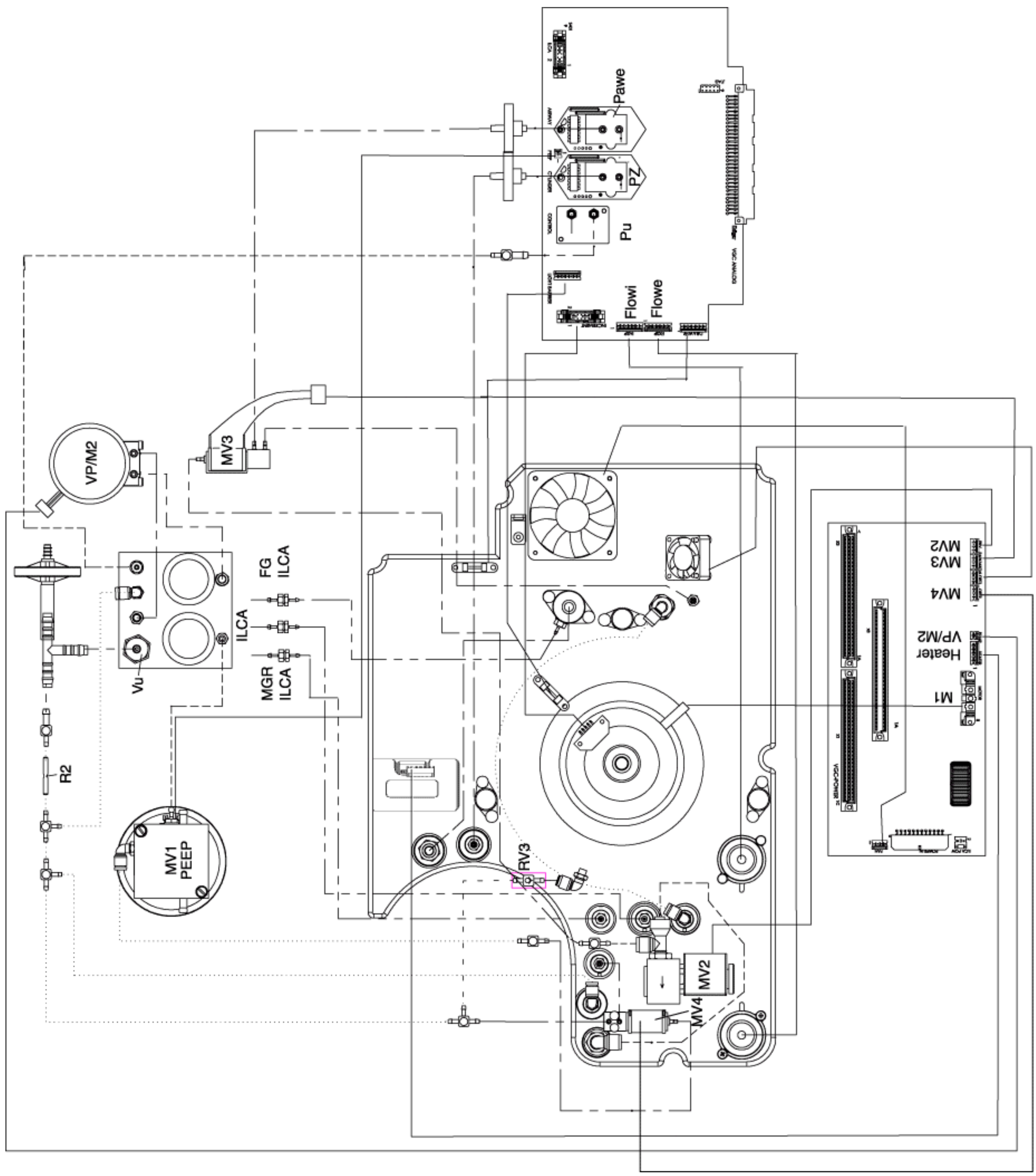


Figure 6 VGC tubing configuration and electrical connections (with RV3)

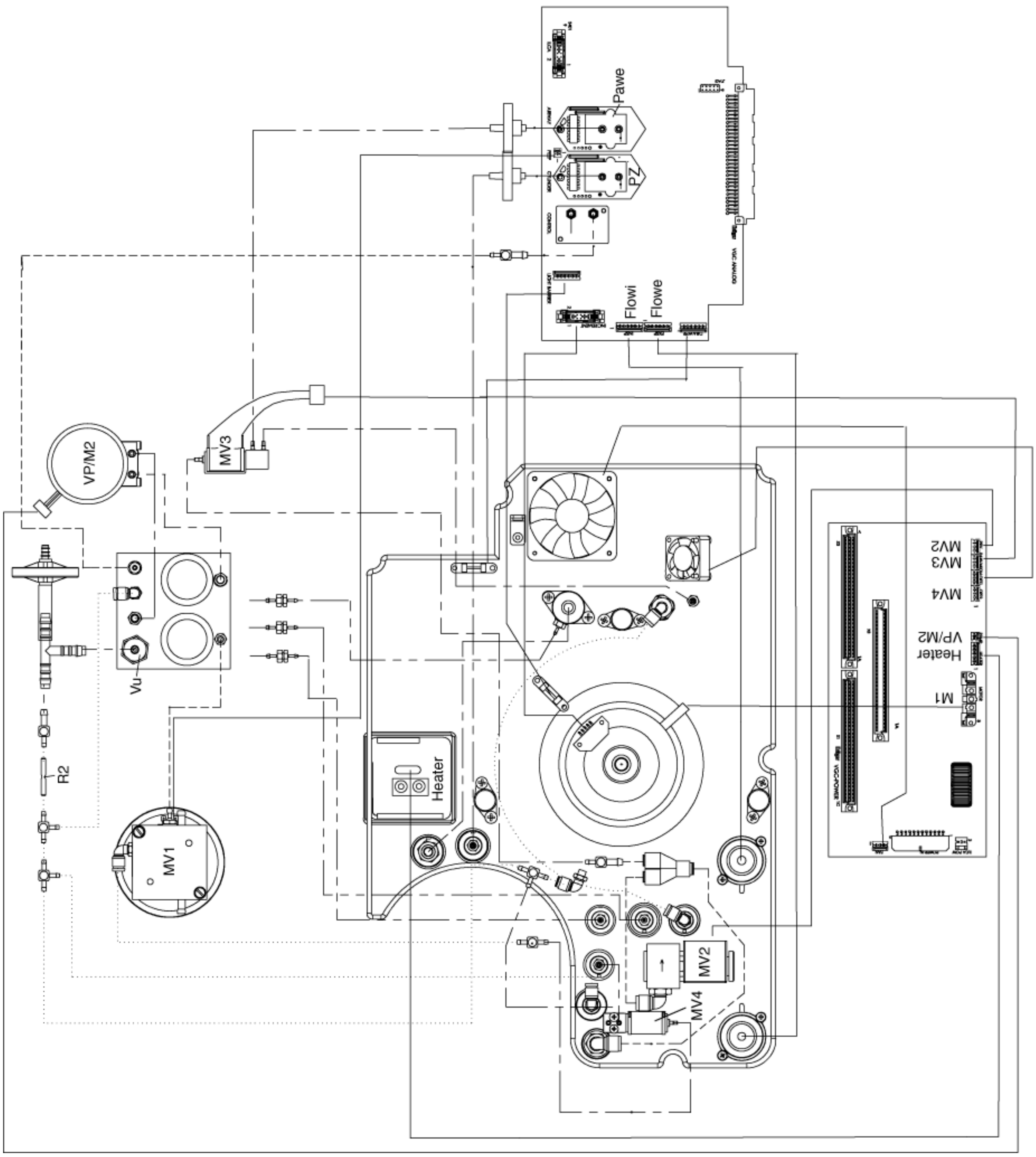


Figure 7 VGC tubing configuration and electrical connections (without RV3)

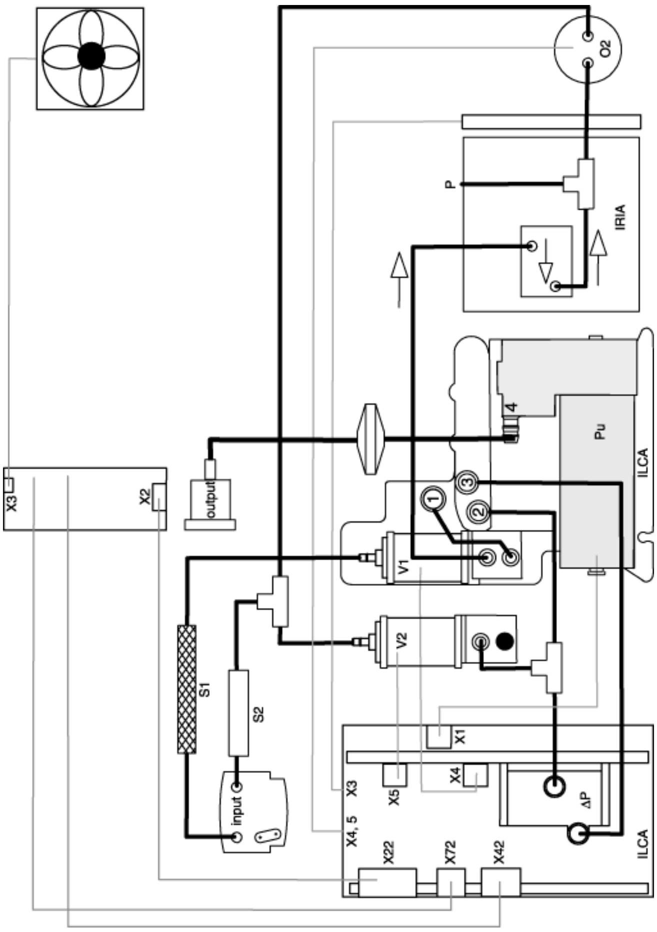


Figure 8 PGM block diagram

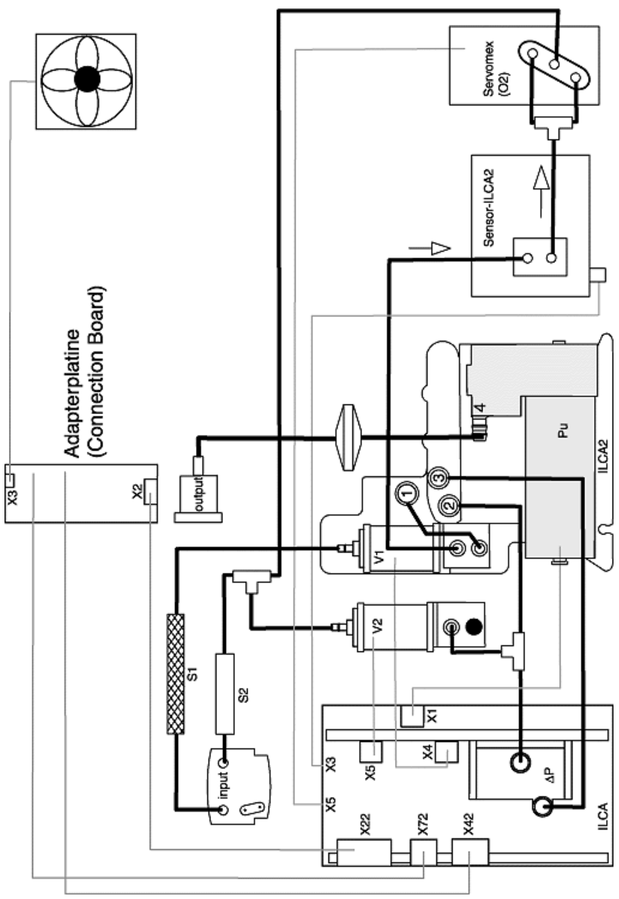


Figure 9 Block diagram of the PGM2 with Servomex O2 sensor

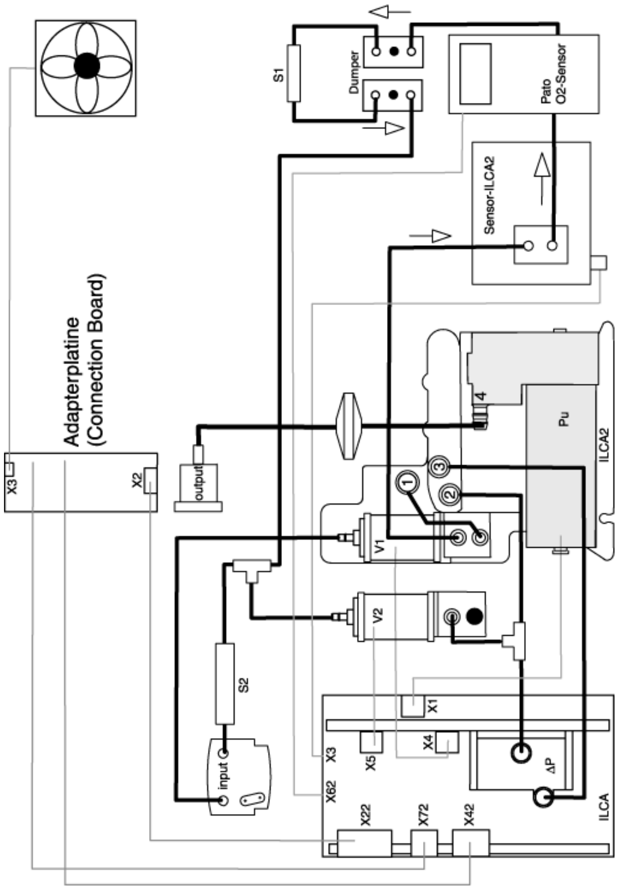


Figure 10 Connection diagram of the PGM2 with Pato O2 sensor

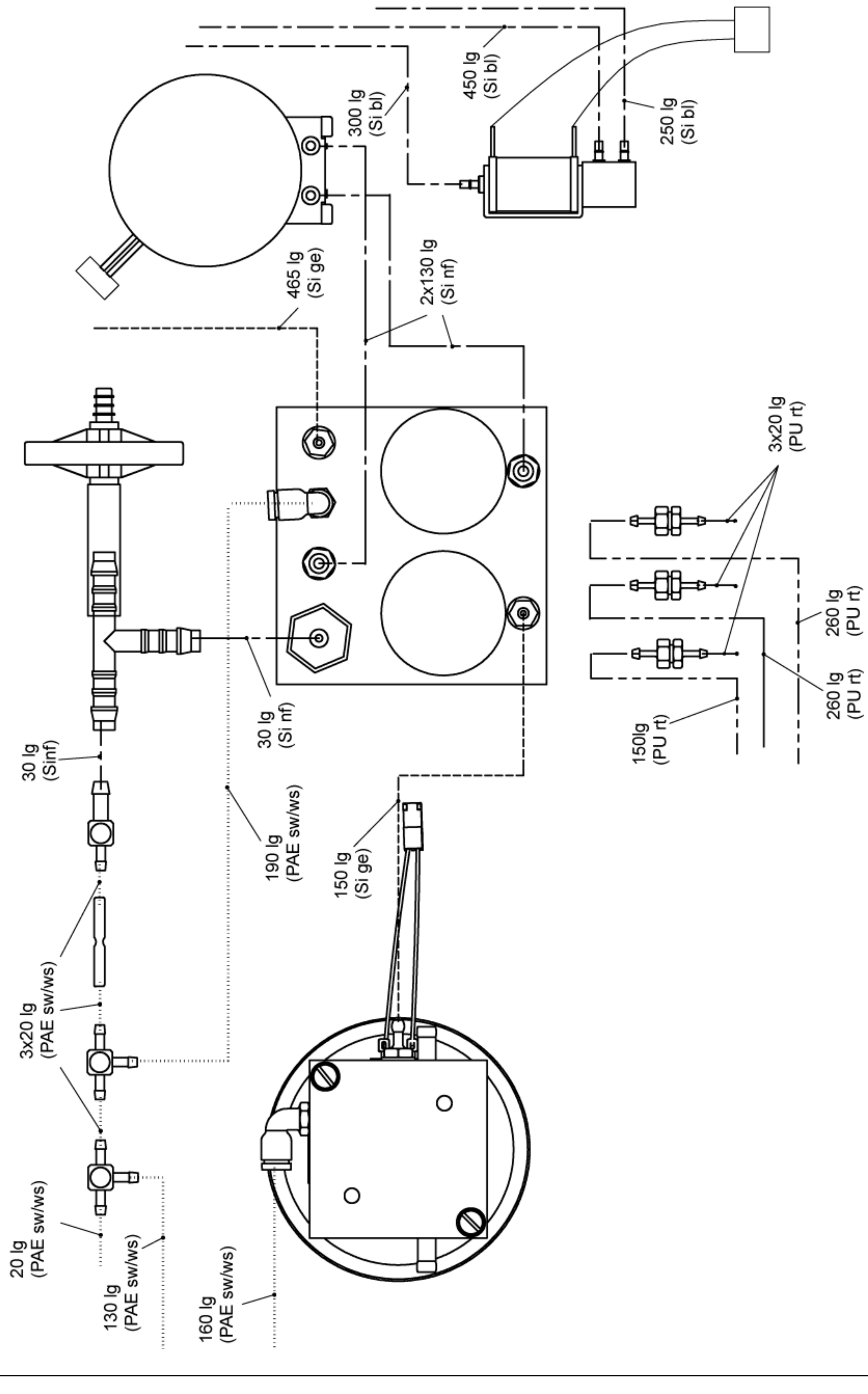


Figure 11 VGC pneumatic block tubing diagram

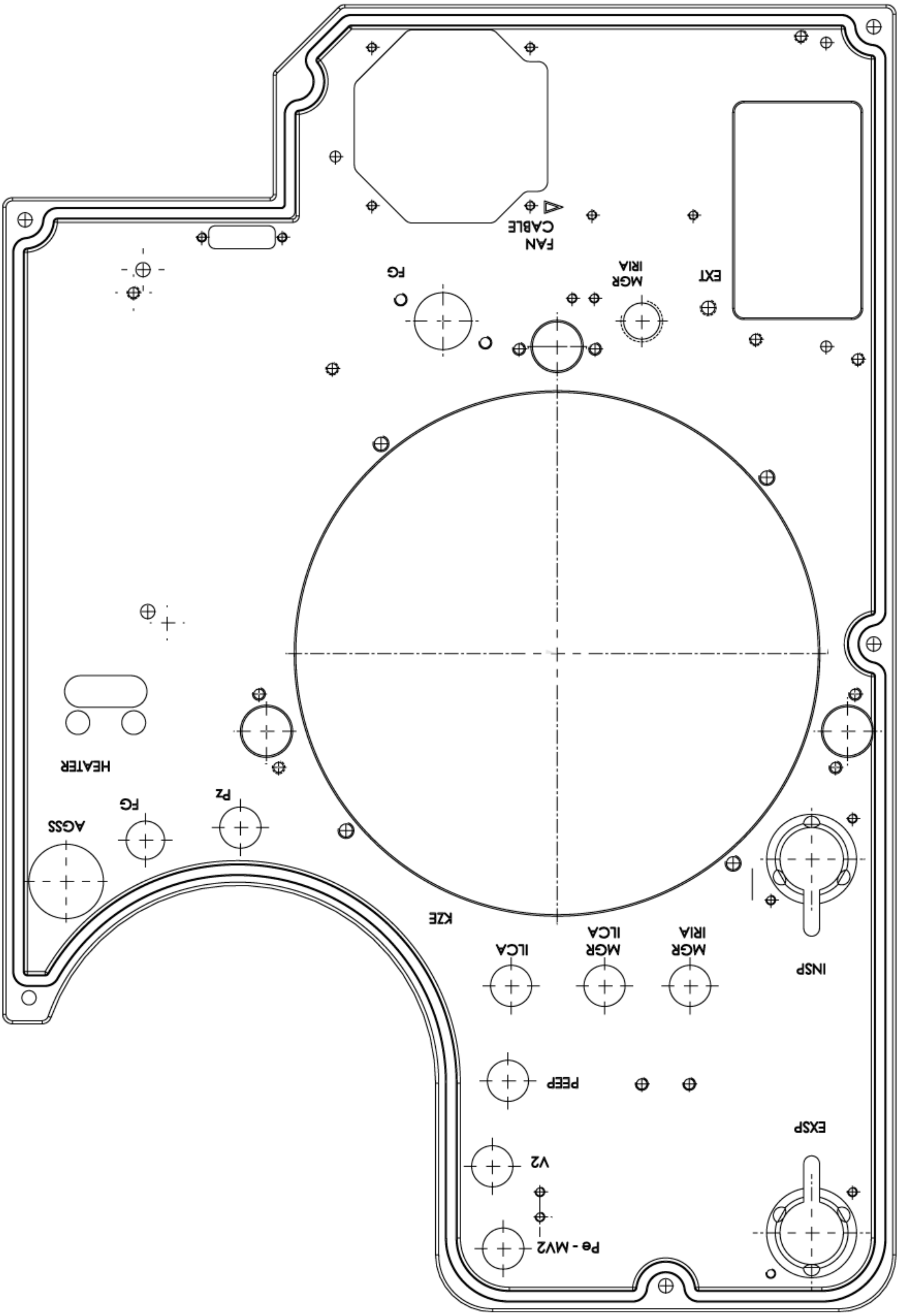


Figure 12 VGC assembly plate

Annex

Parts catalog

Test List

Technical Information

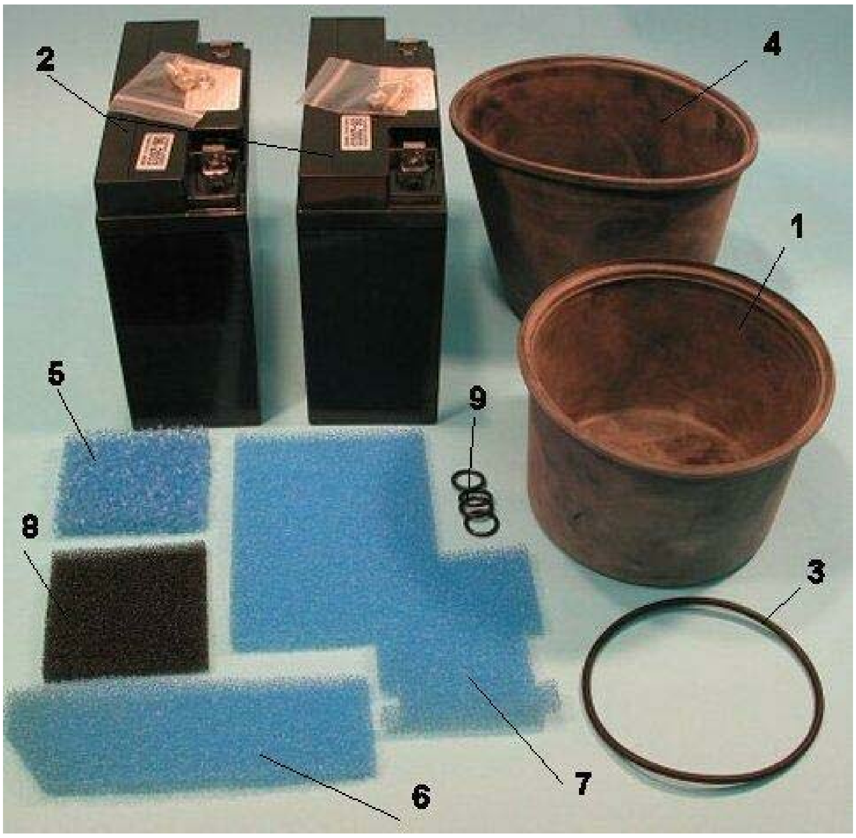
Parts catalog

Primus

Revision: 2006-02

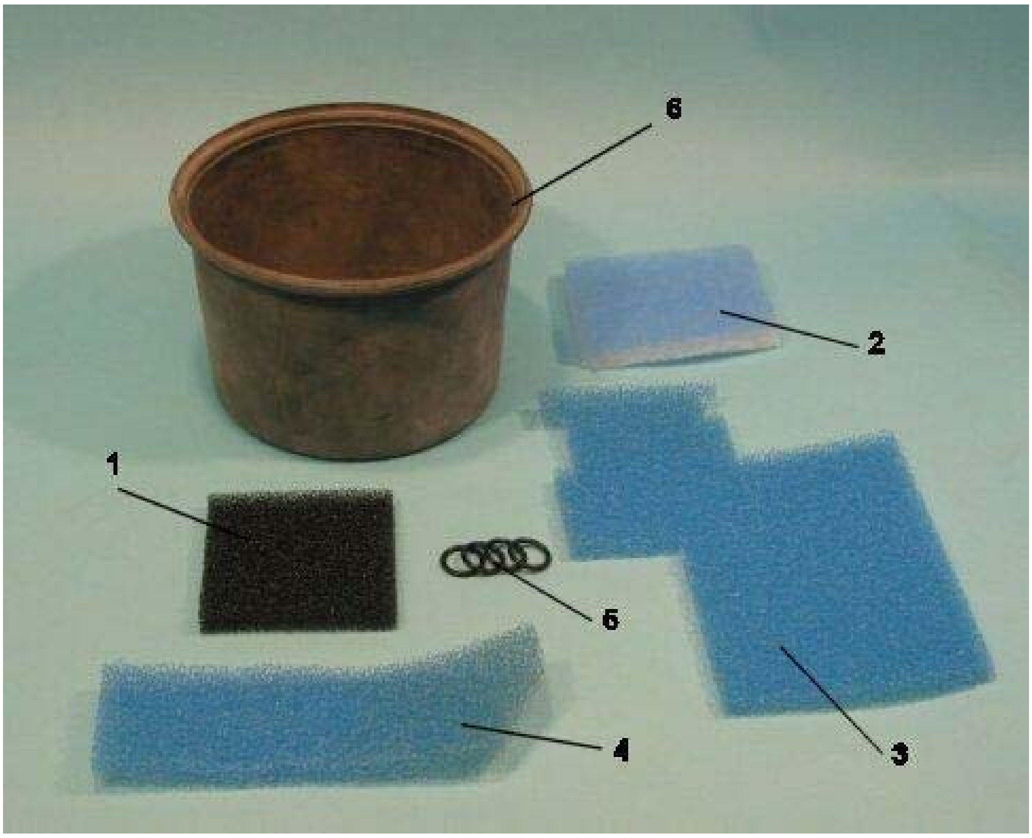
5132.300

Because you care



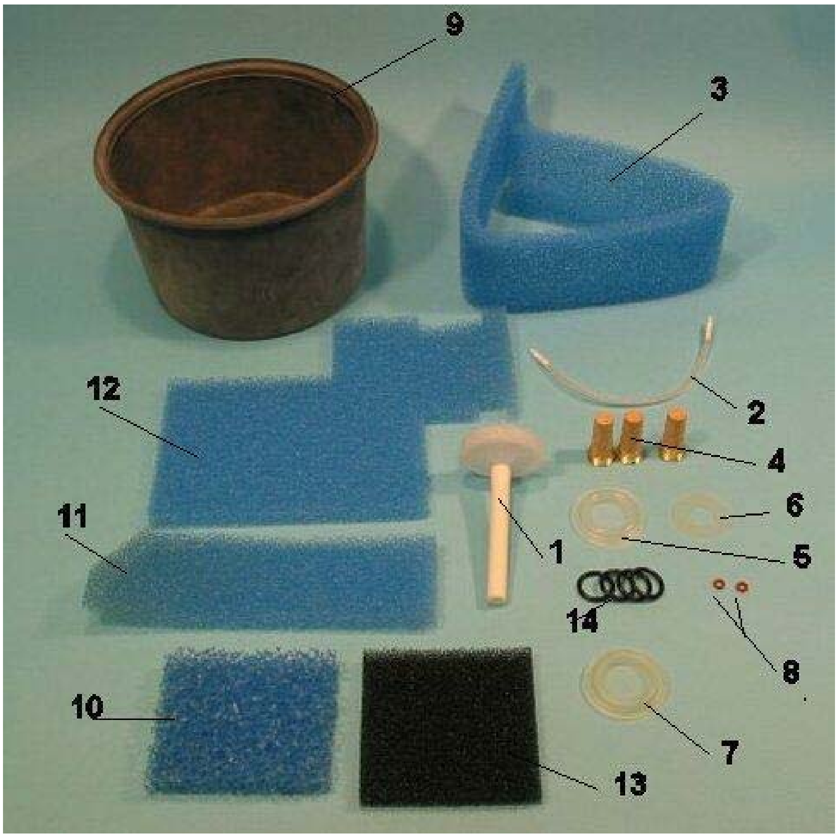
Item No.	Part No.	Description	Qty.	Qty. unit	Remark
2	8603057	Battery	2.000	St	
4	2600650	DIAPHRAGM,CUP	1.000	St	
5	6870910	FILTER MAT	1.000	St	
6	8603144	FILTER MAT	1.000	St	
7	8603301	FILTER MAT	1.000	St	
8	8603662	FILTER MAT	1.000	St	
9	U04314	O-RING SEAL	4.000	St	

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts



Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1	8603662	FILTER MAT	1.000	St	
2	6870910	FILTER MAT	1.000	St	
3	8603301	FILTER MAT	1.000	St	
4	8603144	FILTER MAT	1.000	St	
5	U04314	O-RING SEAL	4.000	St	
6	2600650	DIAPHRAGM,CUP	1.000	St	

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts



Item No.	Part No.	Description	Qty.	Qty. unit	Remark
2	8601238	NAFION HOSE 150 LG.	1.000	St	
3	8603585	FILTER MAT	1.000	St	
4	M19238	MESH BOTTOM	3.000	St	
5	8603780	DIAPHRAGM	1.000	St	
6	8603781	SEALING WASHER	1.000	St	
7	M33275	DIAPHRAGM	1.000	St	
8	R52382	O-RING SEAL	2.000	St	
9	2600650	DIAPHRAGM,CUP	1.000	St	
10	6870910	FILTER MAT	1.000	St	
11	8603144	FILTER MAT	1.000	St	
12	8603301	FILTER MAT	1.000	St	
13	8603662	FILTER MAT	1.000	St	
14	U04314	O-RING SEAL	4.000	St	

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1	M33294	FILTER	1.000	St	

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Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	M33294	FILTER	1.000	St	

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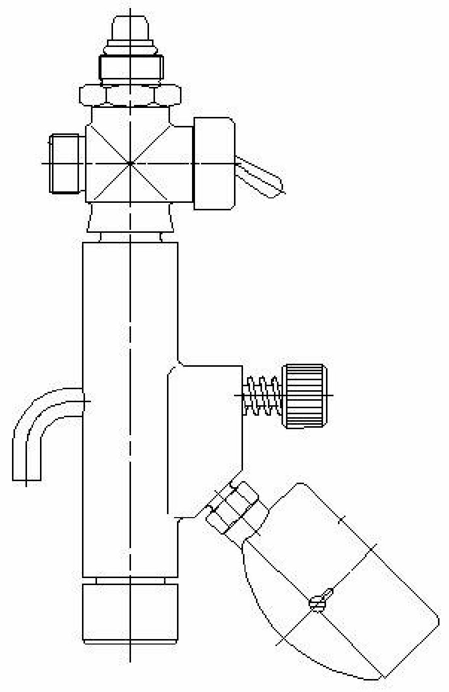
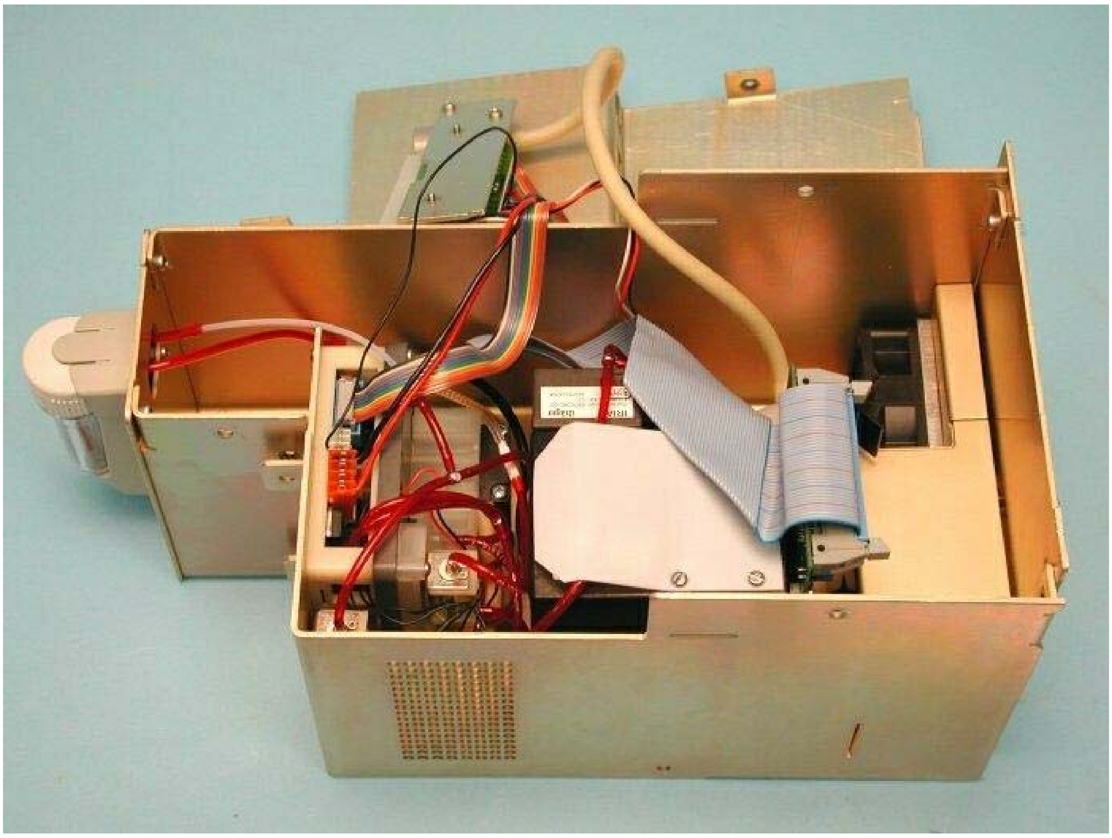
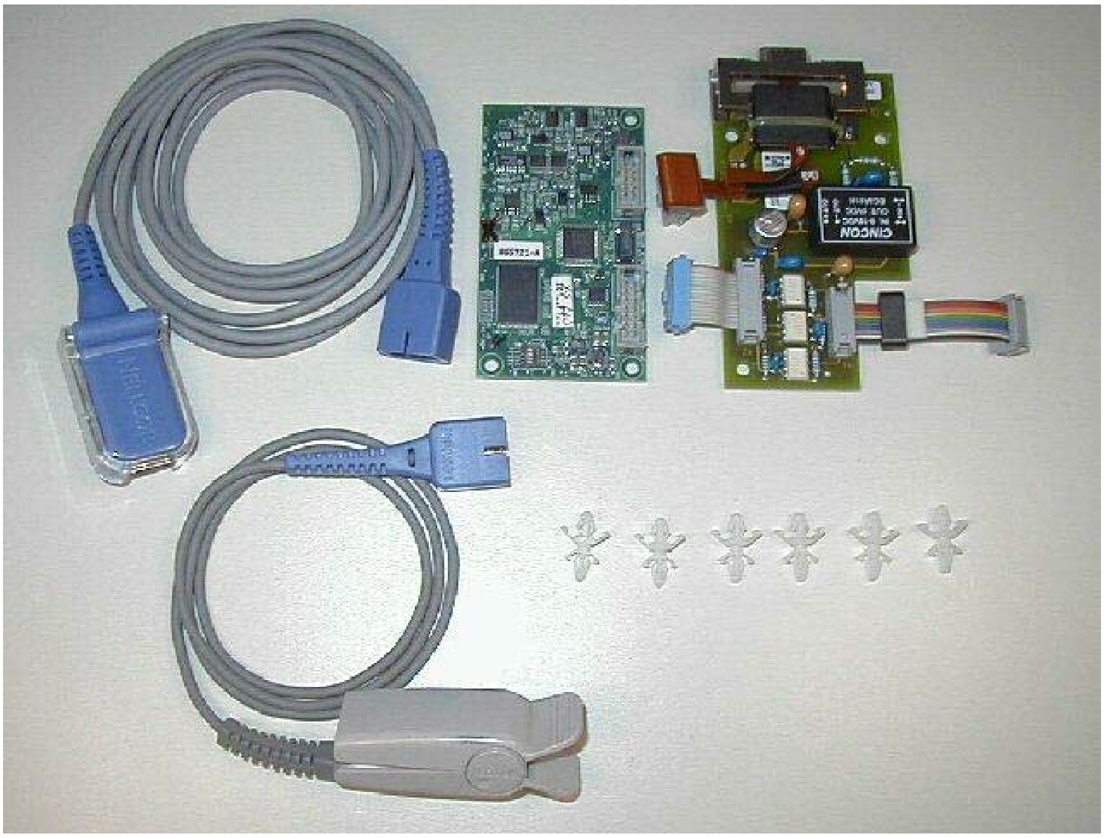


Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	6723976	SET OF 5 BACTERIA FILT.(CH102)	1.000	St	
	CH00102	BACTERIA FILTERS	1.000	St	for shut-offcash sucking off ejector

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts



Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	6850930	O2-SENSOR-S	1.000	St	



Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	8603870	Upgrade kit Spo2 Primus	1.000	St	

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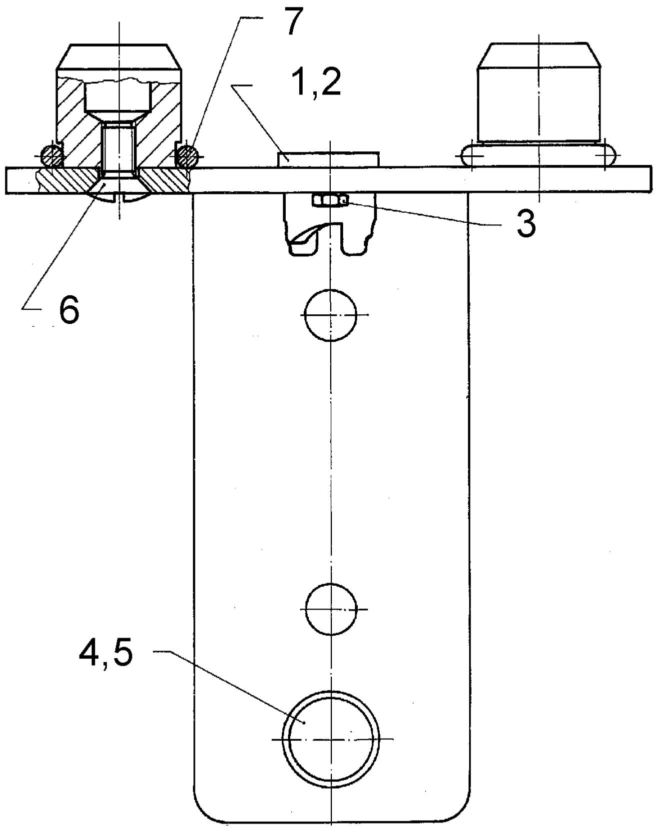


Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1-8	M25102	SUPPORT FOR PARKING POSITION	1.000	St	

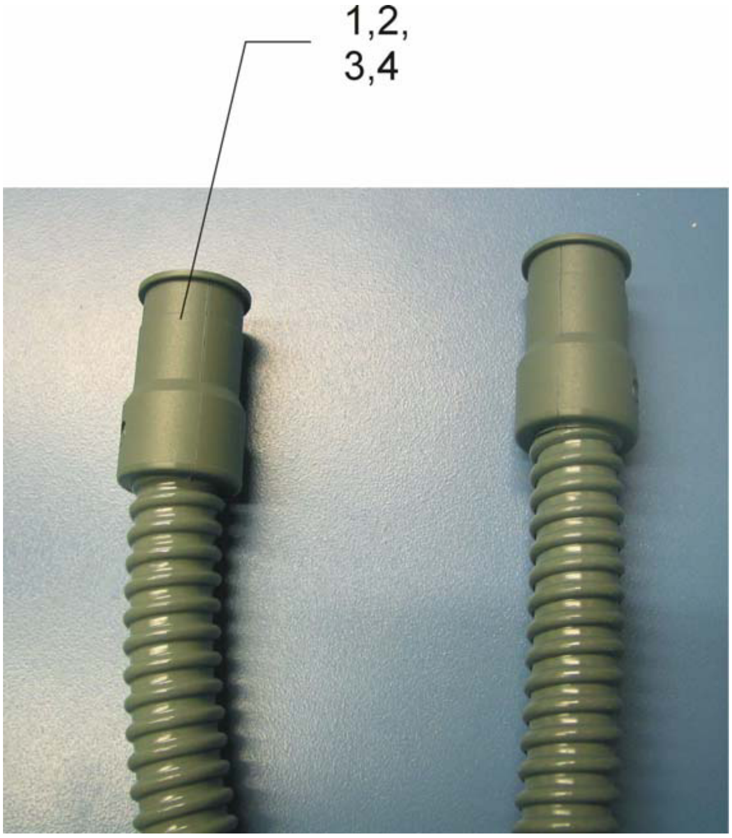
Items that are shown in the illustration but are not listed below the illustration are not available as spare parts

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	M07582	SECRETION CONTROL GLASS	1.000	St	
	2M85594	RECEPTACLE	1.000	St	
	M25780	ASPIRATION HOSE	1.000	St	
	2M85012	CYLINDER CAP WITH VALVE	1.000	St	
	1203606	HOSE 5X2SI 60SHA NF M25779	1.000	m	
	2M19063	ANGULAR PORCELAIN BUSH	1.000	St	
	M30159	ANGULAR PORCELAIN BUSH	1.000	St	
	8601179	ACCESS.SUCTION UNIT F.JULIAN	1.000	St	

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	8290286	Sample Line Set (10pcs)	10.000	St	
	M25647	NOZZLE 22/22	1.000	St	
	2166046	BREATH.HOSE 150CMLONG SLEEVE	1.000	St	
	2166038	BREATH.HOSE LONG 110CM SLEEVE	1.000	St	
	M33278	Y-PIECE ADULT,LUER LOCK	1.000	St	
	2166062	SILICON-BREATHING BAG 2,3 L	1.000	St	

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts



Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1	M35015	AGS-SCAVANGER HOSE 0,5M	1.000	St	
2	M33297	AGS-SCAVANGER HOSE 1,5M	1.000	St	
3	M33298	AGS-SCAVANGER HOSE 3M	1.000	St	
4	M33299	AGS-SCAVANGER HOSE 5M	1.000	St	

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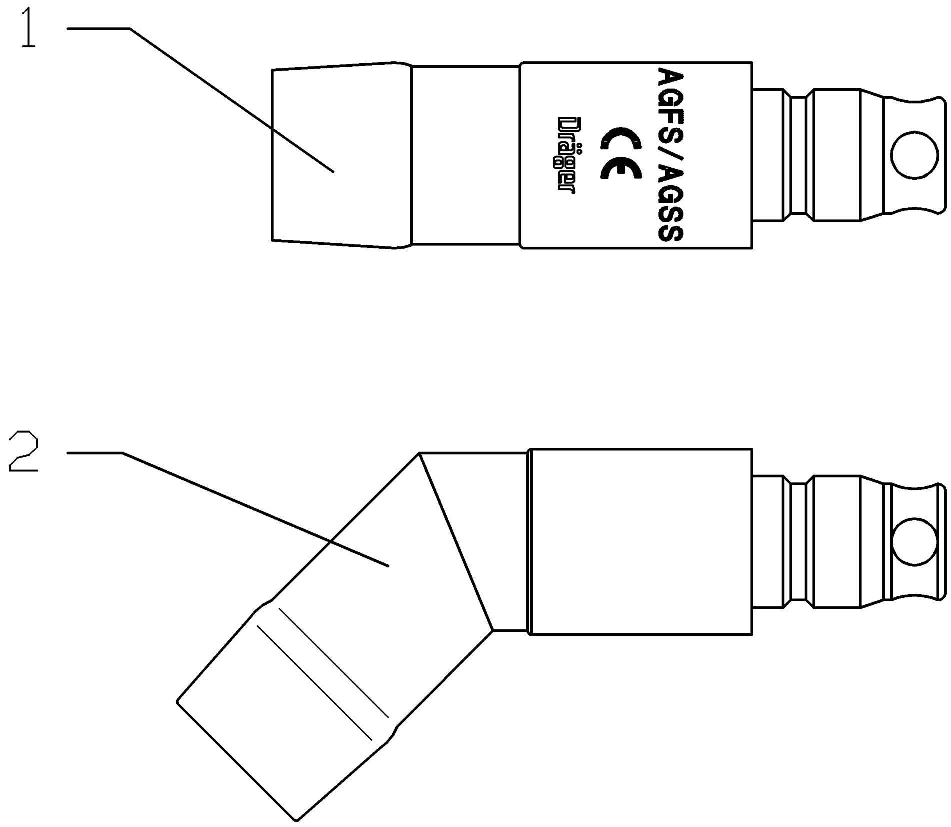
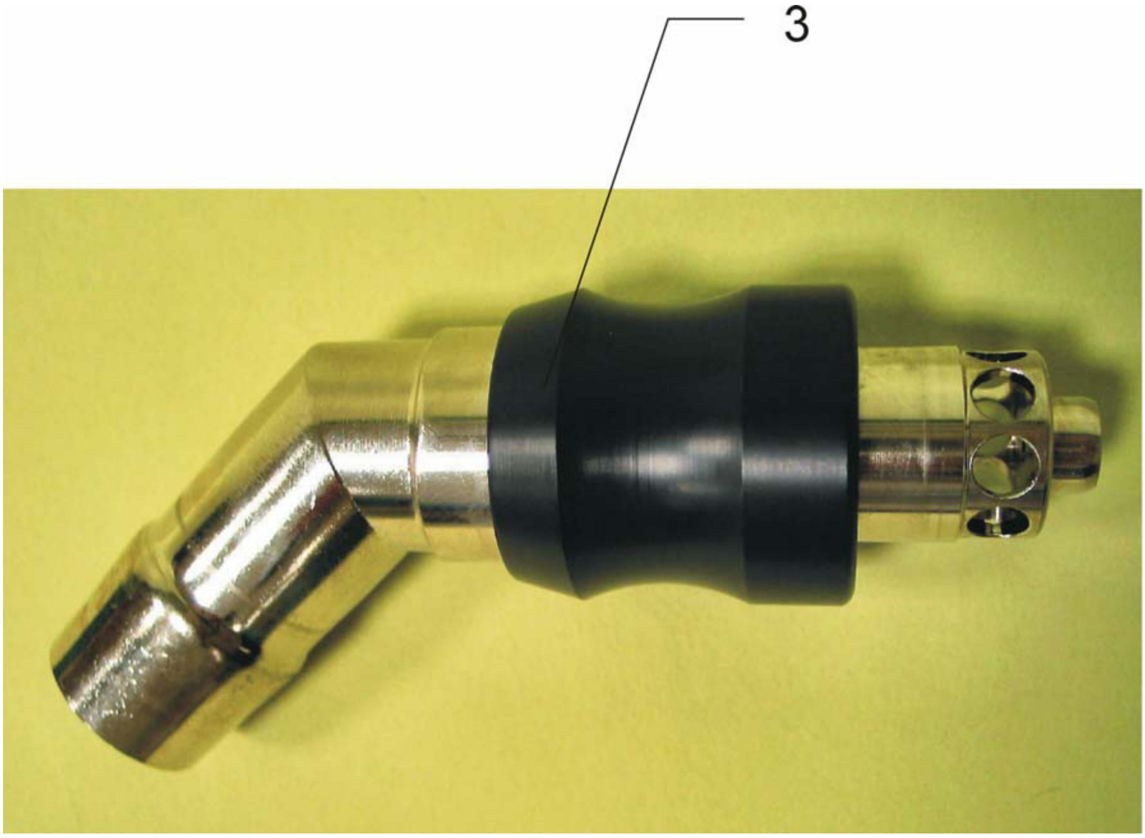


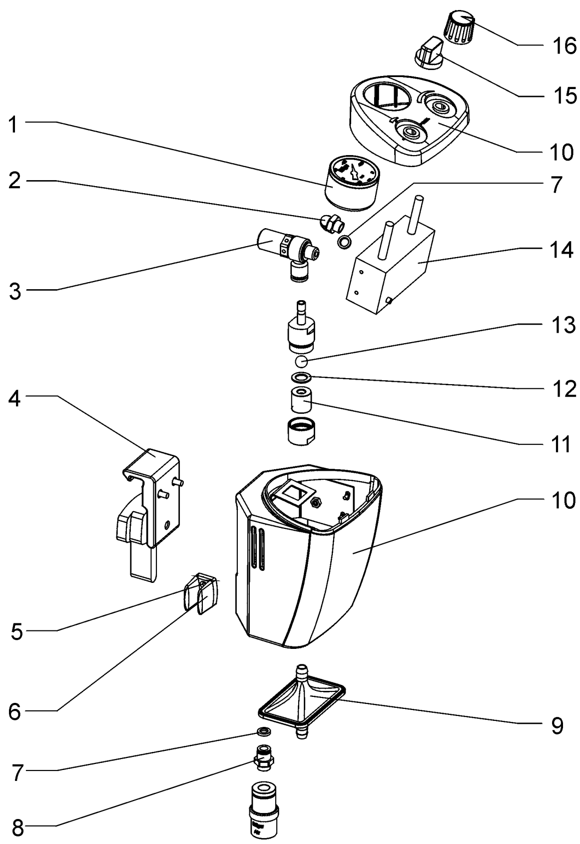
Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1	G60580	AGSS PROBE/STRAIGHT-TYPE1/ EN	1.000	St	
2	G60495	AGSS ANGLE PROBE / TYPE 1 / EN	1.000	St	

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts



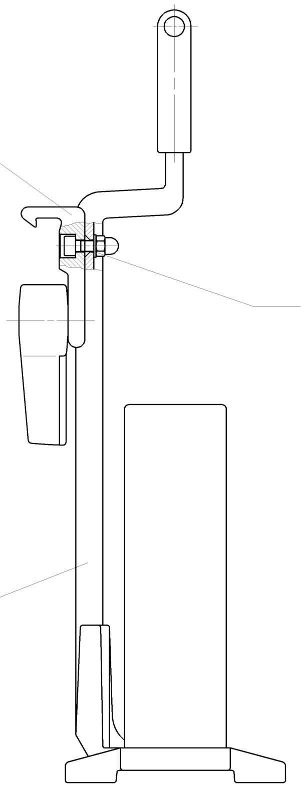
Item No.	Part No.	Description	Qty.	Qty. unit	Remark
3	G60440	ANAESTH.WASTE GAS PROBE 45	1.000	St	

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts



Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1-16	MK01420	Suction Ejector, NIST	1.000	St	
9	MK00514	FILTER	1.000	St	

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts

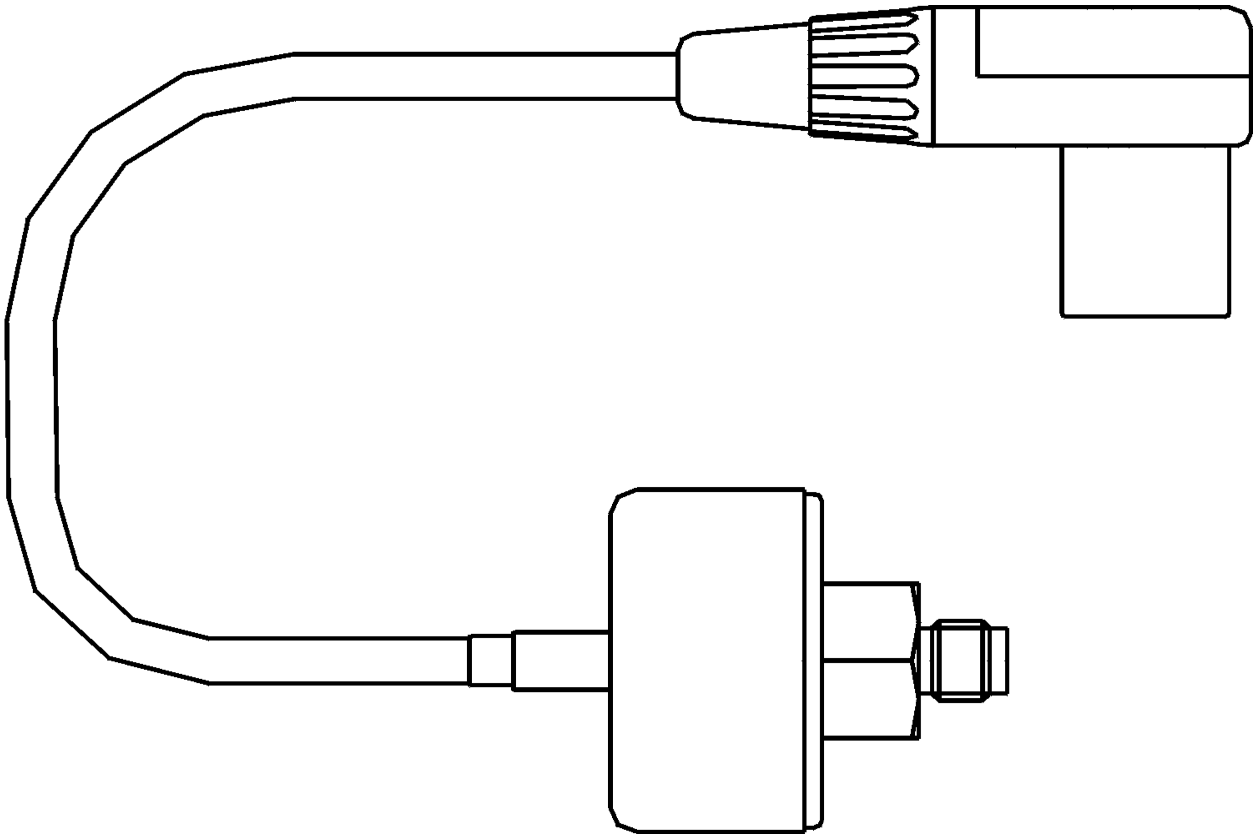


Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	2M85594	RECEPTACLE	1.000	St	
1	M25739	Lever-type clamp	1.000	St	

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	8603465	Press.Red.o2, DIN477-1,Primus	1.000	St	
	8603466	Press.Red.o2,PIN INDEX,Primus	1.000	St	
	8603706	Press.Red.o2,DIN477-1/6,Primus	1.000	St	
	8603707	Press.Red.o2,NF E29-650,Primus	1.000	St	
	8603718	Press.Red.Air,PIN IND.Primus	1.000	St	
	8603719	Press.Red.Air,DIN477-1,Primus	1.000	St	
	8603720	Press.Red.Air.NF E29-650,Prim	1.000	St	
	8603462	Press.Red.N2o,PIN IND.Primus	1.000	St	
	8603463	Press.Red.N2o,DIN477-1/11,Prim	1.000	St	
	8603464	Press.Red.N2o,DIN477-1/12,Prim	1.000	St	
	8603711	Press.Red.N2o,NF E29-650,Prim	1.000	St	

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts



Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	8603316	HIGH PRESSURE SENSOR O2	1.000	St	
	8603520	HIGH PRESSURE SENSOR AIR	1.000	St	
	8603315	HIGH PRESSURE SENSOR N2O	1.000	St	

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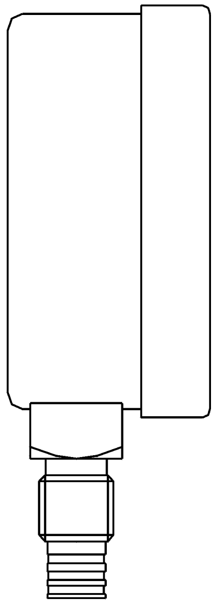

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	MX08048	PRESSURE GAUGE O2	1.000	St	
	MX08049	PRESSURE GAUGE AIR	1.000	St	
	MX08050	PRESSURE GAUGE N2O,CO2,XE	1.000	St	

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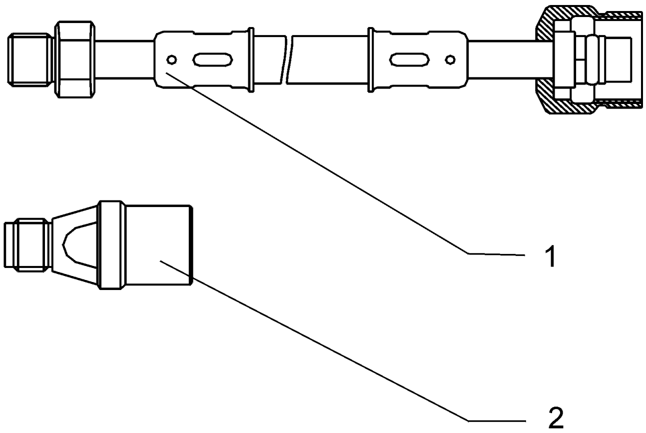

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1	MX08058	CONNECTING HOSE 1,2M AIR/DISS	1.000	St	
1	MX08056	HOSELINE NIST-NIST N2O, O,5M	1.000	St	
1	MX08055	HOSEINE NIST,O2 0,5M	1.000	St	
1	MX08057	HOSELINE NIST/AIR 0,5M	1.000	St	
2	MX08053	N2O-NIST-CONNECTION	1.000	St	
2	MX08054	AIR-NIST-CONNECTION	1.000	St	
2	MX08052	OXYGENE-NIST-CONNECTION	1.000	St	

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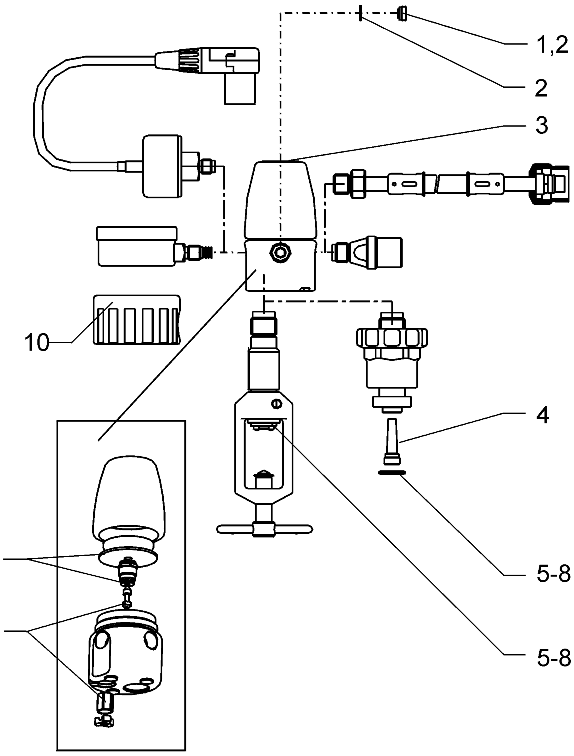

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
4	D02316	MESH BOTTOM	1.000	St	
5	MX08157	REP.SET GASKET/F (FRANKREICH)	1.000	St	
6	MX08158	REP.SET GASKET/C (USA)	1.000	St	
7	MX08159	REP.SET GASKET/B (ENGLAND)	1.000	St	
8	MX08160	REP.SET GASKET/N (NIEDERLANDE)	1.000	St	
10	MX08051	PROTECTING CAP	1.000	St	
O.A	MX08061	REP.SET GASKET	1.000	St	Contents:MX08157,MX08158,MX08159,D02316,D43929
O.A.	D20215	SET OF PACKING RINGS	1.000	St	

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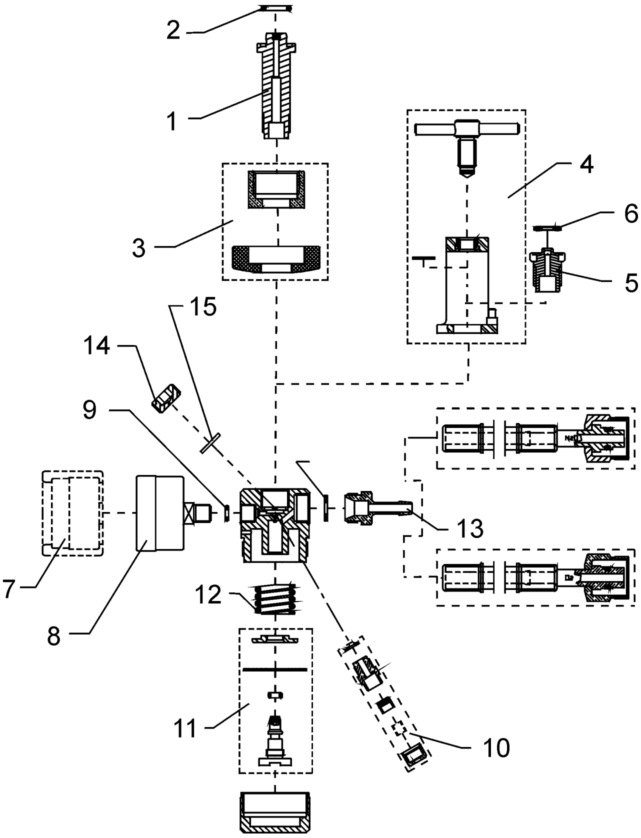

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	AF00528	HIGH PRESSURE SENSOR O2	1.000	St	
	8603704	HIGH PRESSURE SENSOR O2	1.000	St	
	AF00529	PRESS.RED.+SENSOR O2 PIN INDEX	1.000	St	
	AF00530	PRESS.RED.+SENSOR N2O PIN IND.	1.000	St	
	8603709	HIGH PRESSURE SENSOR N2O	1.000	St	
	AF00532	HIGH PRESSURE SENSOR N2O	1.000	St	
1-3,7-15	M34017	N2O-PRESSURE REDUCER G3/4I	1.000	St	
1-3,7-15	M34012	O2-PRESSURE REDUCER GB-HS	1.000	St	
1-3,7-15	M34022	N2O-PRESSURE REDUCER GI	1.000	St	
1-3,7-15	M34021	N2O-PRESSURE REDUCER GX	1.000	St	
1-3,7-15	M34014	O2-PRESSURE REDUCER GO	1.000	St	
1-3,7-15	M34020	N2O-PRESSURE REDUCER GH	1.000	St	
1-3,7-15	M34016	O2-PRESSURE REDUCER GC-HT	1.000	St	
1-3,7-15	M34013	O2-PRESSURE REDUCER GE	1.000	St	

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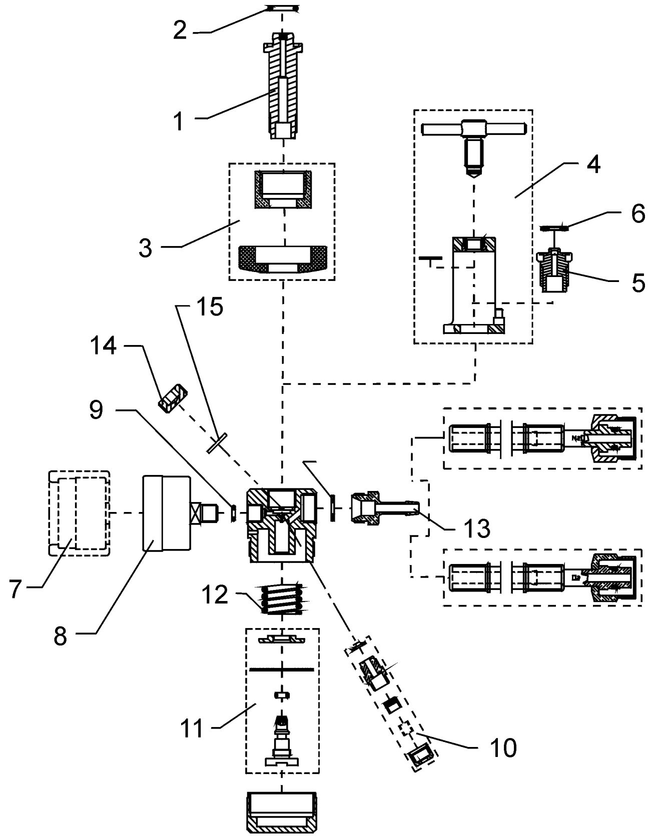

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1-3,7-15	M34009	O2-PRESSURE REDUCER GA	1.000	St	
1-3,7-15	M34007	O2-PRESSURE REDUCER G3/4	1.000	St	
1-3,7-15	M34018	N2O-PRESSURE REDUCER G3/8	1.000	St	
2	2312573	O-RING SEAL O2 GA	1.000	St	
2	2312572	O-RING SEAL O2 GERMANY	1.000	St	
2	2312571	O-RING SEAL O2 GC+GB	1.000	St	
2	2312578	O-RING SEAL N2O GH	1.000	St	
2	2312574	O-RING SEAL O2 GE	1.000	St	
2	2312579	O-RING SEAL N2O GJ	1.000	St	
2	2312577	O-RING SEAL N2O GERMANY 3/8"	1.000	St	
2	2312576	O-RING SEAL N2O GERMANY	1.000	St	
2	2312575	O-RING SEAL O2 GO	1.000	St	
3	2312586	NUT N2O GER. G 3/8"	1.000	St	
3	2312585	NUT N2O GER. G 3/4"	1.000	St	

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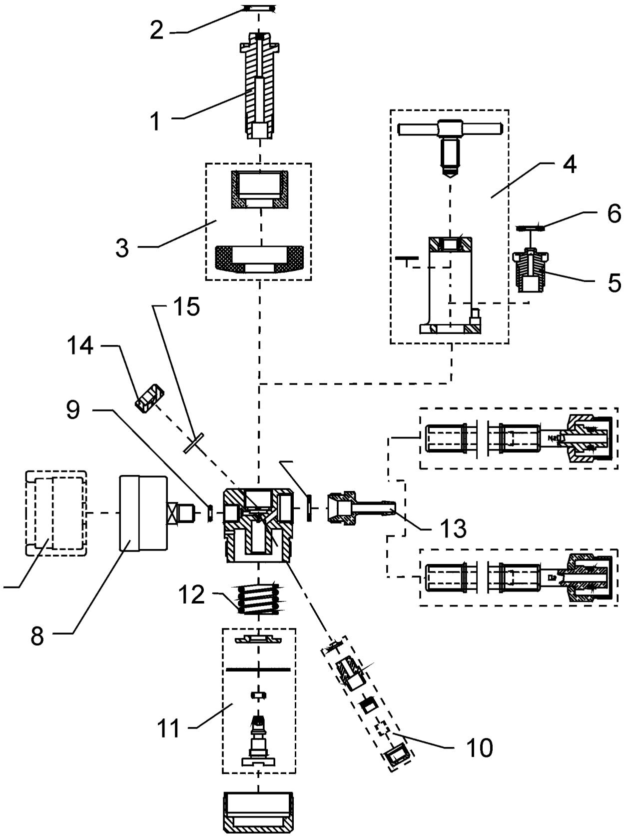

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
3	2312580	TERMINAL NUR O2 GER.	1.000	St	
4	2312591	PIN-INDEX BOW N2O	1.000	St	
4	2312590	PIN-INDEX BOW O2	1.000	St	
4-15	M34008	O2-PRESSURE REDUCER PIN INDEX	1.000	St	
4-15	M34019	N2O-PRESSURE REDUCER PIN INDEX	1.000	St	
5	2312592	PIN-INDEX CONNECTING BRANCH	1.000	St	
6	2312593	FLAT PACKING	1.000	St	
7	2312594	PRESSURE GAUGE PROTECTING CAP	1.000	St	
8	2312596	PRESSURE GAUGE N2O	1.000	St	
8	2312595	PRESSURE GAUGE O2	1.000	St	
9	2312597	PRESSURE GAUGE PACKING RING	1.000	St	
10	2312599	SAFETY VALVE N2O	1.000	St	
10	2312598	SAFETY VALVE O2	1.000	St	
11	2312600	DIAPHRAGM VALVE W.O-RING SEAL	1.000	St	

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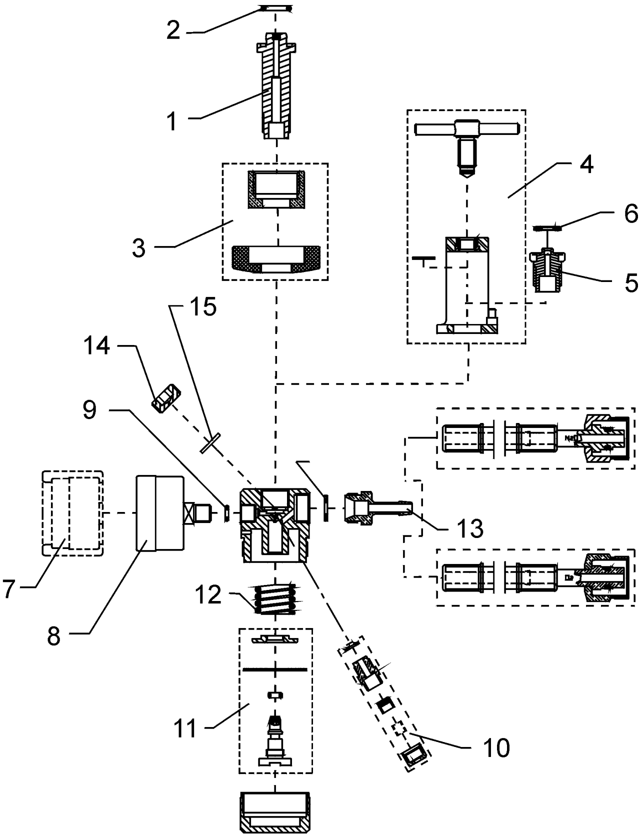

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
12	2312601	PRESSURE SPRING	1.000	St	
13	2312603	CONNECTION PIECE	1.000	St	ab 01.97/ from 01.97
13	2312602	CONNECTION PIECE	1.000	St	bis 01.97/ up to 01.97
14	2312605	LOCK M10X1	1.000	St	ab 01.97/ from 01.97
14	2312604	LOCK G 3/8"	1.000	St	bis 01.97/ up to 01.97
15	2312607	NYLON-GASKET F. THREAD M10X1	1.000	St	ab 01.97/ from 01.97
15	2312606	NYLON-GASKET 3/8"	1.000	St	bis 01.97/ up to 01.97

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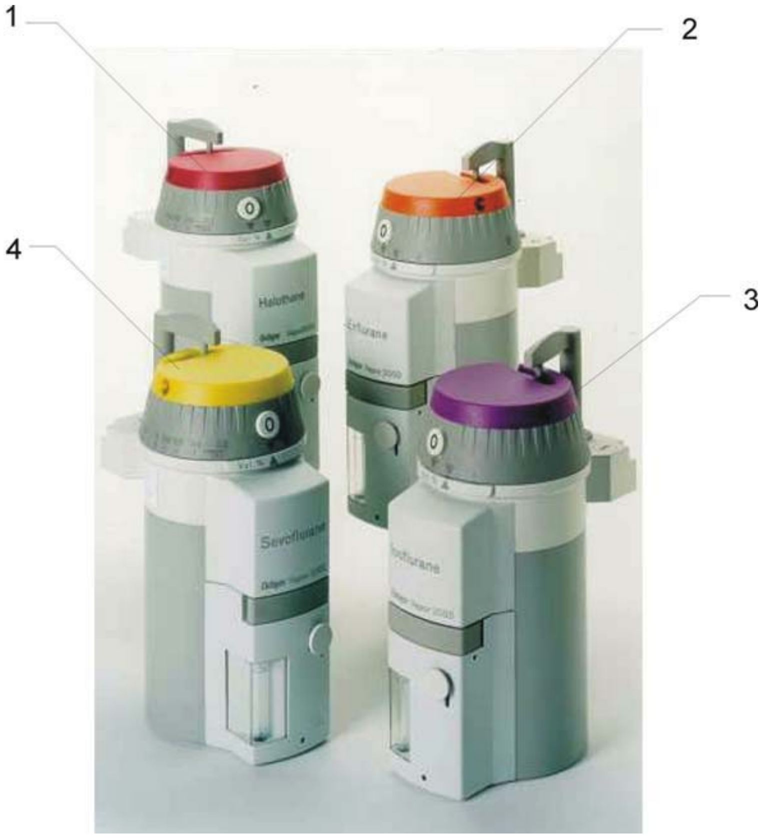

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1	M35140	Vapor 2000 Halothane	1.000	St	
2	M35150	Vapor 2000 Enflurane	1.000	St	
3	M35160	Vapor 2000 Isoflurane	1.000	St	
4	M35170	Vapor 2000 Sevoflurane	1.000	St	

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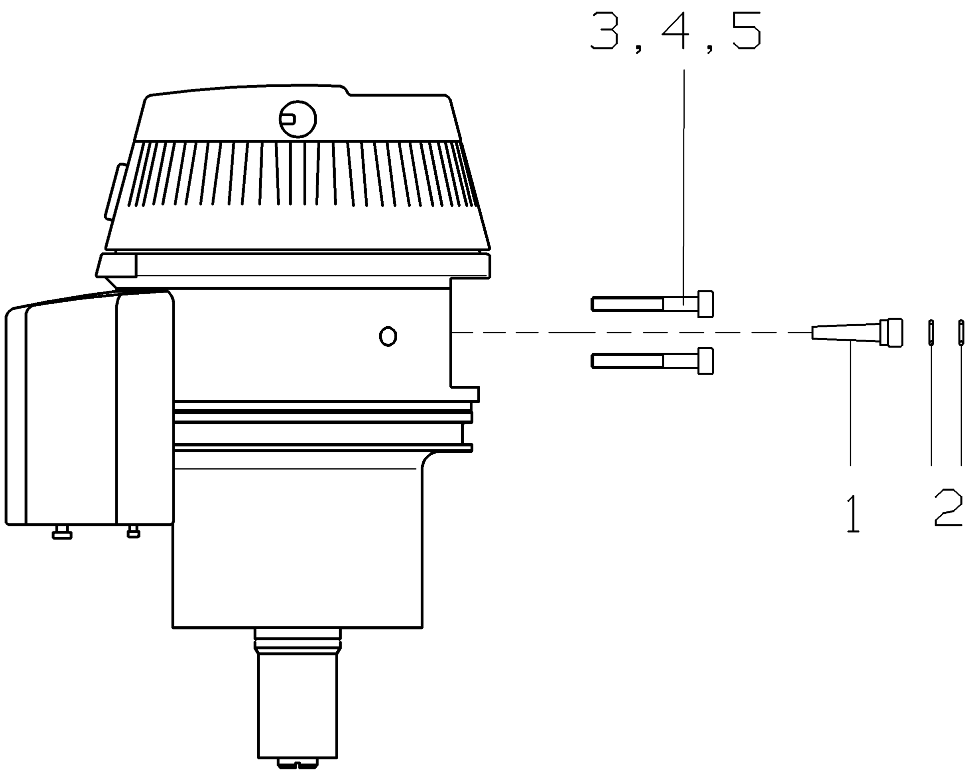

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1	D18440	MESH BOTTOM	1.000	St	
1-3	MX08235	2-year Vapor kit	1.000	St	
2	M21929	O-RING SEAL	2.000	St	
3	1343866	SCREW M 4X12	2.000	St	tightening 270-300Ncm
4	1343904	CHEESE HEAD SCREW M4x30 DIN912	2.000	St	tightening 270-300Ncm
5	1343947	SCREW M 4X25	2.000	St	tightening 270-300Ncm

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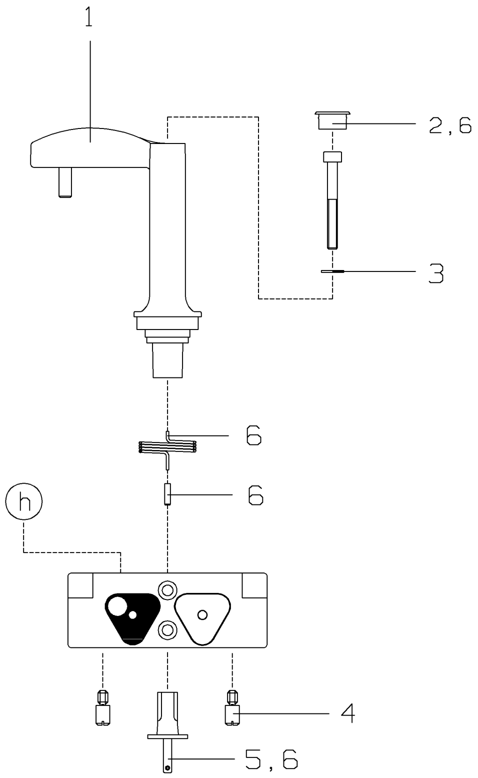

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	1343866	SCREW M 4X12	2.000	St	tightening 270 - 300Ncm
1	M34676	HANDLE (PLUG-IN SYSTEM DW)	1.000	St	
1-6	M34725	Plug-in adapter DW-2000 H	1.000	St	
2	M34677	CAP FOR HANDLE	1.000	St	
3	1327542	WASHER A 4,3 DIN 125-A4	1.000	St	
5	M34662	BOLT	1.000	St	

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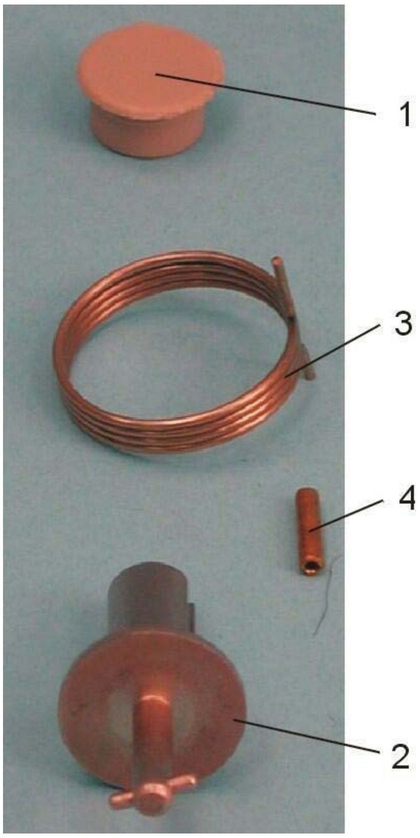

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1-4	M34907	REP.SET PLUG-IN SYSTEM	1.000	St	

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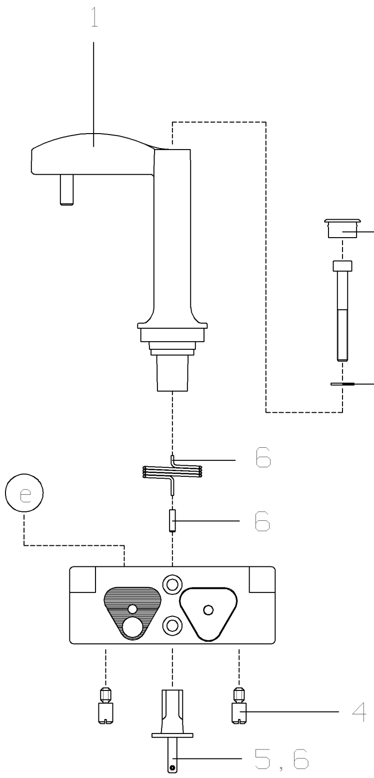

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	1343866	SCREW M 4X12	2.000	St	tightening 270 - 300Ncm
1	M34676	HANDLE (PLUG-IN SYSTEM DW)	1.000	St	
1-6	M34726	Plug-in adapter DW-2000 E	1.000	St	
2	M34677	CAP FOR HANDLE	1.000	St	
3	1327542	WASHER A 4,3 DIN 125-A4	1.000	St	
5	M34662	BOLT	1.000	St	

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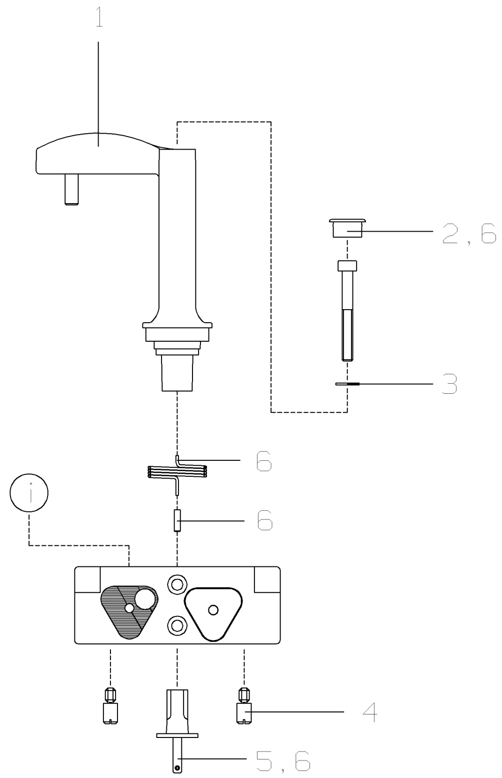

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	1343866	SCREW M 4X12	2.000	St	tightening 270 - 300 Ncm
1	M34676	HANDLE (PLUG-IN SYSTEM DW)	1.000	St	
1-6	M34727	Plug-in adapter DW-2000 I	1.000	St	
2	M34677	CAP FOR HANDLE	1.000	St	
3	1327542	WASHER A 4,3 DIN 125-A4	1.000	St	
5	M34662	BOLT	1.000	St	

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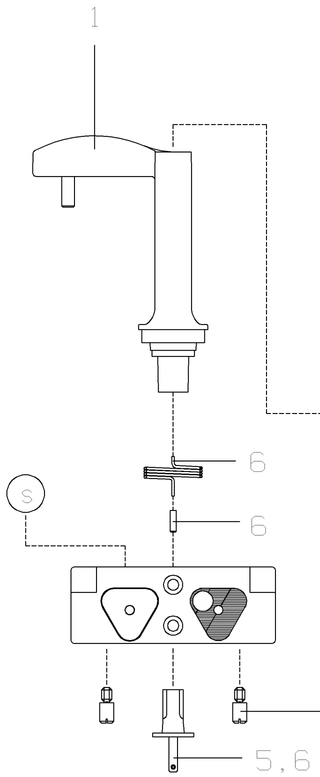

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	1343866	SCREW M 4X12	2.000	St	tightening 270 - 300Ncm
1	M34676	HANDLE (PLUG-IN SYSTEM DW)	1.000	St	
1-6	M34728	Plug-in adapter DW-2000 S	1.000	St	
2	M34677	CAP FOR HANDLE	1.000	St	
3	1327542	WASHER A 4,3 DIN 125-A4	1.000	St	
5	M34662	BOLT	1.000	St	

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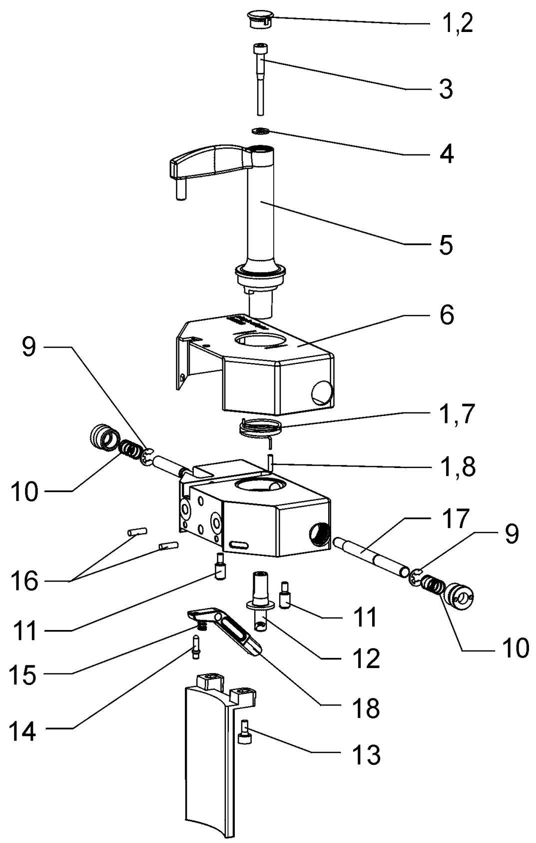

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	1343866	SCREW M 4X12	2.000	St	tightening 270-300Ncm
1-18	M34821	Plug-in adapter S-2000	1.000	St	
2	M34677	CAP FOR HANDLE	1.000	St	
4	1327542	WASHER A 4,3 DIN 125-A4	1.000	St	
5	M34758	Hand lever	1.000	St	
12	M34817	BOLT	1.000	St	

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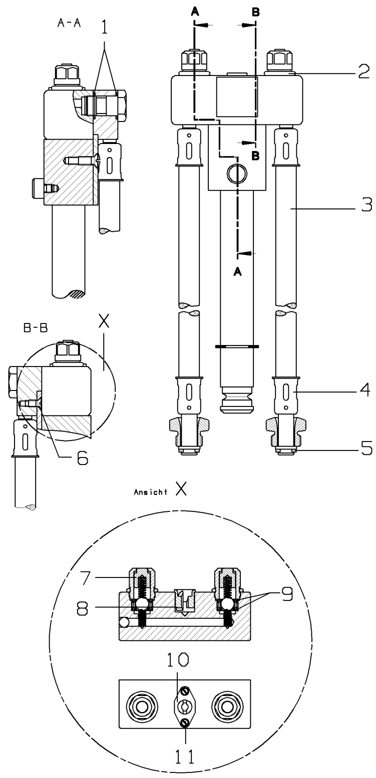

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1	D18400	O-RING SEAL	4.000	St	
1-11	M26588	VAPOR PLUG-IN SYSTEM W.PIVOT	1.000	St	
2	U04314	O-RING SEAL	2.000	St	
5	M05128	PACKING RING	2.000	St	
6	1329324	AM4X8 DIN 963-A4/051	2.000	St	
10	M28935	FIXING CAM	1.000	St	
11	1334514	SCREW AM2X4 DIN 963-A4	2.000	St	secured with Loctite 221 and tightening 27-30Ncm

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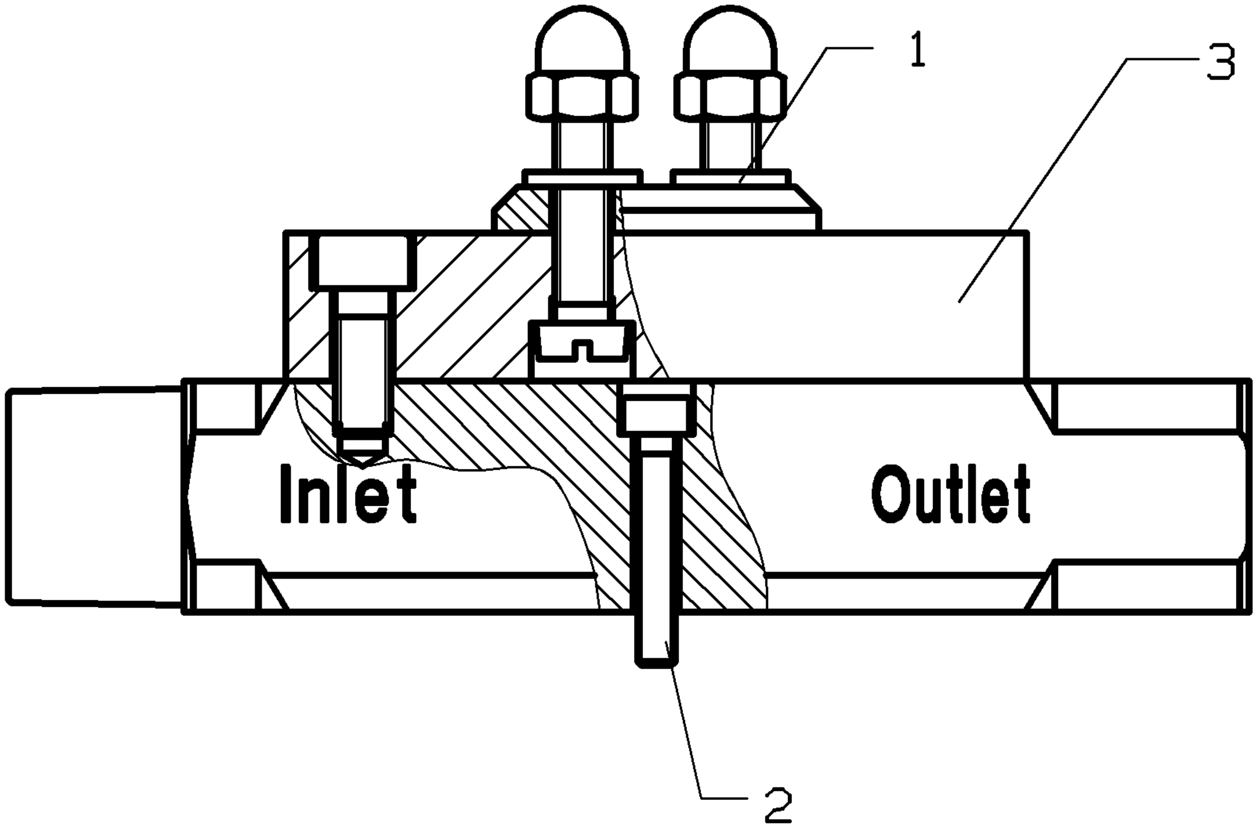

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1	1330705	WASHER B 6,4 DIN 125-A4	2.000	St	
2	1343947	SCREW M 4X25	2.000	St	tightening 270-300Ncm
3	M35059	CAGEMOUNT	1.000	St	

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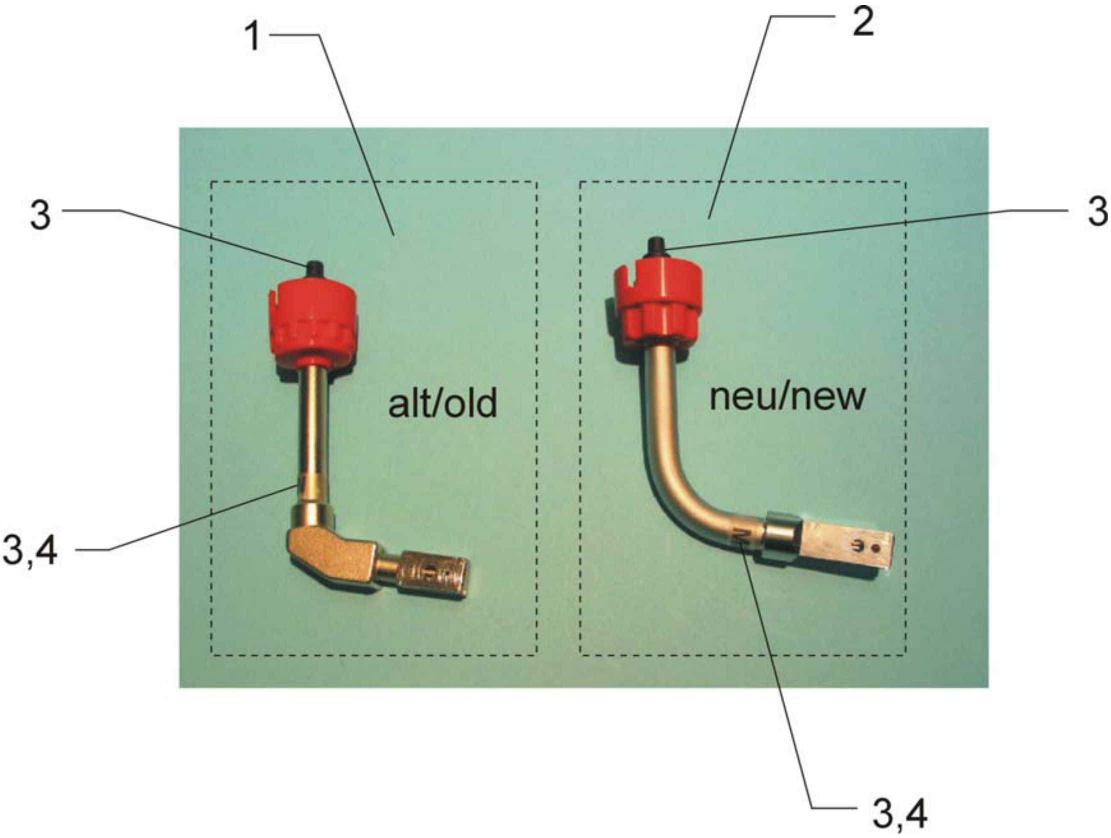

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	9028953	MA check valve filling adapter	1.000	St	
1	M30288	Keyed filler adapter H	1.000	St	old version
2	M35320	Keyed Filling Adapter H	1.000	St	new version
3	M34614	MODIF.KIT BALL VALVE	1.000	St	
4	M35209	MRI Label	1.000	St	

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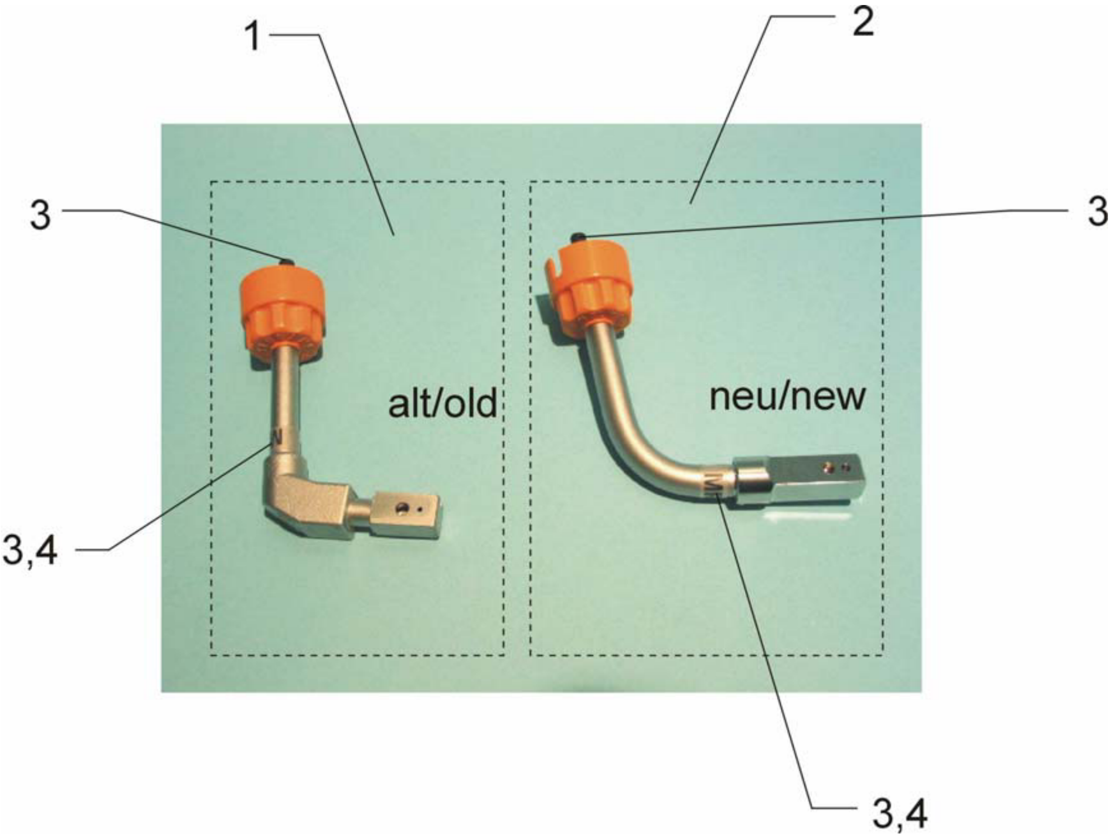

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	9028953	MA check valve filling adapter	1.000	St	
1	M30289	Keyed filler adapter E	1.000	St	old version
2	M35321	Keyed Filling Adapter E	1.000	St	new version
3	M34614	MODIF.KIT BALL VALVE	1.000	St	
4	M35209	MRI Label	1.000	St	

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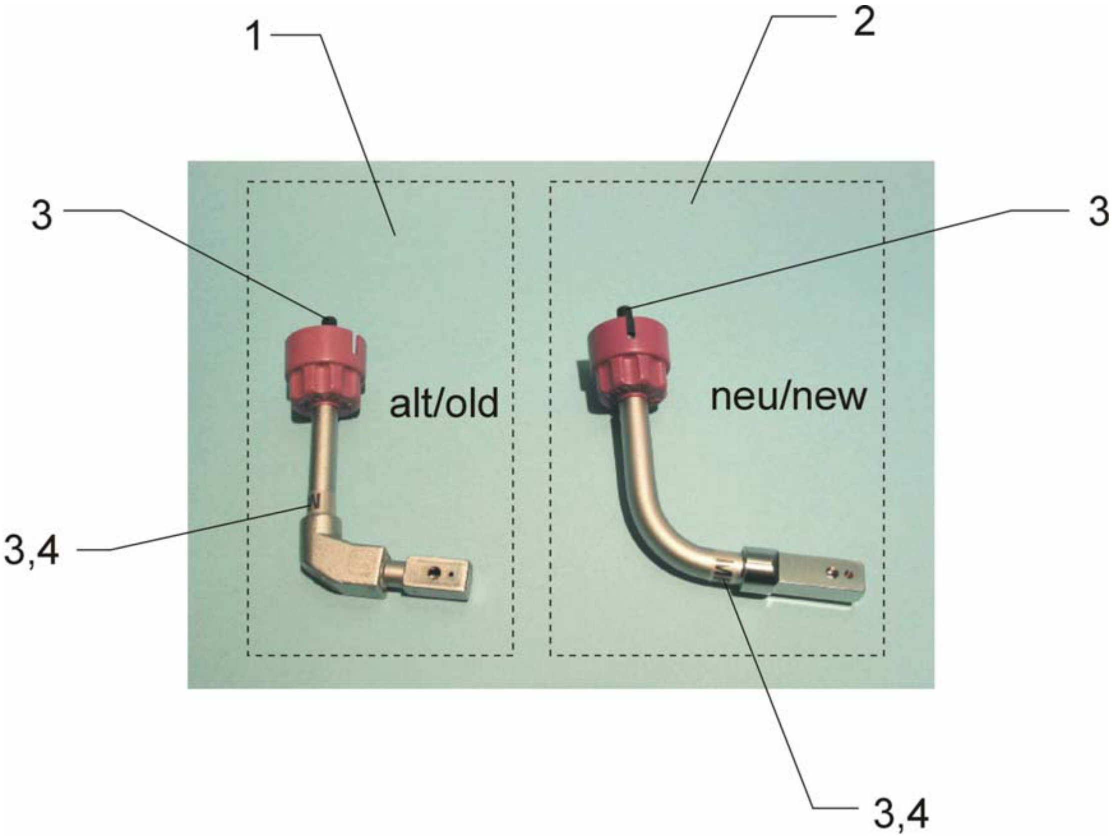

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	9028953	MA check valve filling adapter	1.000	St	
1	M30290	Keyed filler adapter I	1.000	St	old version
2	M35323	Keyed Filling Adapter I	1.000	St	new version
3	M34614	MODIF.KIT BALL VALVE	1.000	St	
4	M35209	MRI Label	1.000	St	

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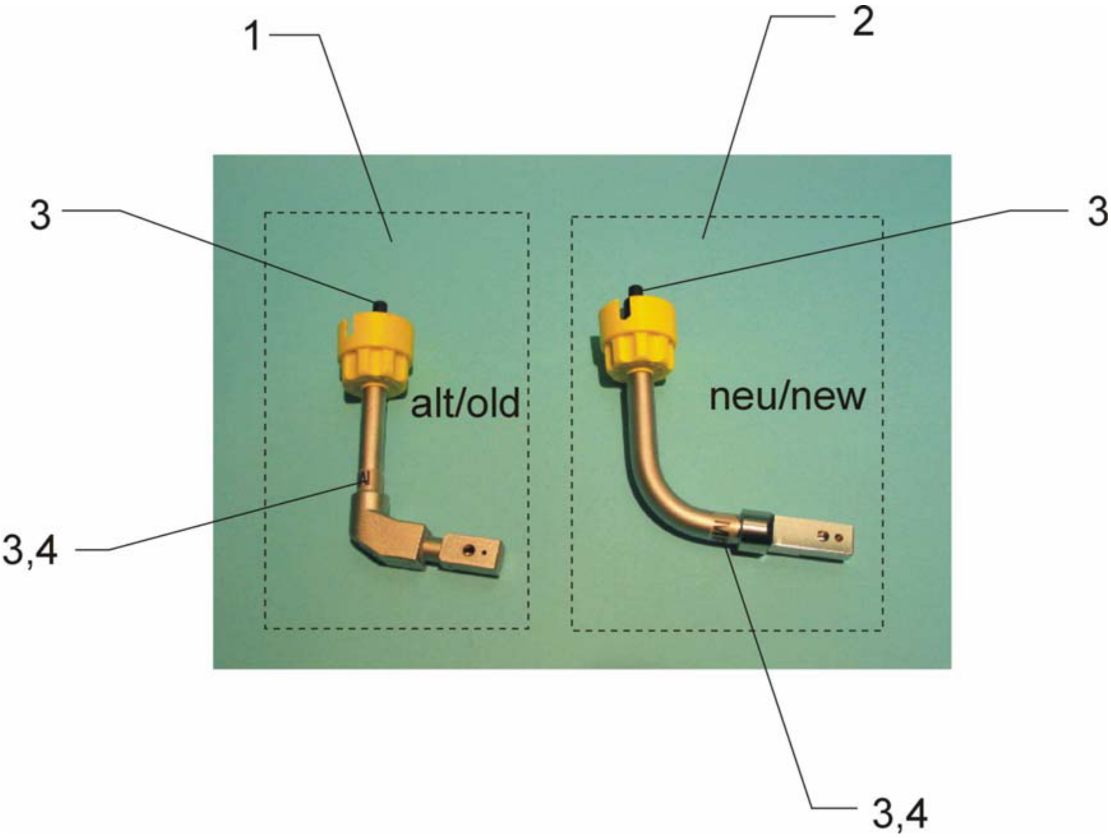

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	9028953	MA check valve filling adapter	1.000	St	
1	M31930	Keyed filler adapter S	1.000	St	old version
2	M35322	Keyed Filling Adapter S	1.000	St	new version
3	M34614	MODIF.KIT BALL VALVE	1.000	St	
4	M35209	MRI Label	1.000	St	

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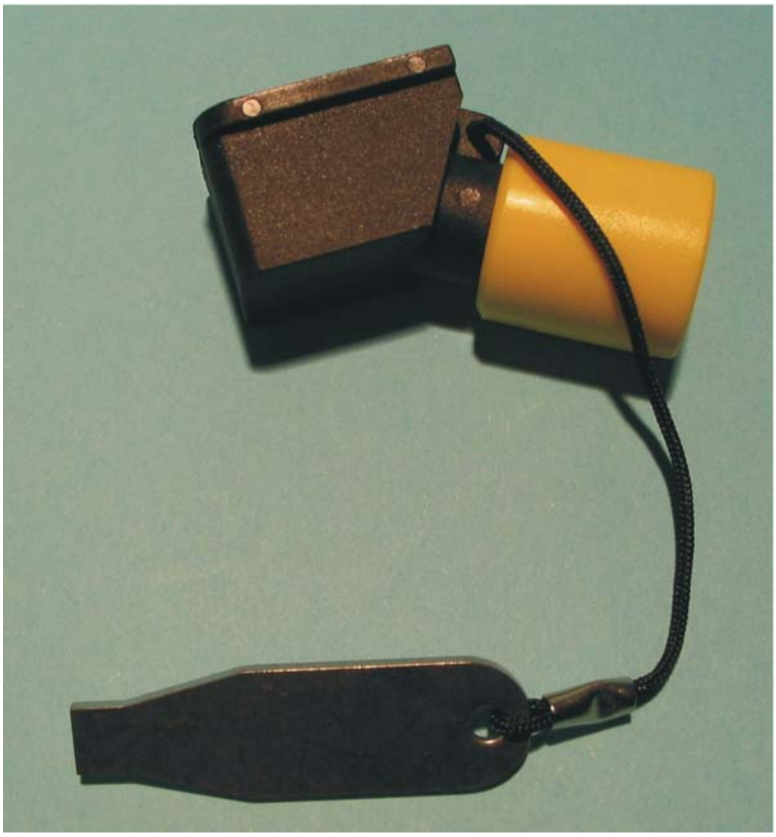

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	M34206	QUIK FIL DRAIN ADAPTER	1.000	St	

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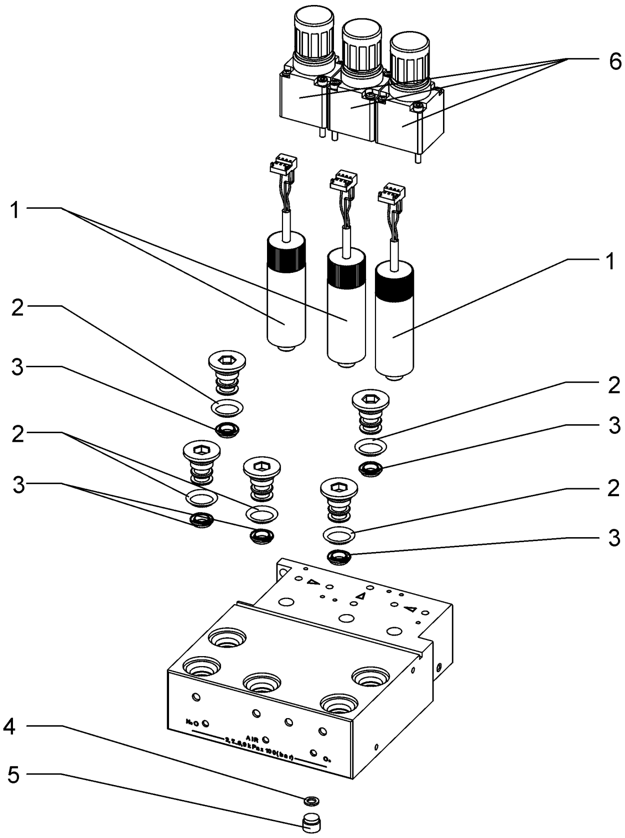

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
1	8602767	PRESSURE SENSOR	1.000	St	
2	M19241	TOROIDAL SEALING RING	1.000	St	
3	AF00220	CUFF	1.000	St	
4	D04873	COPPER RING	1.000	St	
5	D18348	SCREW PLUG	1.000	St	
6	8413666	Pressure regulator	1.000	St	

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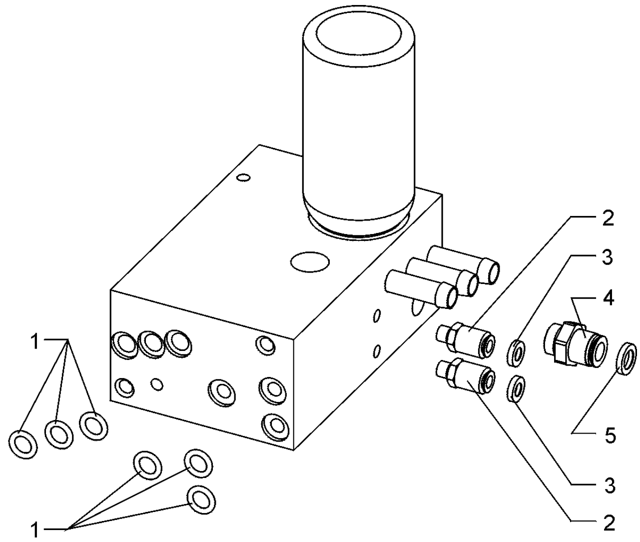

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
	M31348	PLUG 04	1.000	St	
	M30954	L PLUG-TYPE CONNECTION	1.000	St	
	M30963	THRUST COLLAR 4, BLACK	1.000	St	
1	R50117	O-RING SEAL	6.000	St	
2	M30952	PLUG-TYPE CONNECTION	2.000	St	
3	M31602	THRUST COLLAR 4, WHITE	2.000	St	
4	M30960	PLUG-TYPE CONNECTION	1.000	St	
5	M31601	THRUST COLLAR 6 BLACK	1.000	St	

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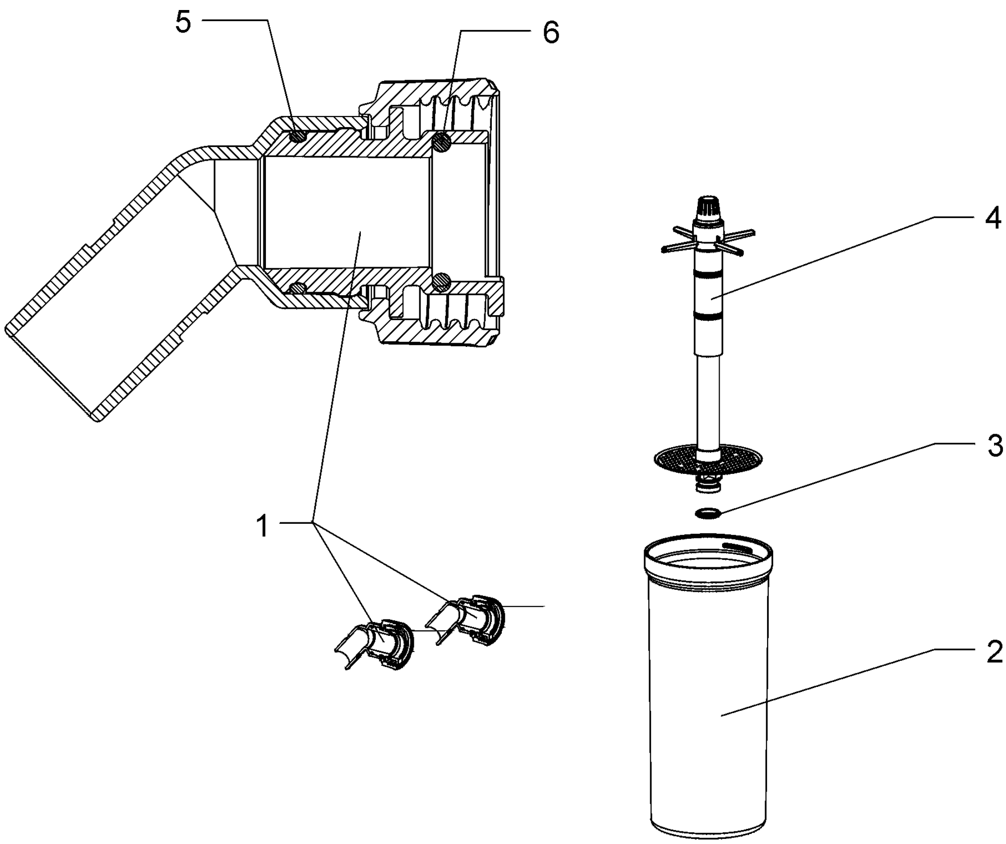

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
2	M33719	ABSORBER POT	1.000	St	
3	M33728	PACKING RING	1.000	St	
4	M33720	ABSORBER INSERT, CPL.	1.000	St	

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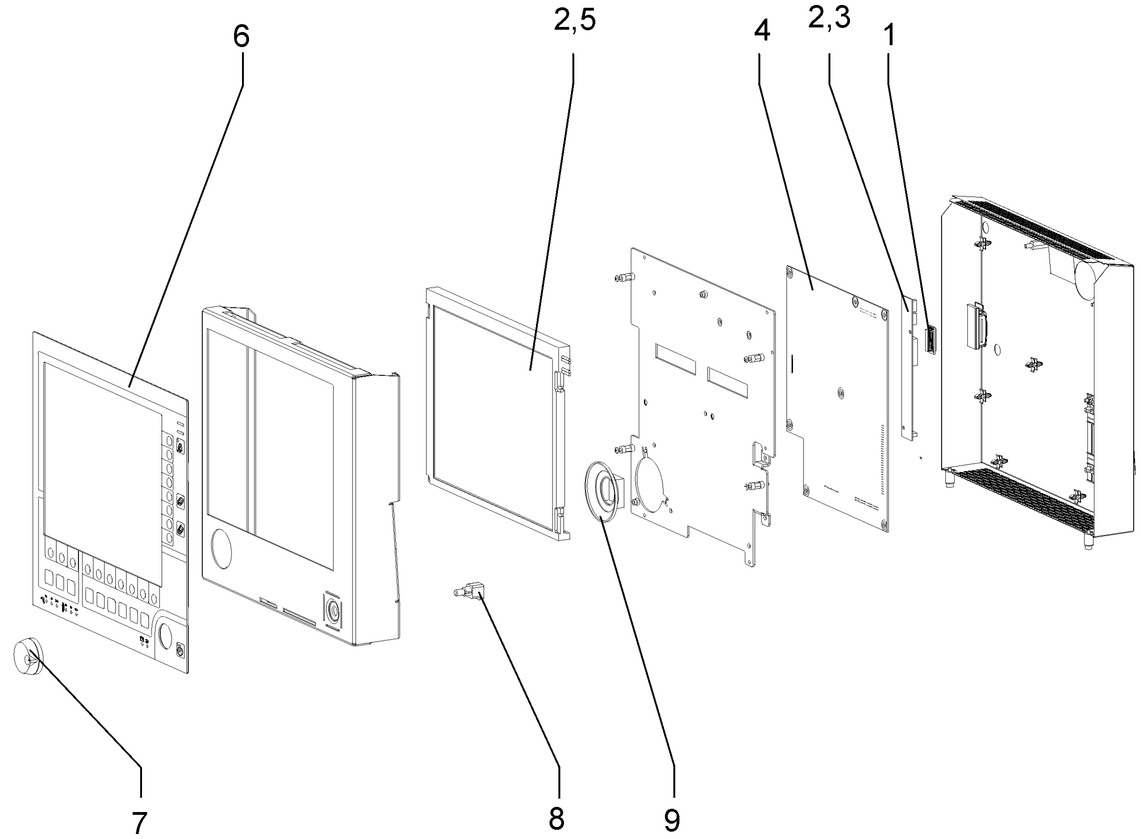

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
2	8603235	DISPLAY	1.000	St	

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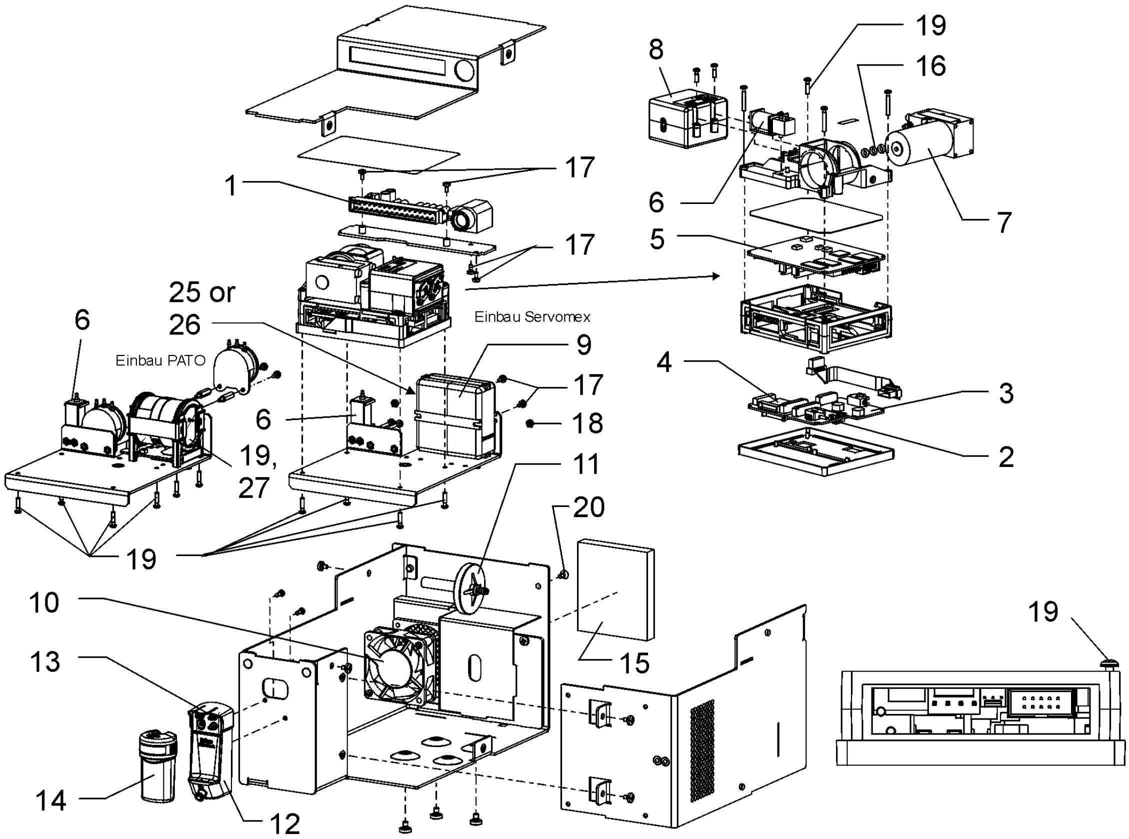

Item No.	Part No.	Description	Qty.	Qty. unit	Remark
14	6870567	WATERTRAPS SET OF 12	1.000	St	besteht aus 12x 6870530

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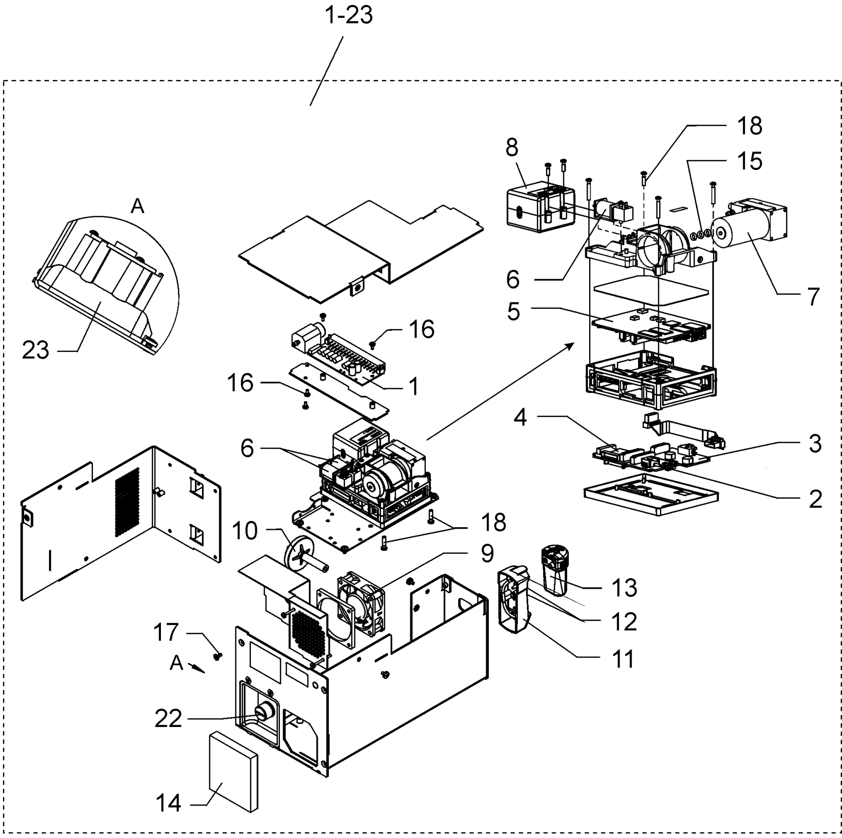


Item No.	Part No.	Description	Qty.	Qty. unit	Remark
13	6870567	WATERTRAPS SET OF 12	1.000	St	12 x 6870511

Items that are shown in the illustration but are not listed below the illustration are not available as spare parts

Assembly	Description	Part No.

Absorber and Sleeves

ABSORBER INSERT, CPL.	M33720
ABSORBER POT	M33719
PACKING RING	M33728

Accessories

GA Endotracheale Bronchusabsau	9037477
GA WaterLock me	9029423

Accessories Anaesthesia

ANAEST.-SET KUHN TYPE K	M34823
ANAEST.-SET KUHNTYPE E	M34822
ANAESTHETIC-MASK SZ,3	2165759
ANAESTHETIC-MASK SZ.1	2165732
ANAESTHETIC-MASK SZ.2	2165740
Connection nozzle O2 6mm	M06258
O2 flowmeter 16L, rail, Nist	2M86248
O2 flowmeter 16L,rail,90g,Nist	2M86249

Accessories Jar Set

FILTER	MK00514

Accessories Julian

BREATH.HOSE 150CMLONG SLEEVE	2166046
BREATH.HOSE LONG 110CM SLEEVE	2166038
NOZZLE 22/22	M25647
Sample Line Set (10pcs)	8290286
SILICON-BREATHING BAG 2,3 L	2166062
Y-PIECE ADULT,LUER LOCK	M33278

Accessories Pedeatrics

90 -LUERLOCK FOR NEONATES	M34568
Breathing bag 0,5L ISO	2165686
BREATHING HOSE K 22/10 1,5M	2165961
BREATHING HOSE K 22/22 1,1M	2165678
CONNECTION PIECE	2M12754
CORRUGATED BELLOWS K	8410079
HOSE 4X1,5-SI 50 SH A NF	1190520
HOSESET CIRCLESYSTEM CHILDREN	M27542
NOZZLE 22/22	M25647
PEDIATRIC ACCESSORY	M33681
SET CAPS	8402953
Y-PIECE 90DEGREE	8403075

Assembly	Description	Part No.

Accessories Suction

	ACCESS.SUCTION UNIT F.JULIAN	8601179
	ANGULAR PORCELAIN BUSH	2M19063
	ANGULAR PORCELAIN BUSH	M30159
	ASPIRATION HOSE	M25780
	CYLINDER CAP WITH VALVE	2M85012
	HOSE 5X2SI 60SHA NF M25779	1203606
	RECEPTACLE	2M85594
	SECRETION CONTROL GLASS	M07582

AGS system

	FILTER	M33294

AGS system Canada

	FILTER	M33294

AGS-System

	AGS CONTAINER	M33292
	AGS-SYSTEM, BASIC UNIT	M33300
	FILTER	M33294
	Label Vacuum Suction	8605459

AIR

	AIR CONNECTING HOSE 3M (BLACK)	M29241
	AIR CONNETING HOSE 1,5M(BLACK)	M29281
	AIR-CONNECTING HOSE 1,5M	M29279
	AIR-CONNECTING HOSE 5M	M29259
	AIR-CONNECTING HOSE 5M (BLACK)	M29261
	AIR-HOSE NIST 1,5M DIN PROBE	M34407
	AIR-HOSE NIST 3M DIN PROBE	M34408
	AIR-HOSE NIST 5M DIN PROBE	M34409
	AIR-ZV-HOSE 1,5M NIST EN-COLOR	8602519
	AIR-ZV-HOSE 3M NIST EN-COLOR	8602520
	AIR-ZV-HOSE 5M NIST EN-COLOR	8602521

Assembly	Description	Part No.
AIR/O2		
	02/AIR-CONNECTING HOSE 3M	M29243
	AIR/O2-ZV-HOSE 1,5M NIST EN-C.	8602525
	AIR/O2-ZV-HOSE 3M NIST EN-COL.	8602526
	AIR/O2-ZV-HOSE 5M NIST EN-COL.	8602527
	O2/AIR-HOSE NIST 1,5MDIN PROBE	M34410
	O2/AIR-HOSE NIST 3M DIN PROBE	M34411
	O2/AIR-HOSE NIST 5M DIN PROBE	M34412
	O2-AIR CONNECT.HOSE 3M(BLACK)	M29245
	O2-AIR CONNECT.HOSE 5M (BLACK)	M29265
	O2-AIR CONNECTING HOSE 1,5M	M29283
	O2-AIR CONNECTING HOSE 5M	M29263
	O2-AIR-CONNECT.HOSE 1,5(BLACK)	M29285
Anaesthesia Acc. Kuhn		
	ANAEST.-SET KUHN TYPE K	M34823
	ANAESTHETIC-GAS SCAV.(KUHN)	M25838
	COUPLING SLEEVE	M13506
Basic Unit		
	AGS-SYSTEM, BASIC UNIT	M33300
Cagemount		
	CAGEMOUNT	M35059
	SCREW M 4X25	1343947
	WASHER B 6,4 DIN 125-A4	1330705
Central Air distributor		
	AIR-DISTRIBUTOR 1,5M	M28963
	AIR-DISTRIBUTOR 1,5M (BLACK)	M29866
	AIR-DISTRIBUTOR 1,5M DIN PROBE	M34561
	AIR-DISTRIBUTOR 3M	M30709
	AIR-DISTRIBUTOR 3M (BLACK)	M30711
	AIR-DISTRIBUTOR 3M DIN-PROBE	M34562
	AIR-DISTRIBUTOR 5M	M30710
	AIR-DISTRIBUTOR 5M (BLACK)	M30712
	AIR-DISTRIBUTOR 5M DIN-PROBE	M34563
	AIR-ZV-DISTRIB.1,5M NIST EN-C.	8602531
	AIR-ZV-DISTRIB.3M NIST EN-COL.	8602532
	AIR-ZV-DISTRIB.5M NIST EN-COL.	8602533

Assembly	Description	Part No.
Central O2 distributor		
	DIAPHRAGM SEPARATION	M34492
	O2-DISTR.1,5M DIN-ST.NIST-FN	M34941
	O2-HOSE NIST 5M DIN PROBE	M34403
	O2-ZV-DISTRIB.1,5M DIN BLUE	8602534
	O2-ZV-DISTRIB.1,5M NIST EN-C.	8602528
	O2-ZV-DISTRIB.3M DIN BLUE	8602535
	O2-ZV-DISTRIB.3M NIST EN-COLOR	8602529
	O2-ZV-DISTRIB.5M DIN BLUE	8602536
	O2-ZV-DISTRIB.5M NIST EN-COLOR	8602530
Clutch adapter		
	Adapter AIR DIN/DIN-coupling	M28031
	Adapter AIR NIST/DIN-coupling	M35058
	Adapter N2O DIN/DIN-coupling	M23875
	Adapter N2O NIST/DIN-coupling	M35057
	Adapter O2 NIST/DIN-coupling	M35056
	O2-COUPLING HOSE 0,15M	M23874
Connecting block		
	L PLUG-TYPE CONNECTION	M30954
	O-RING SEAL	R50117
	PLUG 04	M31348
	PLUG-TYPE CONNECTION	M30960
	PLUG-TYPE CONNECTION	M30952
	THRUST COLLAR 4, WHITE	M31602
	THRUST COLLAR 4, BLACK	M30963
	THRUST COLLAR 6 BLACK	M31601
Connectors and Hoses		
	AIR-NIST-CONNECTION	MX08054
	CONNECTING HOSE 1,2M AIR/DISS	MX08058
	HOSEINE NIST,O2 0,5M	MX08055
	HOSELINE NIST/AIR 0,5M	MX08057
	HOSELINE NIST-NIST N2O, O,5M	MX08056
	N2O-NIST-CONNECTION	MX08053
	OXYGENE-NIST-CONNECTION	MX08052
Draeger Sorb		
	Draegersorb FREE (5L)	MX50050
Ejector type aspirat. NIST Air		
	FILTER	MK00514
	Suction Ejector, NIST	MK01420

Ejector type aspirator

BACTERIA FILTERS	CH00102
SET OF 5 BACTERIA FILT.(CH102)	6723976

Filling Adapters

Keyed filler adapter E	M30289
Keyed filler adapter H	M30288
Keyed filler adapter I	M30290
Keyed filler adapter S	M31930
QUIK FIL DRAIN ADAPTER	M34206

Filters

BACTERIA FILTER	8402868
BACTERIA FILTERS	CH00102
FILTER	MK00514
SET MIC.FILTER 654ST-ISOCLICK	6733895
SET OF 5 BACTERIA FILT.(CH102)	6723976

Gas supply block

COPPER RING	D04873
CUFF	AF00220
Pressure regulator	8413666
PRESSURE SENSOR	8602767
SCREW PLUG	D18348
TOROIDAL SEALING RING	M19241

High Pressure Sensors

HIGH PRESSURE SENSOR AIR	8603520
HIGH PRESSURE SENSOR N2O	8603315
HIGH PRESSURE SENSOR O2	8603316

Holders Vaporizer

HOLDING DEVICE PARK.POS.RAIL	M26966
SUPPORT FOR PARKING POSITION	M25102

Hose DIN, device NIST

ADAPTER O2 (DIN/NIST)	M32366
ADAPTOR AIR (DIN/NIST)	M32368
ADAPTOR AIR/O2 (DIN/NIST)	M32370
ADAPTOR N2O (DIN/NIST)	M32367
ADAPTOR VAC (DIN/NIST)	M32369

Hose DISS, device NIST

ADAPTOR-AIR,DISS-NIST	M34877
ADAPTOR-N2O,DISS-NIST	M34876
ADAPTOR-O2,DISS-NIST	M34875
ADAPTOR-VAC,DISS-NIST	M34878

Assembly	Description	Part No.

Hose NIST, device DIN

ADAPTOR AIR (NIST/DIN)	M32495
ADAPTOR AIR/O2 (NIST/DIN)	M32497
ADAPTOR N2O (NIST/DIN)	M32494
ADAPTOR O2 (NIST/DIN)	M32493
ADAPTOR VAC (NIST/DIN)	M32496

Instructions for Use

AGS A-Gas Awayline hu/cz	9038239
AGS A-Gas Awayline ru/pl	9038207
AGS A-Gas Awayline sv/no	9038206
AGS A-Gas Awayline zh/jp	9038208
INSTRUCTIONS FOR USE AGS DA/IT	9029425
Instructions for Use AGS de/en	9029327
INSTRUCTIONS FOR USE AGS FR/ES	9029426
INSTRUCTIONS FOR USE AGS FR/NL	9037424

Keyd filler adapter S

Keyed filler adapter S	M31930
Keyed Filling Adapter S	M35322
MA check valve filling adapter	9028953
MODIF.KIT BALL VALVE	M34614
MRI Label	M35209

Keyed filler adapter E

Keyed filler adapter E	M30289
Keyed Filling Adapter E	M35321
MA check valve filling adapter	9028953
MODIF.KIT BALL VALVE	M34614
MRI Label	M35209

Keyed filler adapter H

Keyed filler adapter H	M30288
Keyed Filling Adapter H	M35320
MA check valve filling adapter	9028953
MODIF.KIT BALL VALVE	M34614
MRI Label	M35209

Keyed filler adapter I

Keyed filler adapter I	M30290
Keyed Filling Adapter I	M35323
MA check valve filling adapter	9028953
MODIF.KIT BALL VALVE	M34614
MRI Label	M35209

Assembly	Description	Part No.

KIT AGS Adapter

	MODIF.AGS-ADAPTER TITUS/SA2	M32976

Kit Parking holder

	SUPPORT FOR PARKING POSITION	M25102

Maintanance Parts/Service Sets

	FILTER	M33294

Maintenance parts

	2-year Vapor kit	MX08235
	CHEESE HEAD SCREW M4x30 DIN912	1343904
	MESH BOTTOM	D18440
	O-RING SEAL	M21929
	SCREW M 4X12	1343866
	SCREW M 4X25	1343947

Manual Ventilation

	Baby-Resutator 2000	2120941
	Resutator 2000 adults	2120046
	SILICON-BREATHING BAG 2,3 L	2166062

Assembly	Description	Part No.

Manuals\Techn. Documentation

	GA VAPOR 2000 cs	DB01358
	GA VAPOR 2000 da	DB01359
	GA VAPOR 2000 DE	DB01188
	GA VAPOR 2000 EN	DB01189
	GA VAPOR 2000 ES	DB01191
	GA VAPOR 2000 FR	DB01190
	GA VAPOR 2000 hu	DB01356
	GA VAPOR 2000 IT	DB01260
	GA VAPOR 2000 ja	DB01353
	GA VAPOR 2000 NL	DB01261
	GA VAPOR 2000 no	DB01355
	GA Vapor 2000 pl	DB01357
	GA VAPOR 2000 pt	DB01352
	GA VAPOR 2000 ru	DB01351
	GA Vapor 2000 sk	DB01362
	GA VAPOR 2000 SV	DB01262
	GA Vapor 2000 tr	DB01363
	GA VAPOR 2000 zh	DB01354
	GA-VAPOR 2000 - FI	DB01263
	IFU VAPOR 2000 en US	DB01273
	TD Vapor 2000 de	9036025
	TD Vapor 2000 en	9036026
	TD Vapor 2000 es	9036197
	TD Vapor 2000 fr	9036027

Medibus

	GA Dräger RS 232 Medibus de	9028320
	GA MEDIBUS f. Primus en	9037426
	Manual Dräger RS232 Medibus EN	9028258

Monitor control pannel

	DISPLAY	8603235

Assembly	Description	Part No.
N2O		
	N2O-CONNECT.HOSE 1,5M (BACK)	M29277
	N2O-CONNECT.HOSE 3M (BLACK)	M29237
	N2O-CONNECT.HOSE 5M (BLACK)	M29257
	N2O-CONNECTING HOSE 1,5M	M29275
	N2O-CONNECTING HOSE 5M	M29255
	N2O-CONNECTION HOSE 3M	M29235
	N2O-HOSE NIST 1,5M DIN PROBE	M34404
	N2O-HOSE NIST 3M DIN PROBE	M34405
	N2O-HOSE NIST 5M DIN PROBE	M34406
	N2O-ZV-HOSE 1,5M NIST EN-COLOR	8602516
	N2O-ZV-HOSE 3M NIST EN-COLOR	8602517
	N2O-ZV-HOSE 5M NIST EN-COLOR	8602518
O2		
	O2-CONNECT.HOSE 1,5M (BLACK)	M29273
	O2-CONNECT.HOSE 3M (BLACK)	M29233
	O2-CONNECT.HOSE 5M (BLACK)	M29253
	O2-CONNECTING HOSE 1,5M	M29271
	O2-CONNECTING HOSE 5M	M29251
	O2-CONNECTION HOSE 3M	M29231
	O2-HOSE NIST 1,5M DIN-PROBE	M34401
	O2-HOSE NIST 3M DIN PROBE	M34402
	O2-HOSE NIST 5M DIN PROBE	M34403
	O2-ZV-HOSE 1,5M NIST EN-COLOR	8602513
	O2-ZV-HOSE 5M NIST EN-COLOR	8602515
	O2-ZV-HOSE3M NIST EN-COLOR	8602514

Assembly	Description	Part No.

O2-Pressure reducer G3/4

	CONNECTION PIECE	2312602
	CONNECTION PIECE	2312603
	DIAPHRAGM VALVE W.O-RING SEAL	2312600
	FLAT PACKING	2312593
	HIGH PRESSURE SENSOR N2O	8603709
	HIGH PRESSURE SENSOR N2O	AF00532
	HIGH PRESSURE SENSOR O2	8603704
	HIGH PRESSURE SENSOR O2	AF00528
	LOCK G 3/8"	2312604
	LOCK M10X1	2312605
	N2O-PRESSURE REDUCER G3/4I	M34017
	N2O-PRESSURE REDUCER G3/8	M34018
	N2O-PRESSURE REDUCER GH	M34020
	N2O-PRESSURE REDUCER GI	M34022
	N2O-PRESSURE REDUCER GX	M34021
	N2O-PRESSURE REDUCER PIN INDEX	M34019
	NUT N2O GER. G 3/4"	2312585
	NUT N2O GER. G 3/8"	2312586
	NYLON-GASKET 3/8"	2312606
	NYLON-GASKET F. THREAD M10X1	2312607
	O2-PRESSURE REDUCER G3/4	M34007
	O2-PRESSURE REDUCER GA	M34009
	O2-PRESSURE REDUCER GB-HS	M34012
	O2-PRESSURE REDUCER GC-HT	M34016
	O2-PRESSURE REDUCER GE	M34013
	O2-PRESSURE REDUCER GO	M34014
	O2-PRESSURE REDUCER PIN INDEX	M34008
	O-RING SEAL N2O GERMANY	2312576
	O-RING SEAL N2O GERMANY 3/8"	2312577
	O-RING SEAL N2O GH	2312578
	O-RING SEAL N2O GJ	2312579
	O-RING SEAL O2 GA	2312573
	O-RING SEAL O2 GC+GB	2312571
	O-RING SEAL O2 GE	2312574
	O-RING SEAL O2 GERMANY	2312572
	O-RING SEAL O2 GO	2312575
	PIN-INDEX BOW N2O	2312591
	PIN-INDEX BOW O2	2312590
	PIN-INDEX CONNECTING BRANCH	2312592
	PRESS.RED.+SENSOR N2O PIN IND.	AF00530
	PRESS.RED.+SENSOR O2 PIN INDEX	AF00529
	PRESSURE GAUGE N2O	2312596
	PRESSURE GAUGE O2	2312595
	PRESSURE GAUGE PACKING RING	2312597

Assembly	Description	Part No.
	PRESSURE GAUGE PROTECTING CAP	2312594
	PRESSURE SPRING	2312601
	SAFETY VALVE N2O	2312599
	SAFETY VALVE O2	2312598
	TERMINAL NUR O2 GER.	2312580

PGM 2 w. servomex / pato

	WATERTRAPS SET OF 12	6870567

PGM 3

	WATERTRAPS SET OF 12	6870567

PGM Primus

	O2-SENSOR-S	6850930

Plug-in adapter DW 2000 E

	BOLT	M34662
	CAP FOR HANDLE	M34677
	HANDLE (PLUG-IN SYSTEM DW)	M34676
	Plug-in adapter DW-2000 E	M34726
	SCREW M 4X12	1343866
	WASHER A 4,3 DIN 125-A4	1327542

Plug-in adapter DW 2000 I

	BOLT	M34662
	CAP FOR HANDLE	M34677
	HANDLE (PLUG-IN SYSTEM DW)	M34676
	Plug-in adapter DW-2000 I	M34727
	SCREW M 4X12	1343866
	WASHER A 4,3 DIN 125-A4	1327542

Plug-in adapter DW 2000 S

	BOLT	M34662
	CAP FOR HANDLE	M34677
	HANDLE (PLUG-IN SYSTEM DW)	M34676
	Plug-in adapter DW-2000 S	M34728
	SCREW M 4X12	1343866
	WASHER A 4,3 DIN 125-A4	1327542

Plug-in adapter DW-2000 H

	BOLT	M34662
	CAP FOR HANDLE	M34677
	HANDLE (PLUG-IN SYSTEM DW)	M34676
	Plug-in adapter DW-2000 H	M34725
	SCREW M 4X12	1343866
	WASHER A 4,3 DIN 125-A4	1327542

Assembly	Description	Part No.

Plug-in adapter S-2000

	BOLT	M34817
	CAP FOR HANDLE	M34677
	Hand lever	M34758
	Plug-in adapter S-2000	M34821
	SCREW M 4X12	1343866
	WASHER A 4,3 DIN 125-A4	1327542

Plugs

	AGSS ANGLE PROBE / TYPE 1 / EN	G60495
	AGSS PROBE/STRAIGHT-TYPE1/ EN	G60580
	ANAESTH.WASTE GAS PROBE 45	G60440

Pressure Gauges

	PRESSURE GAUGE AIR	MX08049
	PRESSURE GAUGE N2O,CO2,XE	MX08050
	PRESSURE GAUGE O2	MX08048

Pressure Reducer

	Press.Red.Air,DIN477-1,Primus	8603719
	Press.Red.Air,PIN IND.Primus	8603718
	Press.Red.Air.NF E29-650,Prim	8603720
	Press.Red.N2o,DIN477-1/11,Prim	8603463
	Press.Red.N2o,DIN477-1/12,Prim	8603464
	Press.Red.N2o,NF E29-650,Prim	8603711
	Press.Red.N2o,PIN IND.Primus	8603462
	Press.Red.o2, DIN477-1,Primus	8603465
	Press.Red.o2,DIN477-1/6,Primus	8603706
	Press.Red.o2,NF E29-650,Primus	8603707
	Press.Red.o2,PIN INDEX,Primus	8603466

Primus 1 annual

	DIAPHRAGM,CUP	2600650
	FILTER MAT	6870910
	FILTER MAT	8603662
	FILTER MAT	8603301
	FILTER MAT	8603144
	O-RING SEAL	U04314

Assembly	Description	Part No.

Primus 2 annual

DIAPHRAGM	8603780
DIAPHRAGM	M33275
DIAPHRAGM,CUP	2600650
FILTER MAT	6870910
FILTER MAT	8603301
FILTER MAT	8603585
FILTER MAT	8603662
FILTER MAT	8603144
MESH BOTTOM	M19238
NAFION HOSE 150 LG.	8601238
O-RING SEAL	R52382
O-RING SEAL	U04314
SEALING WASHER	8603781

Primus 3 annual

Battery	8603057
DIAPHRAGM,CUP	2600650
FILTER MAT	8603662
FILTER MAT	8603144
FILTER MAT	8603301
FILTER MAT	6870910
O-RING SEAL	U04314

Products concerned

Vapor 2000 Enflurane	M35150
Vapor 2000 Halothane	M35140
Vapor 2000 Isoflurane	M35160
Vapor 2000 Sevoflurane	M35170

Quik Fil Drain Adapter

QUIK FIL DRAIN ADAPTER	M34206

Rep. Set Pflug-In System

REP.SET PLUG-IN SYSTEM	M34907

RS AGS- Schienenklaue

Lever-type clamp	M25739
MODIFICATION AGS-RAIL CLAMP	M32967

RS SpO2

Upgrade kit Spo2 Primus	8603870

Secretion bottles with claw

Lever-type clamp	M25739
RECEPTACLE	2M85594

Assembly	Description	Part No.
Sensors and Gas Measurement		
	O2-SENSOR-S	6850930
	Sample Line Set (10pcs)	8290286
	Set of 5 Spirolog sensors	8403735
	SpiroLife	MK01900
	WATERTRAPS SET OF 12	6870567
Sets and Spare Parts		
	MESH BOTTOM	D02316
	PROTECTING CAP	MX08051
	REP.SET GASKET	MX08061
	REP.SET GASKET/B (ENGLAND)	MX08159
	REP.SET GASKET/C (USA)	MX08158
	REP.SET GASKET/F (FRANKREICH)	MX08157
	REP.SET GASKET/N (NIEDERLANDE)	MX08160
	SET OF PACKING RINGS	D20215
Software 1.n		
	EB zur GA Primus de/en	9037930
	GA Primus SW 1.06 fr	9037731
	GA Primus SW 1.06 no	9037738
	GA Primus SW 1.06 da	9037668
	GA Primus SW 1.06 en	9037730
	GA Primus SW 1.06 es	9037732
	GA Primus SW 1.06 fi	9037737
	GA Primus SW 1.06 ge	9037729
	GA Primus SW 1.06 hu	9037742
	GA Primus SW 1.06 it	9037733
	GA Primus SW 1.06 nl	9037734
	GA Primus SW 1.06 pl	9037740
	GA Primus SW 1.06 pt	9037741
	GA Primus SW 1.06 ru	9037736
	GA Primus SW 1.06 sk	9037748
	GA Primus SW 1.06 sv	9037735
	GA Primus SW 1.06 zh	9037739

Assembly	Description	Part No.

Software 2.n

Assembly	Description	Part No.
	50 Primus SW 2.n fr	9037992
	GA Primus SW 2.n cs	9038006
	GA Primus SW 2.n da	9038000
	GA Primus SW 2.n de	9037990
	GA Primus SW 2.n el	9038008
	GA Primus SW 2.n en	9037991
	GA Primus SW 2.n es	9037993
	GA Primus SW 2.n fi	9037998
	GA Primus SW 2.n hu	9038003
	GA Primus SW 2.n it	9037994
	GA Primus SW 2.n nl	9037995
	GA Primus SW 2.n no	9037999
	GA Primus SW 2.n pl	9038005
	GA Primus SW 2.n pt	9038001
	GA Primus SW 2.n ru	9037997
	GA Primus SW 2.n sk	9038004
	GA Primus SW 2.n sv	9037996
	GA Primus SW 2.n zh	9038002

Suction hoses

Assembly	Description	Part No.
	AGS-SCAVANGER HOSE 0,5M	M35015
	AGS-SCAVANGER HOSE 1,5M	M33297
	AGS-SCAVANGER HOSE 3M	M33298
	AGS-SCAVANGER HOSE 5M	M33299

TD Primus

Assembly	Description	Part No.
	TD Primus de	9036003
	TD Primus de	9036180
	TD Primus en	9036004
	TD Primus es	9036005
	TD Primus fr	9036006
	TDPrimus es	9036179

Assembly	Description	Part No.
VAC		
	VAC.-CONNECT.HOSE 1,5M(BLACK)	M29289
	VAC.-CONNECT.HOSE 3M (BLACK)	M29249
	VAC.-CONNECT.HOSE 5M (BLACK)	M29269
	VAC-HOSE NIST 1,5M DIN PROBE	M34413
	VAC-HOSE NIST 3M DIN PROBE	M34414
	VAC-HOSE NIST 5M DIN PROBE	M34415
	VACUUM-CONNECTION HOSE 1,5M	M29287
	VACUUM-CONNECTION HOSE 3M	M29247
	VACUUM-CONNECTION HOSE 5M	M29267
	VAC-ZV-HOSE 1,5M NIST EN-COLOR	8602522
	VAC-ZV-HOSE 3M NIST EN-COLOR	8602523
	VAC-ZV-HOSE 5M NIST EN-COLOR	8602524
Valve		
	CAP 1,BLACK	M24597
Vapor plug-in system w. pivot		
	AM4X8 DIN 963-A4/051	1329324
	FIXING CAM	M28935
	O-RING SEAL	U04314
	O-RING SEAL	D18400
	PACKING RING	M05128
	SCREW AM2X4 DIN 963-A4	1334514
	VAPOR PLUG-IN SYSTEM W.PIVOT	M26588
Vaporizer 19.n		
	DEVAPOR GERMAN	M32600
	E-VAPOR 19.3/5% PIN SAFETY	DB01128
	H.VAPOR 19.3/4% PIN SAFETY	DB01154
	I-VAPOR 19.3/5% PIN SAFETY	DB01129
	S-VAPOR 19.3/8% ABBOTT	DB01180
	S-VAPOR 19.3/8% PIN SAFETY	DB01166
Without plug, color EN 739		
	AIR-DISTRIBUTOR 5M,NO PLUG	M34564
	CS-HOSE N2O,5M,NO PLUG	M34417
	CS-HOSE AIR 5M, NO PROBE	M34418
	CS-HOSE AIR-O2,5M,NO PLUG	M34420
	CS-HOSE O2 5M, NO PROBE	M34416
	CS-HOSE VAC,5M,NO PLUG	M34419
	O2-DISTRIBUTOR 5M,NO PLUG	M34565

Assembly	Description	Part No.

Without plug, no color

	AIR-DISTRIB.NIST 5M,BL,N.PROBE	M32677
	AIR-HOSE 5M NIST BL., NO PROBE	M32039
	N2O-HOSE 5M,NIST,BL.,NO PROBE	M32038
	O2/AIR HOSE 5M NIST,BL.,NO PR.	M32047
	O2-DISTRIB.NIST 5M,BL,N.PROBE	M32679
	O2-HOSE 5M NIST BL., NO PROBE	M32037
	VAC.HOSE 5M,NIST,BL.,NO PROBE	M32046

Y-Pieces

	Y-PIECE	8405435
	Y-PIECE 90DEGREE	8403075
	Y-PIECE ADULT	M25682
	Y-PIECE ADULT,LUER LOCK	M33278
	Y-PIECE ADULT,STRAIGHT	M25650
	Y-PIECE F.TEMPERATURE SENSING	M30543
	Y-PIECE F+P	8412220
	Y-PIECE STRAIGHT PAED	M27077

Test List (TL)

Primus

This test list can be processed with standard commercially available test aids and tools, but does not replace the inspections and maintenance work carried out by the manufacturer.

Tests marked with the "check" symbol are listed in the Test List Report and can be documented there.

Country-specific ventilation mode terms in SW versions earlier than 2.0:

International: Man./Spont = France: Man./Spont.
International: IPPV mode = France: VC
International: PCV mode = France: VPC

Country-specific ventilation mode terms in SW versions 2.0 or later:

International: Man./Spont. = France: Man./Spont.
International: Vol.Mode = France: Mode Vol.
International: Press.Mode = France: Mode Press.
International: Press.Supp. = France: A.I. = (option)

Conversion table: 1 bar = 14.504 PSI / 1 mbar = 1.01973 cm H2O

1 Device configuration

1.1 Serial numbers

☑ **1.1.1 Primus** [________txt]

The serial number is located on the rear of the Primus.

☑ **1.1.2 Breathing system cover** [________txt]

The serial number is located on the rim of the cover.

☑ **1.1.3 Breathing system valve plate** [________txt]

The serial number is located on the heating surface.

☑ **1.1.4 Respiratory gas block** [________txt]

The serial number is located under the cover of the piston cylinder unit.

1.2 Serial numbers (options)

☑ **1.2.1 External bronchial suction device** [________txt]

(If a number is present.)

☑ **1.2.2 High-pressure regulator O2** [________txt]

☑ **1.2.3 High-pressure regulator N2O** [________txt]

☑ **1.2.4 High-pressure regulator AIR** [________txt]

☑ **1.2.5 High-pressure cylinder O2** [________txt]

(If a number is present.)

☑ **1.2.6 High-pressure cylinder N2O** [________txt]

(If a number is present.)

☑ **1.2.7 High-pressure cylinder AIR** [________txt]

(If a number is present.)

1.3 Software versions

Primus is in "Standb"y mode.

Press the "Standard Config" softkey and, if necessary, enter the security code.
Press the "System Information" softkey.
Read out the following software versions.

☑ **1.3.1 Mobi** [________txt]

☑ **1.3.2 MIXER MA** [__________txt]

☑ **1.3.3 MIXER SV** [__________txt]

☑ **1.3.4 VGC MA** [__________txt]

☑ **1.3.5 VGC SV** [__________txt]

☑ **1.3.6 PGM** [__________txt]

The software version of the "PGM" is displayed for approximately 2 minutes after power-up.

☑ **1.3.7 Power pack** [__________txt]

2 Electrical safety

For a detailed description of the electrical safety tests, see DORIS under "Electrical tests/Test documents/Electrical safety tests" or eSIS under "General/Electrical tests/Electrical safety tests".

2.1 General

The following steps describe the electrical safety tests according to IEC 60601 (or UL 2601-1) and VDE 0751. Any decision about performing safety checks according to VDE 0751 or IEC 60601 must be made under consideration of applicable national regulations.

The Primus conforms to the requirements of protection class I. With option SpO2 to type BF.

☑ 2.2 Visual check [__________OK]

Precondition:
Primus is switched off.
Power plug is unplugged.

Check the following components are in perfect working condition:
Mains power cable including strain relief.

Auxiliary sockets.

On auxiliary sockets with automatic circuit-breakers, check the circuit-breakers are switched on.
The automatic circuit-breakers are switched on.

On auxiliary sockets with automatic circuit-breakers, check the ratings correspond to the imprint.
The ratings correspond to the imprint.
[OK]

2.3 Electrical safety according to VDE 0751

INFO:
When testing to IEC60-601 or UL2601-1, continue with test item 2.4.

Precondition:
Primus is switched off.
Power plug is unplugged.

2.3.1 Protective earth conductor test

2.3.1.1 Test sequence

Connect the test probe to the following test points one after the other:
Power pack earthing stud
PE contacts on auxiliary sockets

The protective earth conductor resistance at any test point must be less than/equal to 0.3 ohms.

☑ 2.3.1.2 PE conductor test value [__________OK]

Test value including power cable:
R = less than/equal to 0.3 ohms.

2.3.2 Equivalent device leakage current test

☑ **2.3.2.1 Initial equivalent device leakage current** [_________µA]

Ileak less than or equal to 1000 µA

Each initial measured value should be included in a new report.

The repeat measurements may exceed the initial value by max. 50%, but, at the same time, must be less than/equal to 750µA.

☑ **2.3.2.2 Repeat measurement of equivalent device leakage current** [_________µA]

Ileak less than/equal to 1000 µA, but maximum permissible deviation from initial value is 50%.

2.3.3 Equivalent patient leakage current test

INFO:
This test is only required if the SpO2 option is fitted.

☑ **2.3.3.1 Initial equivalent patient leakage current** [_________µA]

Ileak less than/equal to 50 µA.

Each initial measured value should be included in a new report.

The repeat measurements may exceed the first measured value by max. 50%. In the case of initial measured values < 20 µA, repeat measurements may deviate by up to 10 µA.

☑ **2.3.3.2 Repeat measurement of equivalent patient leakage current** [_________µA]

Ileak less than/equal to 50 µA.

2.4 Electrical safety to IEC 60-601

INFO:
The test to UL2601-1 is satisfied by testing to IEC 60-601-1. Differing limit values are marked.

Precondition:
Primus is switched off.
Power plug is unplugged.

2.4.1 Protective earth conductor test

2.4.1.1 Test sequence

Connect the test probe to the following test points one after the other:
Power pack earthing stud.
PE contacts on auxiliary sockets.

The protective earth conductor resistance at any test point must be less than/equal to 0.3 ohms.

☑ **2.4.1.2 PE conductor test value** [_________OK]

Test value including power cable:
R = less than/equal to 0.3 ohms.

2.4.2 Earth leakage current

☑ **2.4.2.1 Earth leakage current N.C. (IEC)** [__________µA]

(normal condition)
Test value to IEC 60-601: less than or equal to 500 µA

☑ **2.4.2.2 Earth leakage current S.F.C. (IEC)** [__________µA]

(single fault condition, open circuit in neutral conductor)
Test value to IEC 60-601: less than or equal to 1000 µA

☑ **2.4.2.3 Earth leakage current N.C. reversed (IEC)** [__________µA]

(normal condition, power plug reversed)
Test value to IEC 60-601: less than or equal to 500 µA

☑ **2.4.2.4 Earth leakage current S.F.C. reversed (IEC)** [__________µA]

(single fault condition, open circuit in neutral conductor, power plug reversed)
Test value to IEC 60-601: less than or equal to 1000 µA

☑ **2.4.2.5 Earth leakage current N.C. (UL)** [__________µA]

(normal condition)
Test value to UL 2601-1: less than or equal to 300 µA

☑ **2.4.2.6 Earth leakage current S.F.C. (UL)** [__________µA]

(single fault condition, open circuit in neutral conductor)
Test value to UL 2601-1: less than or equal to 300 µA

☑ **2.4.2.7 Earth leakage current N.C. reversed (UL)** [__________µA]

(normal condition, power plug reversed)
Test value to UL 2601-1: less than or equal to 300 µA

☑ **2.4.2.8 Earth leakage current S.F.C. reversed (UL)** [__________µA]

(single fault condition, open circuit in neutral conductor, power plug reversed)
Test value to UL 2601-1: less than or equal to 300 µA

2.4.3 Patient leakage current test

INFO:
This test is only required if the "SpO2" option is fitted.

☑ **2.4.3.1 Patient leakage current N.C.** [__________µA]

(normal condition)
Test value: less than or equal to 100 µA

☑ **2.4.3.2 Patient leakage current N.C. reversed** [__________µA]

(normal condition, power plug reversed)
Test value: less than or equal to 100 µA

☑ **2.4.3.3 Patient leakage current S.F.C.** [__________μA]

(single fault condition, open circuit in neutral conductor)
Test value: less than or equal to 500 μA

☑ **2.4.3.4 Patient leakage current S.F.C. reversed** [__________μA]

(single fault condition, open circuit in neutral conductor, power plug reversed)
Test value: less than or equal to 500 μA

3 Function and condition test

3.1 Input test

3.1.1 Note

INFO:
To detect possible device faults at an early stage, this step tests whether the self-test was completed without error.

☑ 3.1.2 Test sequence [__________OK]

Fit up Primus fully and perform power-on test.

The power-on test is run through without error.
[OK]

Primus is in "Standb"y mode.
[OK]

Switch off the Primus.

☑ 3.2 Accompanying documents [__________OK]

The Instructions for Use and the unit log are available (according to the user).

3.3 General condition of equipment

☑ 3.3.1 Checking condition and legibility of markings [__________OK]

☑ 3.3.2 Condition/function of base unit [__________OK]

Condition of membrane keypad.

Condition and function of flush button. The flush button can be operated without sticking.

Condition and function of safety flow control. Unlock, open, close, and lock the safety flow control.

VGC plug-in unit. Condition and function of rail system. Remove the breathing system. Condition and function of spring contacts of electrical interface to breathing system heater. Condition of pneumatic interface connectors at VGC.

Condition of control knob.

Function and condition of writing tray.

Function and condition of drawer, if fitted

Function and condition of rear panel doors with lock.

Condition of unit rails and handles.

Function and condition of castors and brakes, if fitted.

3.3.3 Condition/function of breathing system

Remove the breathing system.

INFO: A layout diagram of the valves of the breathing system is presented in the appendix.

☑ 3.3.3.1 Breathing system cover [__________OK]

Condition of breathing system cover (no cracks or other damage).

Condition of APL valve lever.

Condition of APL valve disk.

Condition of handle.

Condition of the 5 locking screws.

☑ 3.3.3.2 Valve panel [__________OK]

Condition of RV1, inspiratory and expiratory valve. Look especially for dirt contamination and damage to the seat and the ceramic disk.

Condition of APL valve seat.

Condition of PEEP diaphragm V1.

Condition of Man/Spont/Automatic switchover diaphragm V2.

Condition of RV2.

Condition of valve plate sealing surfaces.

Condition of heating surface.

Condition of electrical heating contacts and their silicone protection.

☑ 3.3.3.3 Respiratory gas block [__________OK]

Condition of respiratory gas block. No cracks or other damage.

Condition of inspiratory and expiratory socket. Additionally unscrew sockets, remove flow sensors and check 4 x O-rings for flow sensor sealing.

Condition/function of the 3 locking screws of the breathing system.

Condition/function of manual breathing bag socket.

Condition of PEEP valve seat.

Condition of Man./Spont./Automatic switchover valve seat.

Condition of pneumatic port seals.

Condition of absorber canister seal.

Condition of absorber element seal.

☑ 3.3.3.4 Absorber canister [__________OK]

Condition of absorber canister.

☑ **3.3.3.5** **Absorber insert** [__________OK]

Condition of absorber insert. No damage.

Condition of seal between absorber canister and absorber element.

☑ **3.3.4** **Condition/function of accessories** [__________OK]

Function and condition of bag resuscitator.

Condition of manual breathing bag.

Condition of O2, AIR and N2O central supply connections (check plug coupling, country-specific colour coding and terminal coding).

Function and condition of hinged arm, if fitted.

3.3.5 **Bronchial suction device (if fitted)**

INFO:
Primus may be equipped with a bronchial suction device type 2M85032 or type MK014xx. For illustrations of the different types, see annex.

☑ **3.3.5.1** **Condition of bronchial suction device** [__________OK]

Housing.

Vacuum switch, toggle switch for control loop operation and full capacity.

Control valve.

Pressure gauge.

Connecting hose from suction device to secretion jar.

Vacuum connecting hose (only with vacuum version).

Central supply connecting hose (only with ejector version).

With type MK0014xx, check also: Condition of the silicone plug (MK00762). To do so, remove the bacterial filter (MK00514). The bacterial filter can be removed using a normal amount of force. The silicone plug must be replaced if the bacterial filter can be removed very easily. In case of replacement, apply a small amount of Barrierta ISL/OX grease on the rim of the new silicone plug. Otherwise it will be difficult to change the bacterial filter later.

☑ **3.3.5.2** **Condition/function of cylinder mount** [__________OK]

Condition and function of swivel device.

Condition and function of telescopic arm.

Condition of cylinder holder.

☑ **3.3.5.3 Condition of secretion jar and accessories** [________OK]

Secretion suction hose.

Secretion jar.

Jar caps

Pressure relief valve (if fitted).

3.4 Vaporizer plug-in system

☑ **3.4.1 Vaporizer plug-in system mounting pins** [________OK]

The mounting pins must not be detachable by hand.

☑ **3.4.2 Interlock** [________OK]

Check two-way function with vaporizers fitted. It is only possible to switch on one vaporizer at a time.

☑ **3.4.3 Selectatec plug-in system interlock (if fitted)** [________OK]

Check two-way function with vaporizers fitted. It is only possible to switch on one vaporizer at a time.

3.5 AGS system

☑ **3.5.1 Condition of AGS system** [________OK]

If one of the two excess gas connections is used: Check that screw plug is fitted in socket on side of AGS mounting system.

☑ **3.5.2 Function of AGS system** [________OK]

Connect the AGS suction hose to the anesthetic suction outlet.

The float in the flowmeter tube of the AGS system should move between the upper and lower marks.

☑ **3.5.3 Function of flow control in AGS USA variant** [________OK]

Adjust the fine-control valve at the outlet of the AGS system.
The position of the float in the flowmeter tube of the AGS system changes.
[OK]

Adjust the flow control valve such that the float is in the middle position.

3.6 Bronchial suction device (if fitted)

INFO:
Primus may be equipped with a bronchial suction device type 2M85032 or type MK014xx. For illustrations of the types, see annex to the PMS procedure, section "Technical Information". The required maintenance parts depend on the type fitted. The different performance data must be taken into consideration with the ejector type.

INFO:
Check the ejector suction or vacuum suction device. Depending on which is fitted.

With vacuum suction, continue with "Function of vacuum suction device".

3.6.1 Function of ejector suction device

Fit the complete suction device.

Connect the AIR supply (2.7 bar to 5.5 bar).

If fitted, set the vacuum switch to "Control" mode. Otherwise set the vacuum switch to "On".

Set the flow control valve to maximum vacuum and seal off the secretion suction tube.

Read off the negative pressure from the pressure gauge on the bronchial suction device.

☑ 3.6.1.1 Static end-pressure (type MK014xx) [__________OK]

Pstat = -0.5 bar to -0.95 bar

☑ 3.6.1.2 Static end-pressure (type 2M85032) [__________OK]

The central-supply pressure dependent values are listed in the following table. Interpolate the tolerance for deviating central supply pressure values.

Central supply pressure = 5.5 bar
Tolerance for vacuum = 700 mbar to 900 mbar

Central supply pressure = 4.5 bar
Tolerance for vacuum = 500 mbar to 900 mbar

Central supply pressure = 3.5 bar
Tolerance for vacuum = 300 mbar to 900 mbar

Central supply pressure = 2.5 bar
Tolerance for vacuum = 150 mbar to 900 mbar

Set the vacuum switch to "Off".

☑ **3.6.1.3** **Function of vacuum switch (type MK014xx)** [_________OK]

Set the vacuum switch to "Control" mode.

Seal off the secretion suction tube.

With a flow control valve, set a negative pressure of approx. 1/2 Pstat.

Set the vacuum switch to "full power".
P = Pstat

Set the vacuum switch to "Off".

Disconnect the central supply.

Continue with test item 3.7.

☑ **3.6.2** **Function of vacuum suction device** [_________OK]

Fit the complete vacuum suction device and connect it to the vacuum supply.

If fitted, set the vacuum switch to "Control" mode. Otherwise set the vacuum switch to "On".

Set the flow control valve to maximum pressure and seal off the secretion suction tube.
The vacuum "Pvac" is built up.
[OK]

☑ **3.6.2.1** **Function of vacuum switch (type MK014xx)** [_________OK]

Set the vacuum switch to "Control" mode.

Seal off the secretion suction tube.

With a flow control valve, set a negative pressure of approx. 1/2 Pvac.

Set the vacuum switch to "full power".
P = Pvac

Set the vacuum switch to "Off".

Disconnect the vacuum tube.

3.7 **High-pressure modification set (if fitted)**

3.7.1 **Condition of high-pressure conversion kit**

☑ **3.7.1.1** **Condition test of high-pressure regulator** [_________OK]

Housing.
Labeling.
HD connecting hoses.
High-pressure sensors including unit connectors.

☑ **3.7.1.2** **TÜV expiry date, O2 high-pressure cylinder** [_________dat]

If fitted, check and enter TÜV expiry date of O2 high-pressure cylinder (every 10 years).

☑ **3.7.1.3** **TÜV expiry date, N2O high-pressure cylinder** [________dat]

If fitted, check and enter TÜV expiry date of N2O high-pressure cylinder (every 10 years).

☑ **3.7.1.4** **TÜV expiry date, AIR high-pressure cylinder** [________dat]

If fitted, check and enter TÜV expiry date of N2O high-pressure cylinder (every 10 years).

☑ **3.7.1.5** **Expiry date (AIR, O2 and N2O)** [________OK]

AIR, O2 and N2O class as medication. Check use-by date, if available.

AIR use-by date.
O2 use-by date.
N2O expiry date.

☑ **3.7.1.6** **Condition of high-pressure cylinders** [________OK]

Cylinder jackets.
Cylinder caps.
Velcro strap.

3.7.2 **High-pressure regulator performance test**

Info:
The respective version (2.5 bar or 5 bar) is indicated on the name plate of the high-pressure regulator.

Connect the Primus to the mains power.
Close the high-pressure cylinder.
Disconnect the connecting tube of the high-pressure regulator being tested from the Primus and connect it to a flowmeter (measuring range > 75 L/min).
Switch on the Primus.
Confirm the checklist.
The cylinder pressures (supply pressure) are shown on the self-test screen.
Slowly open the relevant high-pressure cylinder until a supply pressure of approx. 10 bar is set. At the same time, read the flow on the flowmeter.
Close the high-pressure cylinder.
Connect the connecting hose of the high-pressure regulator to the Primus.

☑ **3.7.2.1** **O2 performance test** [________OK]

Measure at a supply pressure of approx. 10 bar:
Pressure regulator type 5 bar >75 L/min.
Pressure regulator type 2.5 bar >40 L/min.

☑ **3.7.2.2** **N2O performance test (if fitted)** [________OK]

Measure at a supply pressure of approx. 10 bar:
Pressure regulator type 5 bar >60 L/min
Pressure regulator type 2.5 bar >35 L/min

☑ **3.7.2.3** **AIR performance test (if fitted)** [________OK]

Measure at a supply pressure of approx. 10 bar:
Pressure regulator type 5 bar >75 L/min
Pressure regulator type 2.5 bar >40 L/min.

3.7.3 Downstream pressure test

Close the high-pressure cylinders.
Disconnect the connecting tube of the high-pressure regulator being tested from the Primus and connect it to a pressure gauge (measuring range 10 bar).
Open the high-pressure cylinder.
Read the downstream pressure on the pressure gauge.

☑ **3.7.3.1 O2 downstream pressure test** [__________bar]

High-pressure regulator type 5 bar, downstream pressure 5 bar to 6 bar.

☑ **3.7.3.2 O2 downstream pressure test** [__________bar]

High-pressure regulator type 2.5 bar, downstream pressure 2.4 bar to 2.95 bar.

☑ **3.7.3.3 N2O downstream pressure test** [__________bar]

High-pressure regulator type 5 bar, downstream pressure 5 bar to 6 bar.

☑ **3.7.3.4 N2O downstream pressure test** [__________bar]

High-pressure regulator type 2.5 bar, downstream pressure 2.4 bar to 2.95 bar.

☑ **3.7.3.5 AIR downstream pressure test** [__________bar]

High-pressure regulator type 5 bar, downstream pressure 5 bar to 6 bar.

☑ **3.7.3.6 AIR downstream pressure test** [__________bar]

High-pressure regulator type 2.5 bar, downstream pressure 2.4 bar to 2.95 bar.

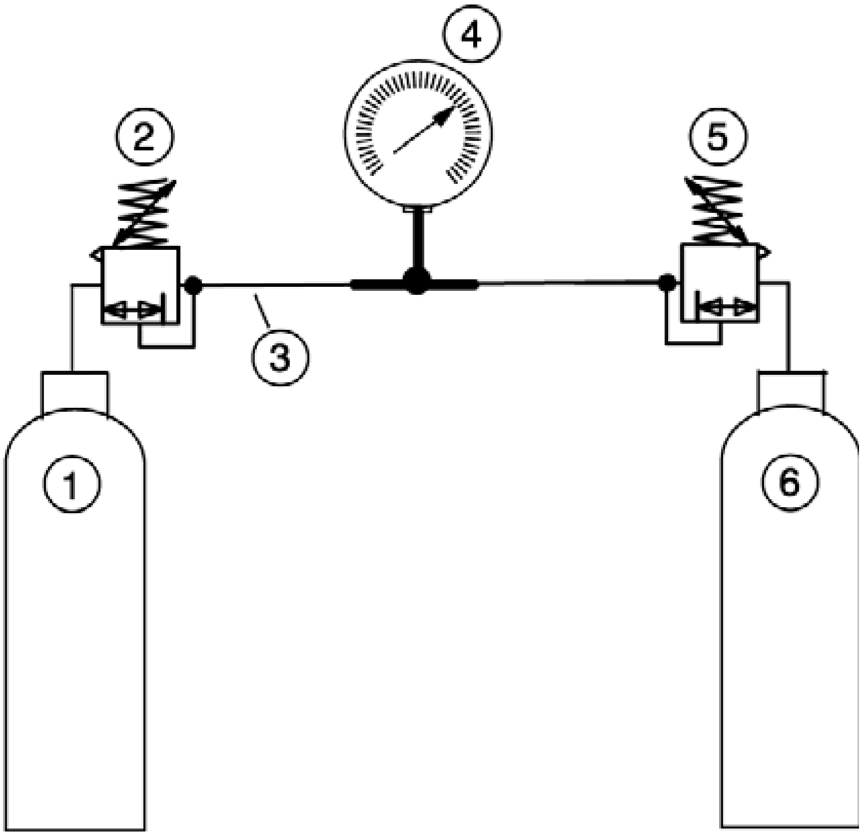
3.7.4 Blow-off valve test

Info:
This test requires the use of a controllable high-pressure regulator (control range up to 10 bar) with an high-pressure cylinder.

Prepare the following test set-up.

Legend to the Figure:
1 = High-pressure cylinder on Primus
2 = High-pressure regulator on Primus
3 = Connecting hose to Primus
4 = Pressure gauge, measuring range 10 bar
5 = Controllable test pressure regulator
6 = Test cylinder

Leave the high-pressure cylinder on Primus (Fig. 1/1) closed.
Adjust the least possible pressure on the test pressure regulator.
Open the test cylinder (Fig. 1/6).
Use the test pressure regulator to increase the pressure until the blow-off valve opens and a flow noise can be heard. Repeat this procedure twice and then read the opening pressure on the pressure gauge of the test pressure regulator (and record the value).



☑ **3.7.4.1 O2 opening pressure** [________bar]

Tolerance: 6,5 bar to 8,5 bar.

☑ **3.7.4.2 N2O opening pressure (if available)** [________bar]

Tolerance: 6,5 bar to 8,5 bar.

☑ **3.7.4.3 AIR opening pressure (if available)** **[__________bar]**

Tolerance: 6,5 bar to 8,5 bar.

Remove the test set-up.

☑ **3.7.5 High-pressure sensors reference pressure test** **[__________OK]**

Info:
The internal pressure of the high-pressure cylinders must be known for this test.

Connect the high-pressure connecting hose to Primus.
Switch on Primus and wait until the check list is displayed.
Open the high-pressure cylinders. Compare the pressure displayed in the check list with the internal pressure of the high-pressure cylinders.
The O2 pressure reading corresponds to the internal pressure of the O2 high-pressure cylinder (maximum deviation 10%). The O2 high-pressure LED on the Primus front lights green.
[OK]

The AIR pressure reading (if available) corresponds to the internal pressure of the AIR high-pressure cylinder (maximum deviation 10%).
The AIR high-pressure LED on the Primus front lights green.
[OK]

The N2O pressure reading (if available) corresponds to the internal pressure of the N2O high-pressure cylinder (maximum deviation 10%).
The N2O high-pressure LED on the Primus front lights green.
[OK]

Close the high-pressure cylinders.
Switch off the Primus.

☑ 3.8 Function of UPS [__________OK]

This test includes a check of the battery capacity. Consequently, the battery must be fully charged.

INFO:
In the battery capacity test, the Primus must be run for 30 minutes without mains power. During this time you can continue with the other tests. After 30 minutes the mains power must be restored.

Connect the Primus to the mains power.
The external power LED lights up. The LED is on the front panel of the Primus.
[OK]

Switch on the Primus.

Confirm the checklist.
The battery charge (percentage) is shown on the display next to the battery symbol. The battery charge must be 90% to 100%.
[OK]

Pull the mains power plug of the Primus from the mains power supply and start the stopwatch.
The external power indicator LED goes out and the battery power indicator LED lights up.
[OK]

Primus is powered by the UPS for 30 minutes.
[OK]

At the end of the 30 minutes reconnect the mains power plug to the mains power supply.

☑ 3.9 External O2 flowmeter (if fitted) [__________OK]

Connect the Primus only to the O2 central supply (the other central supplies must not be connected).
Open the fine control valve of the external O2 flowmeter.
The flowmeter float lifts.

Close the fine control valve of the external O2 flowmeter.

☑ **3.10 LEDs and sensors of the central supply** [__________OK]

Info: The central supply pressure must be known for this test. If necessary, measure it with an appropriate pressure gauge.

Switch Primus off and back on and let it run through until the checklist appears. Do not confirm the checklist.
Connect the Primus to the O2 central supply (the other central supply gases must not be connected).
The O2 central supply LED on the Primus front is lit steadily green. The O2 central supply pressure is displayed in the check list. Maximum permissible deviation is 200 mbar.
[OK]

Additionally connect the Primus to the central AIR supply.
The O2 and AIR central supply LEDs on the Primus front are lit steadily green. The AIR central supply pressure is displayed in the check list. Maximum permissible deviation is 200 mbar.
[OK]

Additionally connect the Primus to the N2O central supply.
The O2, AIR and N2O central supply LEDs on the Primus front are lit steadily green. The N2O central supply pressure is displayed in the check list. Maximum permissible deviation is 200 mbar.
[OK]

☑ **3.11 Fresh gas flow** [__________OK]

Confirm the checklist and run the Primus self-test. Confirm the message indicating that there is no mains power by pressing the relevant softkey. The leakage for "auto" is less than/equal to 100 mL/min.

3.11.1 Fresh gas flow function

Start Primus in "Man/Spont" mode.
Set the APL valve to 70 mbar.
Connect a flowmeter (measuring range 14 L/min) to the manual breathing port and set the fresh gas flow.

☑ **3.11.1.1 Target 1 L/min** [__________L/min]

Set a target value of 1 L/min.
Measured value: 0.9 L/min to 1.1 L/min.

☑ **3.11.1.2 Target 8 L/min** [__________L/min]

Set a target value of 8 L/min.
Measured value: 7.2 L/min to 8.8 L/min.

☑ **3.11.1.3 Target 14 L/min** [__________L/min]

Set a target value of 14 L/min.
Measured value: 12.6 L/min to 15.4 L/min.
Reset the fresh-gas flow to 2 L/min.
Set Primus to "standb"y mode.
Do not change the test set-up.

3.11.2 Function of safety flow control

Switch Primus to standby mode.
Unlock the safety flow control.
Set the safety flow control to 3 L/min.
The flow is between 2.1 L/min and 3.9 L/min.
[OK]

Set the safety flow control to 12 L/min.
The flow is between 8.4 L/min and 15.6 L/min.
[OK]

Set the safety flow control to 0 L/min and lock it.

3.12 Function of O2 flush

Connect a flowmeter (measuring range 45 L/min) to the manual breathing port.

☑ 3.12.1 O2 flush colour marking

[__________OK]

The colour marking conforms to the country-specific requirements.

☑ 3.12.2 Flow of O2 flush

[__________L/min]

Press the O2 Flush button and measure the flow.
The flow must be between 35 L/min and 45 L/min.

☑ 3.12.3 Mechanical functioning of O2 flush

[__________OK]

Press the O2 Flush button and release it again.
The O2 Flush button does not stick.
[OK]

Remove the test set-up.
Connect the manual breathing bag.

3.13 Function of A-cone (if fitted)

☑ 3.13.1 A-cone safety valve

[__________OK]

Select "external fresh gas" mode.
Connect a pressure gauge (measuring range 100 mbar) to the outlet of the A-cone.
Set the safety flow control to 12 L/min.
The pressure indicated on the pressure gauge increases to between 65 mbar and 80 mbar.

Set the safety flow control to 0 L/min and lock it.
Remove the test set-up.
Set Primus to "standb"y mode.

3.14 Checking pressure measurement and APL valve test

Switch Primus to "Man/Spont" mode.
Remove the manual breathing bag.
Connect the pressure gauge (measuring range 100 mbar) to the cone for the manual breathing bag.
Set the safety flow control to approx. 3 L/min and build up a pressure in the system.

☑ **3.14.1** **APL valve test** **[__________hPa]**

Set the APL valve to 30 hPa.
Read off the APL pressure at the pressure gauge and enter it.
The value may be between 25 hPa and 35 hPa.

☑ **3.14.2** **Variation of Primus pressure measurement** **[__________OK]**

To activate its pressure measurement the Primus requires a trigger pulse. To do so, toggle the APL valve back and forth repeatedly between "Man" and "Spont". At the "Man" setting wait each time for the pressure to be limited at approx. 30 hPa.
As soon as the pressure value "Peak" appears, compare it against the pressure readout on the pressure gauge.
The measured values may differ by max. 2 hPa.

Remove the pressure gauge and connect the manual breathing bag.
Close the safety flow control.

☑ **3.15** **SpO2 (if fitted)** **[__________OK]**

Connect the SpO2 sensor.
Connect the finger clip.
Measure oxygen saturation on your own finger.
SpO2 display: > 95 %

☑ **3.16** **Backlighting** **[__________OK]**

Press the softkey to select the "Screen Layout".
Use the "brightness" turn knob to select and change the brightness.
The brightness control is working and the illumination is adequate.

Reset the brightness to its original setting.

3.17 **Checking O2, CO2 and anesthetic gas sampling**

Some test values for the patient gas module with electrochemical O2 cell (PGM) differ from those for the patient gas module with consumption-free O2 sampling (PGM2). A PGM2 can be recognized by the missing O2 cell mount. The type plate of the PGM2 module is attached there instead.

☑ **3.17.1** **Pump flow** **[__________OK]**

Info:
No calibration of the O2 sensor or the anesthetic gas analyzer may take place during checking of the pump flow.

Connect the upper connection of a flowmeter tube (measuring range 200 mL/min) to the water trap.
In a Primus with electrochemical O2 cell (can be recognized by the sensor mount on the rear of the Primus) the pump flow is 125 mL/min to 175 mL/min.
In a Primus with consumption-free O2 measurement (can be recognized by the missing sensor mount on the rear of the Primus) the pump flow is 175 mL/min to 225 mL/min.

Remove the flowmeter tube.

☑ **3.17.2 Checking sampling line** [________OK]

Close off the sampling tube.
The Primus screen indicates "Test sampling line".

Reconnect the sampling tube to the Y-piece.

3.17.3 O2 sampling

☑ **3.17.3.1 Linearity of O2 sampling** [________OK]

Set Primus to "standb"y mode.
Detach the patient tube from the expiratory socket of the breathing system.
Unlock the Primus safety flow control and set to a flow of 12 L/min. Wait approx. 30 s for the breathing system to be flushed.
Trigger a manual 100% O2 only if the PGM is fitted. To do so, open the "Standard Config" menu und confirm the "Parameter softkey.
Select and confirm "Cal. 100%O2" under "gas measurement".
Following successful calibration quit the "Config" menu. In Standby mode press the Standby key and start Monitoring mode.
Read off the O2 measurement.
PGM: Measured value 97% to 103%.
PGM2: Measured value 97% to 100 %.

Close and lock the safety flow control.
Detach the sampling line and hold it open to the ambient air for approx. 2 minutes.
Measured value 18 % to 24 %.

Info:
If the specified measurements are not attained with the electrochemical O2 sampling, replace the O2 sensor cell.
If the specified measurements are not attained with the consumption-free O2 sampling, inform DrägerService.

3.17.4 Gas measuring module function test

☑ 3.17.4.1 Checking anesthetic gas sampling and detection [__________OK]

Info:
For this test connect the anesthetic gas scavenging system or use an anesthetic gas filter.

Detach the anesthetic gas scavenging tube between the Primus and the AGS on the rear panel.
Remove the expiratory patient tube from the breathing system and connect the patient tube to the anesthetic gas scavenging tube.
Close off the expiratory socket of the breathing system.
Primus is in "Monitoring Mode.
Fit a vaporizer to the Primus.
Set the O2 safety flow control to 3 L/min.
Select the middle concentration setting on the vaporizer.
When the measurements have stabilized, the anesthetic gas detected by the Primus must match that of the vaporizer.

The measured anesthetic gas concentration closely matches the anesthetic gas concentration set on the vaporizer.

Close the vaporizer.
Close the O2 safety flow control.
Remove the test set-up.
Reconnect the anesthetic gas scavenging system to the rear panel of the Primus.

☑ 3.17.4.2 Testing of the CO2 and N2O sampling [__________OK]

Info:
Prior to testing, in the "Config" menu under "Parameter Settings" set the units to "vol.%". If the CO2 parameters are not configured, select the data screen.

Connect the calibration gas cylinder (8290271 and 8290272) via the calibration adapter (8290301).
Open the calibration gas cylinder until gas is escaping audibly from the adapter.
Read off the expiratory N2O and CO2 measurements from the Primus.
Measurement variation CO2 max. 0.5 vol.% from test gas.

Measurement variation N2O max. 6 vol.% from test gas.

Remove the test set-up.
Switch off the Primus.

☑ 3.18 Primus power-on test [_________OK]

Fit up and install the complete breathing system.
Connect the central supply.
Connect the mains power supply.
Connect the vaporizers.
Switch on the Primus.
On power-up and after approx. 10 seconds a short tone sounds.
[OK]

All LEDs of the monitor control panel have been activated.
[OK]

When the checklist appears, confirm it.
The power-on test is run through without error.
[OK]

The leakage value ”auto” is less than/equal to 100 mL/min.
[OK]

Primus switches to "Standb"y mode.
[OK]

3.19 Ventilation modes

Precondition:
The breathing system is completely upgraded and installed.
The central supply is connected.
Mains power is connected.
Primus is on.
The checklist has been confirmed.
The power-on test was completed without error.
Primus is in "Standb"y mode.

☑ 3.19.1 Manual ventilation [_________OK]

Connect the test lung.
Set Primus to Man/Spont mode.
Set the fresh gas flow to 2 L/min.
Press and hold down the flush button until the manual breathing bag is filled.
The manual breathing bag can be used to provide manual ventilation.
[OK]

☑ 3.19.2 Spontaneous breathing [_________OK]

Set the APL valve to "Spont" position.
The test lung can be used to provide spontaneous breathing.
[OK]

Set the APL valve to "Man." position.

☑ 3.19.3 Pressure-controlled ventilation and alarm limits test [__________OK]

Switch Primus to "PCV" mode (Press.Mode as of SW 2.0).

Select the following parameters:

Freq: 12 /min
Tinsp: 1.7 s
Ramp: 0.2 s (as of SW 2.0 Tslope: 0.2 s)
PEEP: 0 hPa
Pinsp: 20 mbar

Press the "next page" key to select the data screen.

Check the following measured values:
PLAT = 17 hPa to 23 hPa

PEEP = -2 hPa to +4 hPa

Use the "alarm limits" softkey to set the lower warning limit "Paw" to approx. 25 hPa.
An alarm message (in red) appears on-screen and the red alarm LED lights. A continuous tone sounds.

Use the "alarm limits" softkey to reset the lower warning limit "Paw".

☑ 3.19.4 Volume-controlled ventilation and flow measurement [__________OK]

Switch Primus to "IPPV" mode (Volume Mode as of SW 2.0).
Remove the sampling line of the "PGM" from the Y-piece and close off the connection on the Y-piece.

Select the following parameters:
PMAX: 70 hPa
VT: 500 mL
Freq: 12 /min
TINSP: 1.8 s
TIP:TINSP: 10 %
PEEP: 0 hPa

Press the "Adapt alarm limits" key.
After about 10 breaths check the VT measurement:
VT = 0.46 L/min to 0.54 L/min.
Set the parameter PEEP to 10 hPa.

After about 10 breaths check the following measured values:
PEEP = 8 hPa to 12 hPa.
[OK]

Connect the sampling line of the PGM to the Y-piece.

Set Primus to "standb"y mode.

4 Test equipment

4.1 List of test aids

The test aids are listed in the following table. The table lists the designations, characteristics and order numbers.

4.1.1 Pressure gauge (10 bar)

Measuring range = 10 mbar

4.1.2 Pressure gauge (100 mbar)

Measuring range 100 mbar

4.1.3 Flowmeter (200 mL/min.)

Measuring range to 200 mL/min.

4.1.4 Flowmeter (14 L/min.)

Measuring range to 14 L/min.

4.1.5 Flowmeter (45 L/min.)

Measuring range to 45 L/min.

4.1.6 Stop watch

4.1.7 Test lung (test thorax)

4.1.8 Calibration gas cylinder

Order number 8290271

4.1.9 Fine-control valve, complete

Order number 8290272

4.1.10 Calibration adapter

Order number 8290301

1 Technical Information

1.1 Layout of valves and diaphragms in the breathing system

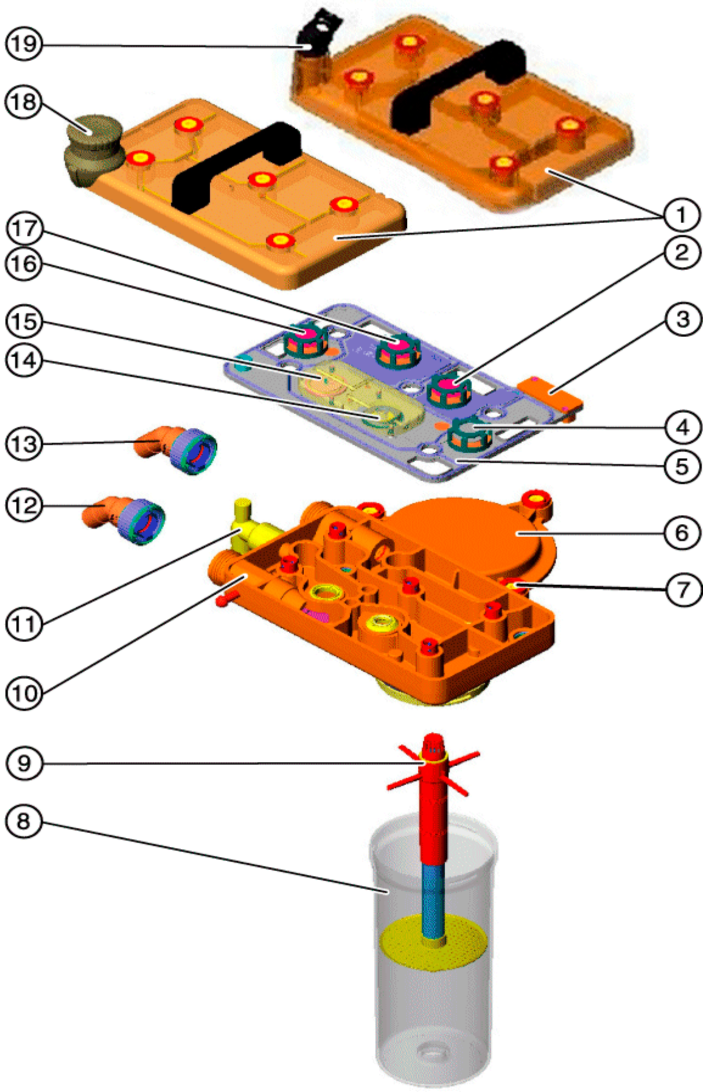


Figure 1 Breathing system

Table 1 **Legend to Figure 1**

Item	Component
1	Breathing system cover.
2	Valve “RV1”.
3	Breathing system heater contacts
4	Valve “RV2” (new design).
5	Valve plate.
6	Respiratory gas block.
7	Fixing screws.

Item	Component
8	Absorber canister.
9	Absorber element.
10	Expiratory flow sensor “Flowe”.
11	Connection for manual breathing bag “Bag”.
12	Expiratory socket.
13	Inspiratory socket with downstream inspiratory flow sensor “Flowi”.
14	APL bypass valve “V2”.
15	Valve “V1”, PEEP diaphragm.
16	Expiratory valve “Ve”.
17	Inspiratory valve “Vi”.
18	“APL” valve (adjustable pressuring limiting valve), new type.
19	“APL” valve (adjustable pressuring limiting valve), old type.

1.2 Bronchial suction devices

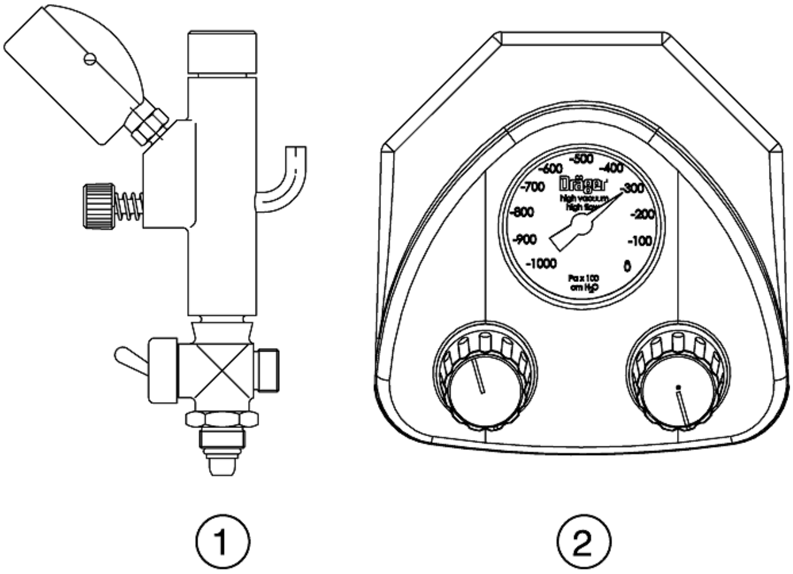


Figure 2 Types of bronchial suction devices

Table 2 **Legend to Figure 2**

Item	Designation
1	2M85032
2	MK01418 thru MK01423 (endotracheal bronchial suction devices).

1.3 Pneumatic diagram

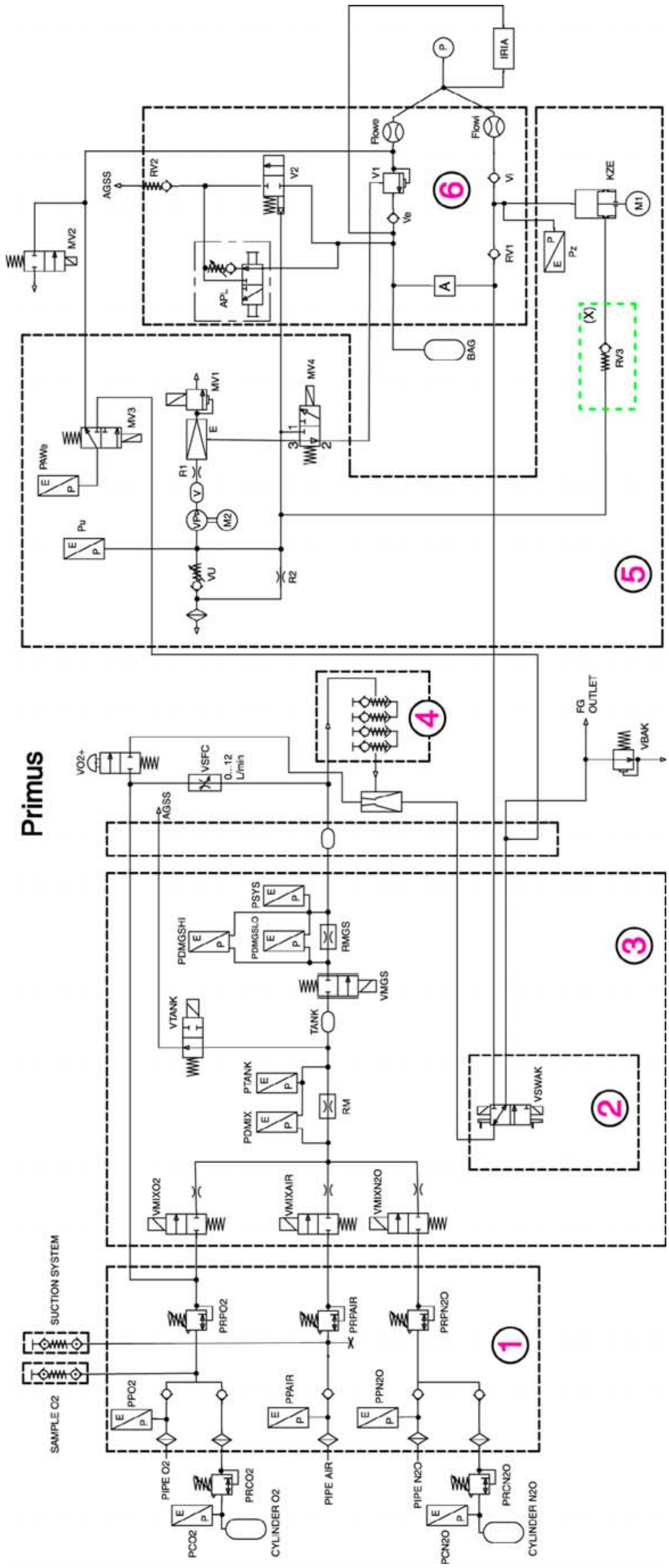


Figure 3 Primus pneumatic components diagram

Table 3 Legend to Figure 3

Item	Component
1	Gas inlet block.
2	A-cone valve (option).
3	Mixer.
4	Vaporizer plug-in system.
5	Ventilator.
6	Breathing system.

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Test Report TL

Institution		Product name	Primus
Contact		Reference number	

OK	Para		Result
	1	**Device configuration**	
	1.1	**Serial numbers**	
☐	1.1.1	Primus	txt
☐	1.1.2	Breathing system cover	txt
☐	1.1.3	Breathing system valve plate	txt
☐	1.1.4	Respiratory gas block	txt
	1.2	**Serial numbers (options)**	
☐	1.2.1	External bronchial suction device	txt
☐	1.2.2	High-pressure regulator O2	txt
☐	1.2.3	High-pressure regulator N2O	txt
☐	1.2.4	High-pressure regulator AIR	txt
☐	1.2.5	High-pressure cylinder O2	txt
☐	1.2.6	High-pressure cylinder N2O	txt
☐	1.2.7	High-pressure cylinder AIR	txt
☐	1.3.1	Mobi	txt
☐	1.3.2	MIXER MA	txt
☐	1.3.3	MIXER SV	txt
☐	1.3.4	VGC MA	txt
☐	1.3.5	VGC SV	txt
☐	1.3.6	PGM	txt
☐	1.3.7	Power pack	txt
	2	**Electrical safety**	
	2.1	**General**	
☐	2.2	**Visual check**	
	2.3	**Electrical safety according to VDE 0751**	
☐	2.3.1.2	PE conductor test value	
☐	2.3.2.1	Initial equivalent device leakage current	µA
☐	2.3.2.2	Repeat measurement of equivalent device l	µA
☐	2.3.3.1	Initial equivalent patient leakage current	µA
☐	2.3.3.2	Repeat measurement of equivalent patient l	µA
	2.4	**Electrical safety to IEC 60-601**	
☐	2.4.1.2	PE conductor test value	
☐	2.4.2.1	Earth leakage current N.C. (IEC)	µA
☐	2.4.2.2	Earth leakage current S.F.C. (IEC)	µA
☐	2.4.2.3	Earth leakage current N.C. reversed (IEC)	µA
☐	2.4.2.4	Earth leakage current S.F.C. reversed (IEC)	µA
☐	2.4.2.5	Earth leakage current N.C. (UL)	µA
☐	2.4.2.6	Earth leakage current S.F.C. (UL)	µA
☐	2.4.2.7	Earth leakage current N.C. reversed (UL)	µA
☐	2.4.2.8	Earth leakage current S.F.C. reversed (UL)	µA
☐	2.4.3.1	Patient leakage current N.C.	µA
☐	2.4.3.2	Patient leakage current N.C. reversed	µA
☐	2.4.3.3	Patient leakage current S.F.C.	µA
☐	2.4.3.4	Patient leakage current S.F.C. reversed	µA
	3	**Function and condition test**	
	3.1	**Input test**	
☐	3.1.2	Test sequence	
☐	3.2	**Accompanying documents**	
	3.3	**General condition of equipment**	
☐	3.3.1	Checking condition and legibility of marking	
☐	3.3.2	Condition/function of base unit	
☐	3.3.3.1	Breathing system cover	

OK	Para		Result
☐	3.3.3.2	Valve panel	
☐	3.3.3.3	Respiratory gas block	
☐	3.3.3.4	Absorber canister	
☐	3.3.3.5	Absorber insert	
☐	3.3.4	Condition/function of accessories	
☐	3.3.5.1	Condition of bronchial suction device	
☐	3.3.5.2	Condition/function of cylinder mount	
☐	3.3.5.3	Condition of secretion jar and accessories	
	3.4	**Vaporizer plug-in system**	
☐	3.4.1	Vaporizer plug-in system mounting pins	
☐	3.4.2	Interlock	
☐	3.4.3	Selectatec plug-in system interlock (if fitted)	
	3.5	**AGS system**	
☐	3.5.1	Condition of AGS system	
☐	3.5.2	Function of AGS system	
☐	3.5.3	Function of flow control in AGS USA variant	
	3.6	**Bronchial suction device (if fitted)**	
☐	3.6.1.1	Static end-pressure (type MK014xx)	
☐	3.6.1.2	Static end-pressure (type 2M85032)	
☐	3.6.1.3	Function of vacuum switch (type MK014xx)	
☐	3.6.2	Function of vacuum suction device	
☐	3.6.2.1	Function of vacuum switch (type MK014xx)	
	3.7	**High-pressure modification set (if fitted)**	
☐	3.7.1.1	Condition test of high-pressure regulator	
☐	3.7.1.2	TÜV expiry date, O2 high-pressure cylinder	dat
☐	3.7.1.3	TÜV expiry date, N2O high-pressure cylinde	dat
☐	3.7.1.4	TÜV expiry date, AIR high-pressure cylinder	dat
☐	3.7.1.5	Expiry date (AIR, O2 and N2O)	
☐	3.7.1.6	Condition of high-pressure cylinders	
☐	3.7.2.1	O2 performance test	
☐	3.7.2.2	N2O performance test (if fitted)	
☐	3.7.2.3	AIR performance test (if fitted)	
☐	3.7.3.1	O2 downstream pressure test	bar
☐	3.7.3.2	O2 downstream pressure test	bar
☐	3.7.3.3	N2O downstream pressure test	bar
☐	3.7.3.4	N2O downstream pressure test	bar
☐	3.7.3.5	AIR downstream pressure test	bar
☐	3.7.3.6	AIR downstream pressure test	bar
☐	3.7.4.1	O2 opening pressure	bar
☐	3.7.4.2	N2O opening pressure (if available)	bar
☐	3.7.4.3	AIR opening pressure (if available)	bar
☐	3.7.5	High-pressure sensors reference pressure te	
☐	3.8	**Function of UPS**	
☐	3.9	External O2 flowmeter (if fitted)	
☐	3.10	**LEDs and sensors of the central supply**	
☐	3.11	Fresh gas flow	
☐	3.11.1.1	Target 1 L/min	L/min
☐	3.11.1.2	Target 8 L/min	L/min
☐	3.11.1.3	Target 14 L/min	L/min
	3.11.2	**Function of safety flow control**	
	3.12	**Function of O2 flush**	
☐	3.12.1	O2 flush colour marking	

☐	3.12.2	Flow of O2 flush ______ L/min	☐	3.17.3.1	Linearity of O2 sampling
☐	3.12.3	Mechanical functioning of O2 flush	☐	3.17.4.1	Checking anesthetic gas sampling and dete
	3.13	**Function of A-cone (if fitted)**	☐	3.17.4.2	Testing of the CO2 and N2O sampling
☐	3.13.1	A-cone safety valve	☐	3.18	**Primus power-on test**
☐	3.14.1	APL valve test ______ hPa		3.19	**Ventilation modes**
☐	3.14.2	Variation of Primus pressure measurement	☐	3.19.1	Manual ventilation
☐	3.15	SpO2 (if fitted)	☐	3.19.2	Spontaneous breathing
☐	3.16	Backlighting	☐	3.19.3	Pressure-controlled ventilation and alarm lim
☐	3.17.1	Pump flow	☐	3.19.4	Volume-controlled ventilation and flow meas
☐	3.17.2	Checking sampling line			

Servicing Parts

Para	Order Number	Qty.	Interv.	Para	Order Number	Qty.	Interv.

Test equipment			Test equipment		
Designation	Serial number	Next calibration	Designation	Serial number	Next calibration

Report			
Date		Institution	
Name		Name	
Signature		Signatur	

Technical Information

Dräger medical
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2006-03-16

Technical Documentation for Primus
according to EMC standard IEC/EN 60601-1-2: 2001

General Information

The EMC conformity of Primus includes the use of following external cables, transducers and accessories .... (refer to the following list with either precise part properties or precise part names):

Description	Order-No.
Mains supply cable, 16A, 5m	8601589 and others
RS-232-cable	8601474
SPO2-sensor extension cable	8600859, 5720071
Draeger Base connection cable	8602718
SPO2 finger sensor DS100A	7262764
Pressure reducer O2	8603465
Pressure reducer N2O	8603464

The Primus should not be used adjacent to or stacked with other equipment; if adjacent or stacked use is inevitable, the Primus should be observed to verify normal operation in the configuration in which it will be used.

Electromagnetic Emissions

Electromagnetic Emissions		
The Primus is intended for use in the electromagnetic environment specified below. The user of the Primus should assure that is used in such an environment.		
Emissions	**Compliance according to**	**Electromagnetic environment**
RF emissions (CISPR 11)	Group 1	The Primus uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
	Class B	The Primus is suitable for use in all establishments including domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions (IEC 61000-3-2)	N/A	Class B
Voltage fluctuations / flicker (IEC 61000-3-3)	N/A	Class B

Information re electromagnetic emissions (IEC 60101-1-2: 2001, table 201)

Electromagnetic Immunity

Electromagnetic Immunity			
The Primus is intended for use in the electromagnetic environment specified below. The user of the Primus should assure that is used in such an environment.			
Immunity against	**IEC 60601-1-2 test level**	**Compliance level (of Primus)**	**Electromagnetic environment**
electrostatic discharge, ESD (IEC 61000-4-2)	contact discharge: 6 kV air discharge: 8 kV	6 kV 8 kV	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.
electrical fast transients / bursts (IEC 61000-4-4)	power supply lines: 2 kV longer input / output lines: 1 kV	2 kV 1 kV	Mains power quality should be that of a typical commercial or hospital environment.
surges on AC mains lines (IEC 61000-4-5)	common mode: 2 kV differential mode: 1 kV	2 kV 1 kV	Mains power quality should be that of a typical commercial or hospital environment.
power frequency magnetic field 50/60 Hz (IEC 61000-4-8)	3 A/m	N/A	In close vicinity to the Primus, no equipment with extraordinary power frequency magnetic fields (power transformers, etc.) should be operated.
voltage dips and short interruptions on AC mains input lines (IEC 61000-4-11)	dip >95%, 0.5 periods dip 60%, 5 periods dip 30%, 25 periods dip >95%, 5 seconds	>95%, 0.5 per. 60%, 5 per. 30%, 25 per. >95%, 5 sec.	Mains power should be that of a typical commercial or hospital environment. If user requires continued operation during power mains interruptions, it is recommended to power the Primus from an uninterruptible supply or a battery.
radiated rf (IEC 61000-4-3)	80 MHz – 2.5 GHz: 10 V/m	10 V/m	Recommended separation distance from portable and mobile rf transmitters with transmission power P_{EIRP} to the Primus including its lines: 1.84 m * P_{EIRP} [X1]
rf coupled into lines (IEC 61000-4-6)	150 kHz – 80 MHz: 10 V within ISM bands, 3 V outside ISM bands [X2]	10 V 3 V	Recommended separation distance from portable and mobile rf transmitters with transmission power P_{EIRP} to the Primus including its lines: 1.84 m * P_{EIRP} [X1]

Information re electromagnetic immunity (IEC 60601-1-2: 2001, tables 202, 203, 204)

[X1]: For P_{EIRP} the highest possible "equivalent isotropic radiated power" of the adjacent rf transmitter has to be inserted (value in Watt). Also in the vicinity of equipment marked with the symbol interference may occur. Field strengths from fixed, portable or mobile rf transmitters at the location of the Primus should be less than 3 V/m in the frequency range from 150 kHz to 2.5 GHz and less than 1 V/m above 2.5 GHz.

[X2]: ISM bands in this frequency range are: 6.765 MHz - 6.795 MHz, 13.553 MHz - 13.567 MHz, 26.957 MHz - 27.283 MHz, 40.66 MHz - 40.70 MHz.

Recommended separartion distances

Recommended separation distances between portable and mobile RF-Telecommunication devices and the Primus			
max. P_{EIRP} (W)	**3 V/m distance* (m)**	**1 V/m distance* (m)**	**Hint**
0.001	0.06	0.17	
0.003	0.10	0.30	
0.010	0.18	0.55	
0.030	0.32	0.95	e.g. WLAN 5250 / 5775 (Europe)
0.100	0.58	1.73	e.g. WLAN 2440 (Europe), Bluetooth
0.200	0.82	2.46	e.g. WLAN 5250 (not in Europe)
0.250	0.91	2.75	e.g. DECT devices
1.000	1.83	5.48	e.g. GSM 1800- / GSM 1900- / UMTS- mobiles, WLAN 5600 (not in Europe)
2.000	2.60	7.78	e.g. GSM 900 mobiles
3.000	3.16	9.49	

Information re separation distances (IEC 60601-1-2: 2001, tables 205 and 206)

* 3 V/m distance to transmitters with frequencies from 150 kHz to 2.5 GHz, otherwise 1 V/m distance.

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Directive 93/42/EEC
concerning Medical Devices

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The warranty and liability conditions of the general terms and conditions for business transactions of Dräger Medical AG & Co. KG are not extended by this Technical Documentation.