HEYER MEDICAL AG

HEYER Narkomat+ ®

Anesthesia System

Service Manual

Rev.2.1.0

Software version	Service software: 1.8.3

HEYER MEDICAL AG

Carl-**HEYER**-Strasse 1-3
56130 Bad Ems

Germany

Tel. +49 - 2603 – 791 - 3

Fax. +49 - 2603 – 791 - 209

E-mail: info@HEYERmedical.de

0 Table of Contents

0.1 Table of Figures

1 General Information

1.1 Guidelines

The information in this service manual exclusively refers to servicing and maintenance work of the anesthesia system **HEYER** Narkomat^{+}.
Please, read from the operator's manual **HEYER** Narkomat^{+} the service, setting, maintenance and care of the apparatus, normally carried out by the user.
These service instructions are to be used only by a skilled, trained and authorized service staff. The servicemen must be provided with the specified special tools and accessories. This service manual is utilized for business affairs and general customized information. **HEYER** gives no guaranty when using the information.
The service technicians should have read and fully understood the service instructions prior to beginning with their service duties. The functional principles of the apparatuses have also been described in the user's manual. The user's manual contains general precautions, which are also of importance to the service technician.

1.2 Product improvements

HEYER reserves the right to improve their products or revise the instructions without prior notice. This manual deals with the status of the anesthesia system **HEYER** Narkomat^{+} at the time of issue.
HEYER is not obliged to retrofit former models subject to improvements and modifications. An exception to be examined will be made when improvements or modifications due to design and production deviations are influencing the patient's safety or would entail malfunctioning of the apparatus.

1.3 Manufacturer's Liability

HEYER can only be held liable for safety, reliability and fail-safe operation of the system, provided that:

- the system was being operated in conformity with the instructions given by the manufacturer,
- certifications, readjustments, changes, or repairs have been carried out by authorized personal,
- service and maintenance was being made in conformity with the instructions given by the manufacturer.
- the system was operated in a building with grounding equipment in compliance with the regulations issued by IEC, NFPA, and UL.

In no event will **HEYER** be liable for any special, incidental, or consequential damages, including loss of profits, whether or not foreseeable and even **HEYER** has been advised of the possibility of such loss or damage.
HEYER disclaims any liability arising from a combination of its product with products from other manufacturers if the combination has not been endorsed by **HEYER**.
Buyer understands that the remedies noted in **HEYER**'s limited warranty are its sole and exclusive remedies.

1.4 Manufacturer's specification

Product: HEYER NARKOMAT^{+}

Manufacturer:

HEYER Medical AG

Carl-**HEYER**-Strasse 1-3
56130 Bad Ems

Germany

Tel. + 49 2603 / 791-3

Fax. +49 2603 / 791-209

E-mail: info@HEYERmedical.de

1.5 Updating status

State of this service manual: Rev. 2.1.0 of March 2004

1.6 Warning, Precautions and Notes

Warnings alert the user to potential serious outcomes (death, injury or serious adverse events) to the patient or user.

Precautions alert the reader to exercise special care necessary for the safe and effective use of the device

Notes are a general information statement concerning the Narkomat^{+}

Please read adhere to all warning, precautions and notes listed here and in the appropriate areas THROUGHOUT THIS MANUAL.

1.6.1 WARNINGS

WARNING: The Narkomat^{+} anesthesia machine works on line voltage and at high pressure. Therefore, an electric shock hazard may exist when the instrument covers are removed. Repair and calibration procedures should only be performed by qualified personnel who follow proper servicing techniques. Warnings are given in appropriate locations

WARNING: In order to prevent an electrical shock, the machine (protection class I) may only be connected to a correctly grounded mains connection (socket outlet with grounding contact).

WARNING: Possible explosion hazard. Do not operate near flammable substances.

WARNING: The use of anti-static or electrically conductive breathing tubes, when utilizing high frequency electric surgery equipment, may cause burns and is therefore not recommended in any application of this machine.

WARNING: Possible fire hazard. Fuses (i.e., additional sockets) must only be replaced by fuses of the same type and with the same rating.

WARNING: Possible shock hazard. The machine may only be opened by qualified and authorized service personnel.

WARNING: Compressed gasses are considered dangerous goods/hazardous materials per I.A.T.A. Regulations. It is a violation of international law to offer any package or over pack of dangerous goods for transportation without the package being appropriately identified, packed, marked, classified, labeled and documented according to I.A.T.A. Regulations. Please refer to the applicable I.A.T.A dangerous goods regulations for further information.

WARNING: Never block airflow at the drive gas outlet. Blocking the drive gas outlet raises internal pressures above specified limits and will result in permanent damage to internal sensors.

1.6.2 PRECAUTIONS

CAUTION: Refer to the maintenance intervals in the preventive maintenance section for guidance on which steps are preformed when.

CAUTION: Use surgical gloves whenever touching or disassembling valves or other internal components of the patient module.

CAUTION: If possible, always connect the output of the APL valve to the anesthetic removal line, usually installed in the operation theater.

CAUTION: Carry out the daily checks specified on the checklist and do not operate the system in case of a fault until the fault has been repaired.

CAUTION: The patient should be visually monitored by qualified personnel. In certain situations circumstances may occur which may not necessarily trigger an alarm.

CAUTION: Always set the alarm limits so that the alarm is triggered before a hazardous situation occurs. Incorrectly set alarm limits may result in operation personnel not being aware of changes in the patient's condition.

CAUTION: This machine must only be operated by trained, skilled medical staff.

CAUTION: Before starting the machine, the operating personnel must be familiar with operating instructions and must have been instructed by a qualified instructor.

CAUTION: If the machine does not function as described, the machine must be examined and possibly repaired by qualified service personnel, before being returned to use.

CAUTION: Handle the machine with care to prevent damage or functional faults.

CAUTION: Ensure that the gas supply of the machine always complies with the technical specification.

CAUTION: Before clinical use, the machine must be correctly calibrated and/or the respective machine tests performed, as described in the operation instructions.

CAUTION: If the machine should show faults during the initial calibration or testing, the machine should not be operated until the fault has been repaired by a qualified service technician.

CAUTION: After servicing, functional, sensor and system tests must be carried out before clinical use.

CAUTION: Only bacteria filters with a low flow resistance must be connected to the patient module and/or patient connector.

CAUTION: Failure to connect device to a grounded mains outlet may elevate leakage current in excess of permissible values.

CAUTION: During transportation of the patient module, transportation should be applied to the rear to protect the valve connectors.

CAUTION: After changing the co_2 absorbent, carry out a system leak test.

CAUTION: The spring in the top of the APL valve may not be stressed. After removal, place to one side, taking care that the spring is not unduly loaded.

CAUTION: Only selectatec™ compatible vaporizers with interlock system may be used with the Narkomat$^+$ unit**.**

CAUTION: After each exchange of a vaporizer, carry out a system leak test.

CAUTION: Use cleaning agent sparingly. Excess fluid could enter the machine causing damage.

CAUTION: The patient dome of the bellows system cannot be autoclaved. It is not in contact with the ventilation gas. If soiled, the patient dome should be cleaned with water and liquid cleaning agent. The unit can be disinfected with a standard surface-disinfecting agent. Do not use alcohol.

CAUTION: Do not clean the machine while it is on and/or plugged in.

CAUTION: Pressing quit at any time during the calibration procedure will cancel the session's settings and reload the previously stored calibration coefficients.

1.6.3 NOTES

NOTE: Unauthorized servicing may void the remainder of the warranty. Check with the factory or with a local authorized **HEYER** dealer to determine the warranty status of a particular instrument.

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2 Theory of Operation

The anesthesia system **HEYER** NARKOMAT$^+$ represents a flexible employable workstation to apply and monitor anesthesia inhalation in semi-closed and almost closed circuits in low flow techniques for minimized consumption of gas and anesthetics.
The basic model Narkomat$^+$ includes the following components:

2.1 Microprocessor-Controlled Ventilator

The Microprocessor-controlled ventilator allows with its dedicated patient module time-controlled, pressure limited, and a constant volume controlled ventilation for all patient groups of a body weight of 3 kg upwards.
The system compliance of the patient module and respiratory tubes are automatically compensated by the ventilator. Low tidal volumes, therefore, can be dosed very accurately.
Thanks to the different ventilation modes, a ventilation is feasible, even in case of complicated lung conditions.
A comprehensive test and alarm management system prevents uncontrollable operating conditions and therefore provides the patient a high safety standard.
The ergonomically designed control surface allows an easy operation of the ventilator. The display informs about the selected ventilation parameters and the measured values for volume, pressure, FiO_2 and shows real time curves of the expiratory flow and airway pressure.

2.2 Patient Module

The patient circuit is integrated in a compact aluminum block. This block is brought to a moderate temperature to avoid the formation of water vapor. In additional, it includes a controlled emergency valve, a reservoir in form of a manual respiratory bag and an expiratory flow sensor.
The patient module is connected to the basic unit through a locking handle. Activating the locking handle pulls the block toward the basic unit, and all connections to the docking block are checked in the compliance- and leak tests.

2.3 Gas Conditioning Unit

The flow meter block features all the necessary safety facilities, such as O_2 pressure loss alarm and N_2O shut-off. An integrated pneumatically controlled system provides a minimum of 25% oxygen concentration in the fresh gas flow at all flow settings (ratio system).

2.4 The Ventilator Unit

The microprocessor-controlled ventilator allows time-controlled, volume-constant and pressure-limited (CMV) or pressure targeted (PCV) artificial respiration without assisted or synchronized control functions. The system also allows manual respiration as well as spontaneous respiration of the patient. Adjustable PEEP, breathing time ratios (I:E) and pressure sustaining plateau functions are available.
Volume-constant respiration is effected by the time control of the respirator and the fresh gas decoupling of the patient module. The ventilator computes the inspiratory flow required for the settings tidal volume (Vt), respiratory rate and the ventilation time ratio (I:E). The resultant tidal volume (Vt) is delivered to the patient at high accuracy

2.5 Adjustable Alarms

Minimum and maximum alarm limit settings are available for Peak Pressure, Mean Pressure and FiO_2 minimum alarm settings are available for tidal volume and minute volume.

2.5.1 P_{max} limiting on alarm violation

Exceeding the P_{max} alarm limit automatically halts the inspiratory phase preventing airway pressure from exceeding the high alarm setting. in the CMV mode, the setting of the p_{max} peak pressure provides pressure limitation. when reaching this pressure limit, a warning (alarm) “peak greater than p_{max}” is displayed, and the inspiration is discontinued. The next inspiration is at a regular time interval, the time control of the respiratory unit does not increase the respiratory rate. the result is a decrease of the tidal volume “Vt” and minute volume “m vol.”. The respirator responses to pressure limitation through displaying the p_{max} alarm constantly.

2.6 Fresh Gas Decoupling

The tidal volume (Vt) is adjusted independently of the adjusted fresh gas flow. This is achieved by fresh gas decoupling. In inspiratory procedure the fresh gas flow is uncoupled by the decoupling and expiratory diaphragm valves from the internal subsystem of the patient module. Fresh gas either is filling the manual respiration bag (reservoir) or is led into the scavenging through the airway pressure relief valve.

2.7 Compliance Compensation

The tidal volume (Vt) is automatically corrected in response to the compliance of the patient module and patient tubes. Volume reduction due to system compliance is compensated as a result of this.

2.8 Electrical supply

The line cord of the Narkomat^{+} is connected to an internal terminal block. Directly connected to this terminal are convenience receptacles and the unit itself. Line supply to the receptacles is available with the line cord connected. Line supply for the unit is switched by the main switch at the right side of the unit. The two pole switched power supply is protected by each one 5A circuit breaker. The switched line supply is connected to the AC IN connector on power supply board AVM 2-1. Another third pole of the main switch is connected via the terminal to the board AVM 2-1 (X5:5,6), enabling to detect a main switch OFF position or missing line supply.

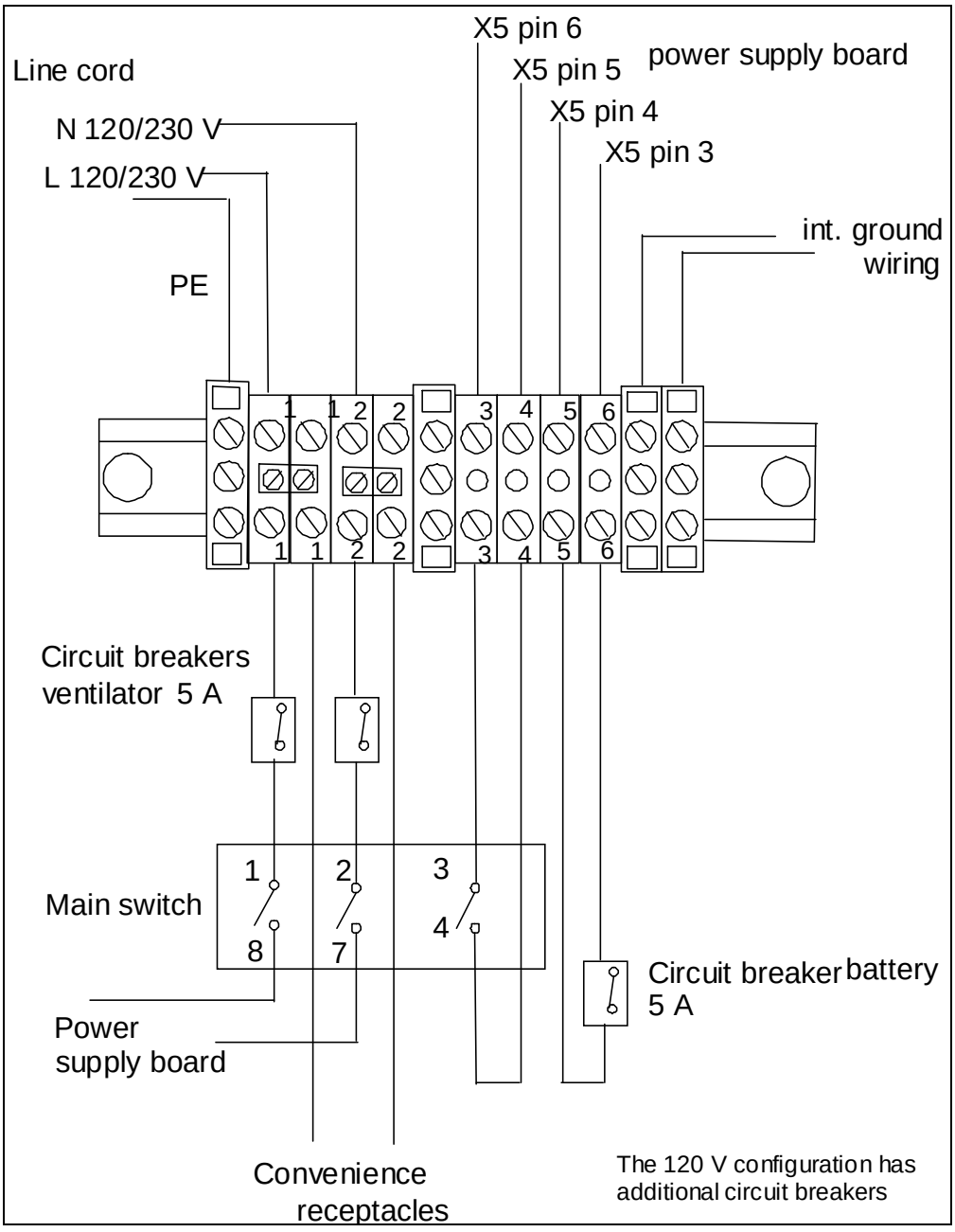


Fig. 1 Line Terminal Block, 120/230V_{AC} Supply

2.8.1 Electrical components

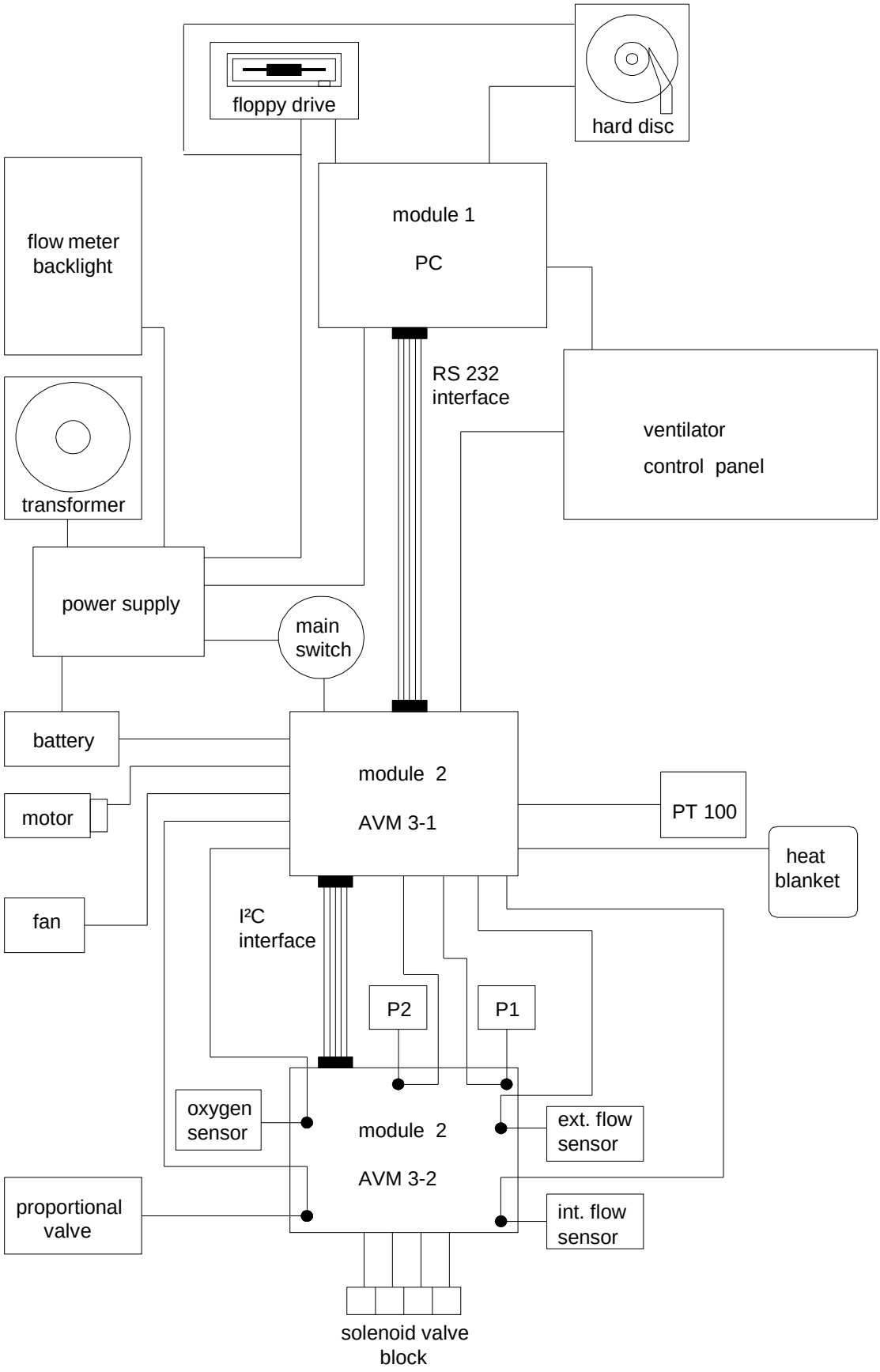


Fig. 2 Overview electrical components

2.9 Power supply module

The power supply module is located in the frame behind the drawers. This module serves for the voltage supply of the ventilator modules 1 and 2, the flow meter block illumination, the patient circuit heating blanket and the charging / discharging control for the battery. The power supply board allows the supply with 230 VAC or 115 VAC, the supply voltage can be selected with a switch on the power supply board.

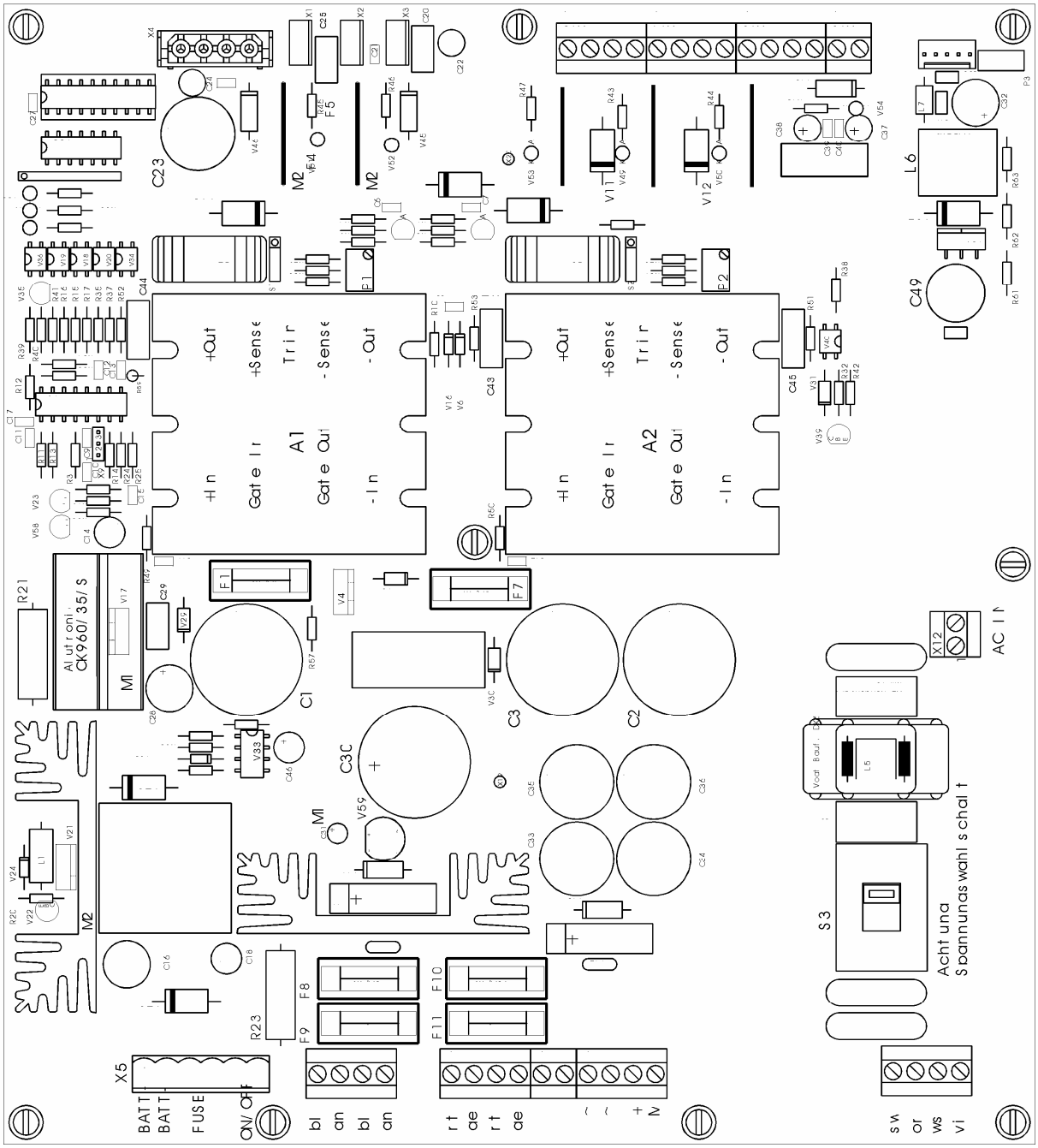


Fig. 3 Power supply module

2.9.1 Connectors on power supply board AVM 2-1

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X1	Module 1	X1-1	+5V	yellow
		X1-2	GND	red
		X1-3	GND	green
		X1-4	+12V	blue

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X2		X2-1	+5V	
		X2-2	GND	
		X2-3	GND	
		X2-4	+12V	

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X3		X2-1	-	
		X2-2	-	
		X2-3	GND	
		X2-4	+12V	

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X4		X4-1	+5V	
		X4-2	GND	
		X4-3	GND	
		X4-4	+12V	

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X5	Battery,	X5-1	BATT+	brown
	Fuse for Battery	X5-2	BATT-	black
	Main switch	X5-3	Cir.break. bat.	black 6
		X5-4	Cir.break. bat.	black 5
		X5-5	Main switch	black 4
		X5-6	Main switch.	black 3

Connector	connected to	Pin. def.	Func. / Signal	Color wire isolat.
X6	Transformer	X6-1	sec.IIa 15V_{AC}	blue
RT110/12	secondary	X6-2	sec IIa	green
		X6-3	sec. IIb 15V_{AC}	blue
		X6-4	sec IIb	green

Connector	connected to	Pin. def.	Func. / Signal	Color wire isolat.
X7	Transformer	X7-1	prim.I, L120/230V_{AC}	black/
RT110/12	primary	X7-2	prim.I, N120/230V_{AC}	orange
		X7-3	prim.II,L120/230V_{AC}	white
		X7-4	prim. II, .	violet

Connector	connected to	Pin. def.	Func. / Signal	Col. wire isolat.
X11	Transformer	X11-1	Sec.Ia 22V_{AC}	red
RT110/22	secondary	X11-2	Sec Ia	yellow
		X11-3	Sec. Ib 22V_{AC}	red
		X11-4	Sec Ib	yellow

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X12	int. connection	X12-1	AC, N 110V/230V	blue
AC IN	terminal	X12-2	AC , L 110V/230V	black

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X13	Module 2	X13-1	+12V	red
	Board	X13-2	GND	blue
	AVM 3-2	X13-3	+5V(1)	red
		X13-4	GND	blue

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X14	Module 2	X14-1	+5V(2)	red
	Board	X14-2	GND	blue
	AVM 3-2	X14-3	-12V	red
		X14-4	GND	blue

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X15	Module 2	X15-1	Control Sign.	white
	Board	X15-2	Control Sign.	white
	AVM 3-2	X15-3	Control Sign.	white
		X15-4	Control Sign.	white

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X16	Module 2	X16-1	GND	blue
	AVM 3-2	X16-2	+31V	red

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X17	solid state relay	X17-1	22VAC to heat. bl.	black
	heating blanket	X17-2	22VAC to relay	black
		X17-3	+ Control voltage	black
		X17-4	GND	black

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X22	DC-AC convert.	X22-1	+supply voltage	red
	for flow meter	X22-2	-	
	illumination	X22-3	-	
		X22-4	GND	black

2.9.2 Fuses on power supply board AVM 2-1

Fuse No.	Fuse value	Fuse protects
F1	4 A MT, medium slow-blow	DC / DC-converter +5V
F7	8 A M, medium -blow	DC / DC-converter +12V
F8	8 A M, medium -blow	Transformer, Sec. IIa
F9	8 A M, medium -blow	Transformer, Sec. IIb
F10	10 A T, slow-blow	Transformer, Sec. Ia
F11	10 A T, slow-blow	Transformer, Sec. Ib

2.9.3 Charging / discharging control for the battery:

The charging / discharging control for the battery is also located on the power supply board AVM 2-1. Status indicators as red, green and yellow LEDs are located on the board to show functions like check or charging of the battery.

2.9.4 Status Indicators Of Battery Control:

LED	**LED light**	**Battery status**
LED yellow (V28)	Continuous	charging
LED yellow (V28)	Flashing	check
LED green (V37)	Continuous	fully charged
LED red (V38)	flashing or continuous.	defect

2.10 Module 1

Ventilator module 1 consists of a File-PC with an I/O card, memory card and 3,5” floppy drive. This module serves for the operation of the user surface with different menus displayed on a 10.4” color TFT display in combination with the settings from the control panel.
All safety functions, e.g. the complete ventilator control, are located on ventilator module 2. Module 1 is connected to module 2 by means of an RS 232C- interface. Module 1 has no safety function for the ventilator control. It serves to give the functions for parameter and alarm settings to module 2. Module 2 sends the measured parameters or generated alarm signals to module 1 to display.

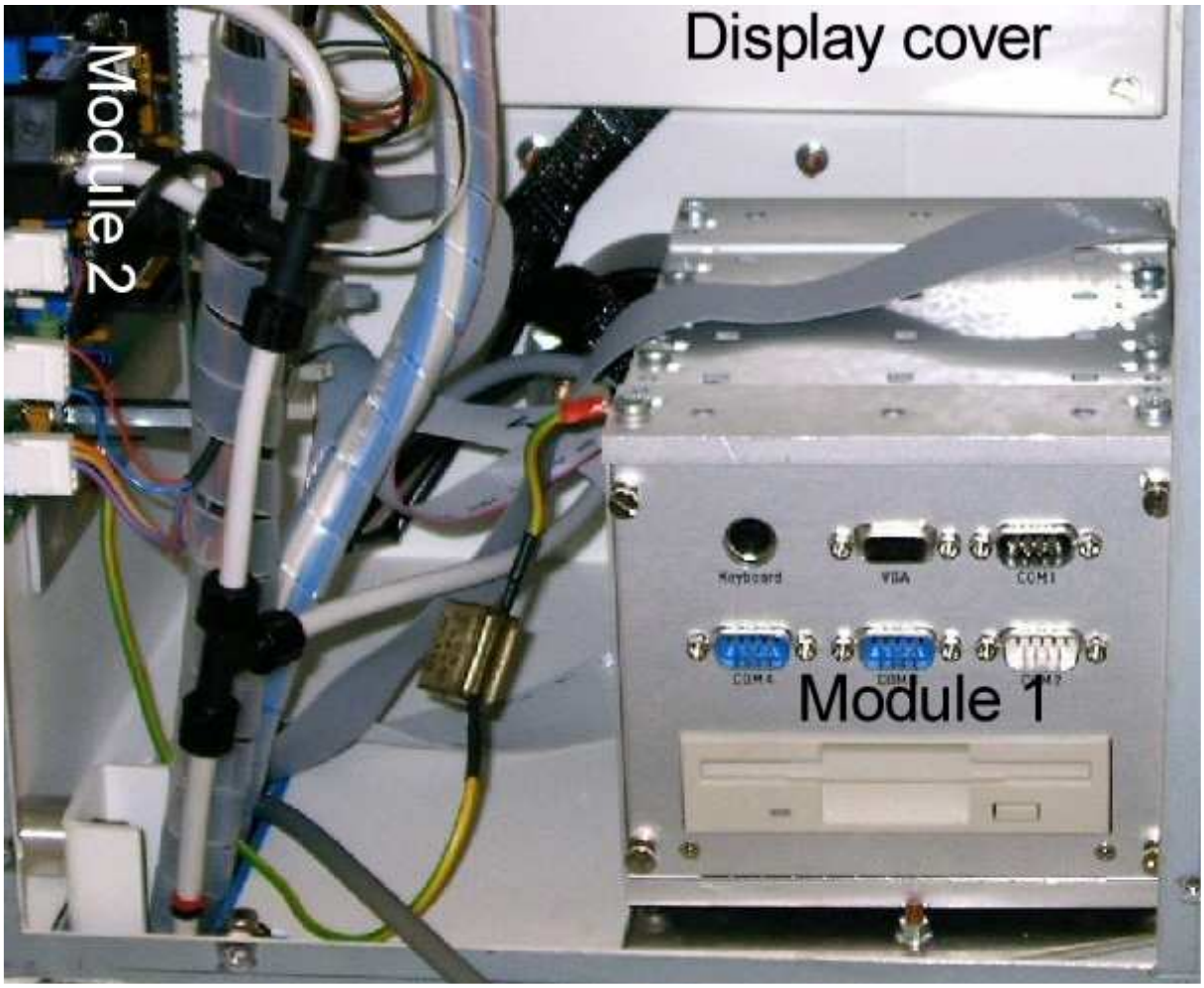


Fig. 4 Module 1 File-PC

2.10.1 Connectors on module 1

Connector	connected to	Plug conf.	Func. / Signal
X4	Module 2	10 pole	Communication with module 2

Connector	connected to	Plug conf.	Func. / Signal
X5	EL Display	20 pole	Connected to the display

Connector	connected to	Plug conf.	Func. / Signal
X6	Power supply	4 pole	Power suppy

Connector	connected to	Plug conf.	Func. / Signal
X7	Touch screen	32 pole	communication with touch screen

Connector	connected to	Plug conf.	Func. / Signal
X8	Module 2	14 pole	communication with module 2

Connector	connected to	Plug conf.	Func. / Signal
X9	Module 2	28 pole	communication with module 2

Connector	connected to	Plug conf.	Func. / Signal
X10	Selector switch	14 pole	communication With the selector switch

Connector	connected to	Plug conf.	Func. / Signal
X19	LCD Display	Flat cable connector	Connected to the display

Connector	connected to	Plug conf.	Func. / Signal
X20 (on the backside)	Display illumination	4 pole	Power supply display illumination

2.11 Ventilator Module 2, AVM 3-1 and AVM 3-2

Ventilator module 2 serves for the active ventilator control. Module 2 consists of two CPU boards, the CPU board AVM3-1 with µP1 serves for a continuous validation of control actions generated by CPU board AVM3-2 and for the communication between module 2 and module 1.
The CPU board AVM3-2 with µP2 generates all active control signals, after a validation of these signals by µP1, AVM3-2 is enabled to operate the different active elements like the solenoid vales and proportional valve.

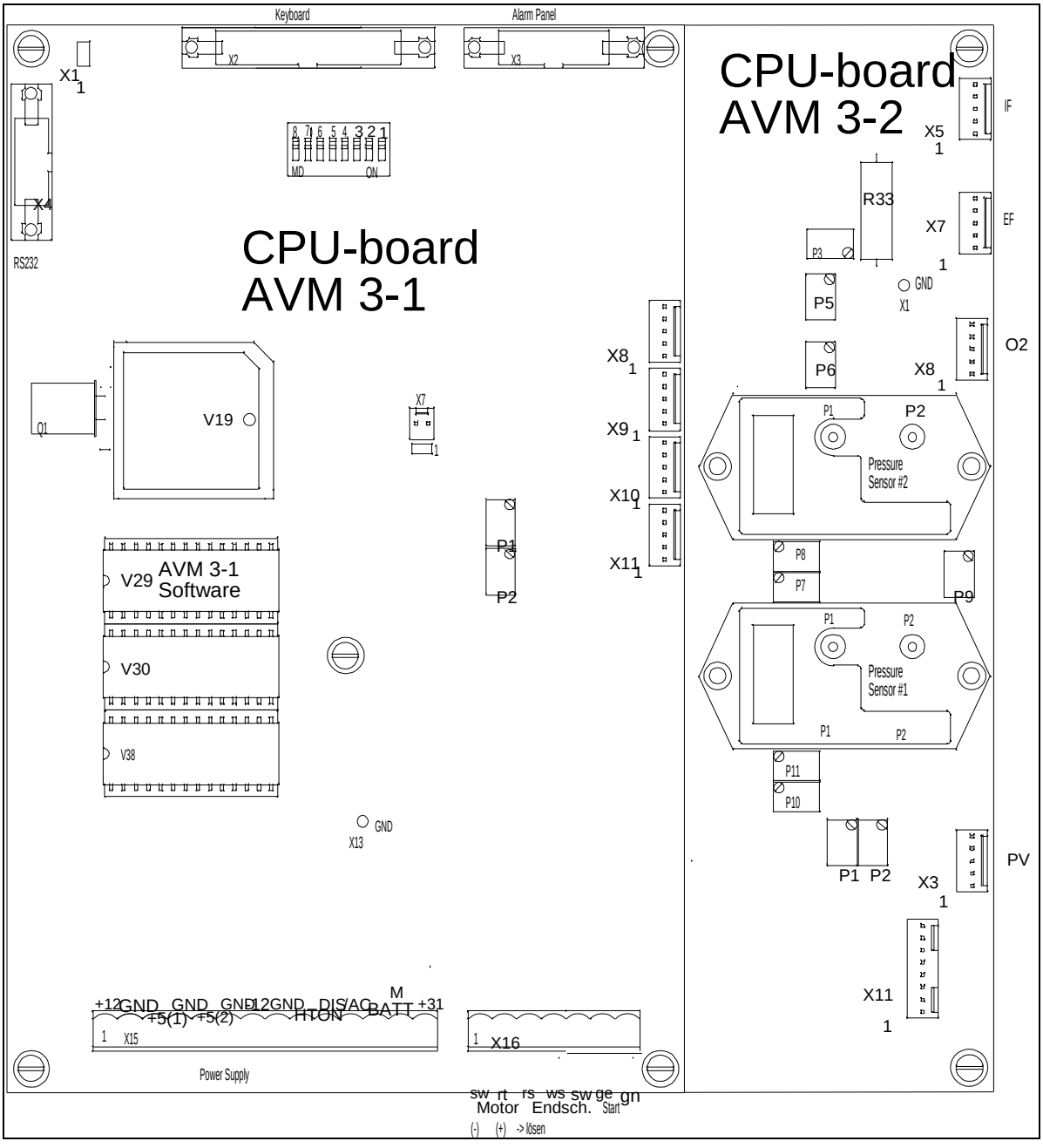


Fig. 5 View on module 2

2.11.1 Parts list module 2

Pos. No.	Description	Order No.
1	Ventilator module 2, complete	460-1150

2.11.2 Connectors on module 2

2.11.2.1 Plug connectors on board AVM 3-1

Connector	**connected to**	**Plug conf.**	**Func. / Signal**
X2	Module 1	28 pole	communication with module 1

Connector	**connected to**	**Plug conf.**	**Func. / Signal**
X3	Module 1	14 pole	communication with module 1

Connector	**connected to**	**Plug conf.**	**Func. / Signal**
X4	Module 1	10 pole	communication with module 1

Connector	**connected to**	**Pin. def.**	**Func. / Signal**	**Color / No.**
X7	PT-100 sensor	X7-1	temperature dep.	blue
		X7-2	resistance	red

Connector	**connected to**	**Pin. def.**	**Func. / Signal**	**Color / No.**
X9 FAN	Fan ventilator pneumatic module	X9-1	+12V	red
		X9-2	fan control signal	yellow
		X9-3	n.c.	
		X9-4	n.c.	
		X9-5	GND	black

Connector	**connected to**	**Pin. def.**	**Func. / Signal**	**Color / No.**
X10 Driving gas switch	Driving gas switch to detect a failure of the gas supply	X11-1	+12V	white
		X11-2	GND	brown
		X11-3	n.c.	
		X11-4	n.c.	
		X11-5	n.c.	

Connector	**connected to**	**Pin. def.**	**Func. / Signal**	**Color / No.**
X11 HTSEC	over temperature switch (NC) patient block heating	X11-1	$22V_{AC}$ when	red
		X11-2	switch is open	blue
		X11-3	n.c.	
		X11-4	n.c.	
		X11-5	n.c.	

2.11.2.2 Plug connectors on board AVM3-2

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X5	internal	X5-1	signal (+1-5 V)	orange
IF	flow sensor	X5-2	+10V	mint
		X5-3	GND.	violet
		X5-4	n. c.	
		X5-5	n. c.	

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X7	external	X7-1	flow dep. signal.	red
EF	flow sensor	X7-2	n.c.	
		X7-3	n.c.	
		X7-4	n.c.	
		X7-5	flow dep. signal.	blue

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X8	Oxygen cell	X8-1	n. c.	
O2		X8-2	+ voltage fuel cell	red
		X8-3	- voltage fuel cell	blue
		X8-4	n.c.	
		X8-5	n.c.	

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X3	proportional	X3-1	+ 12V	blue
PV	valve	X3-2	n. c.	
		X3-3	control volt. 0-5V	gray
		X3-4	n.c.	
		X3-5	GND	green

Connector	connected to	Pin. def.	Func. / Signal	Color / No.
X11	solenoid	X11-1	GND (MV4)	brown / 1
	valve	X11-2	+ 10V (MV4)	red / 2
	block	X11-3	GND (MV3)	orange / 3
		X11-4	+ 10V (MV3)	yellow / 4
		X11-5	GND (MV1)	green /5
		X11-6	+ 10V (MV1)	blue / 6
		X11-7	GND (MV2)	violet / 7
		X11-8	+ 10V (MV2)	gray / 8

2.12 Display

The display of the ventilator is a 10.4” color TFT. It is connected to the module 1.

2.13 Battery

The battery is a maintenance free seal lead acid type. The recharging time is a maximum of 7 hours with a fully depleted battery. The backup time is about 30 minutes with a fully charged battery. To prevent unintended loss of battery operation, it is recommended to replace it with a new **HEYER** battery every 3 years.

2.14 Ventilator pneumatic

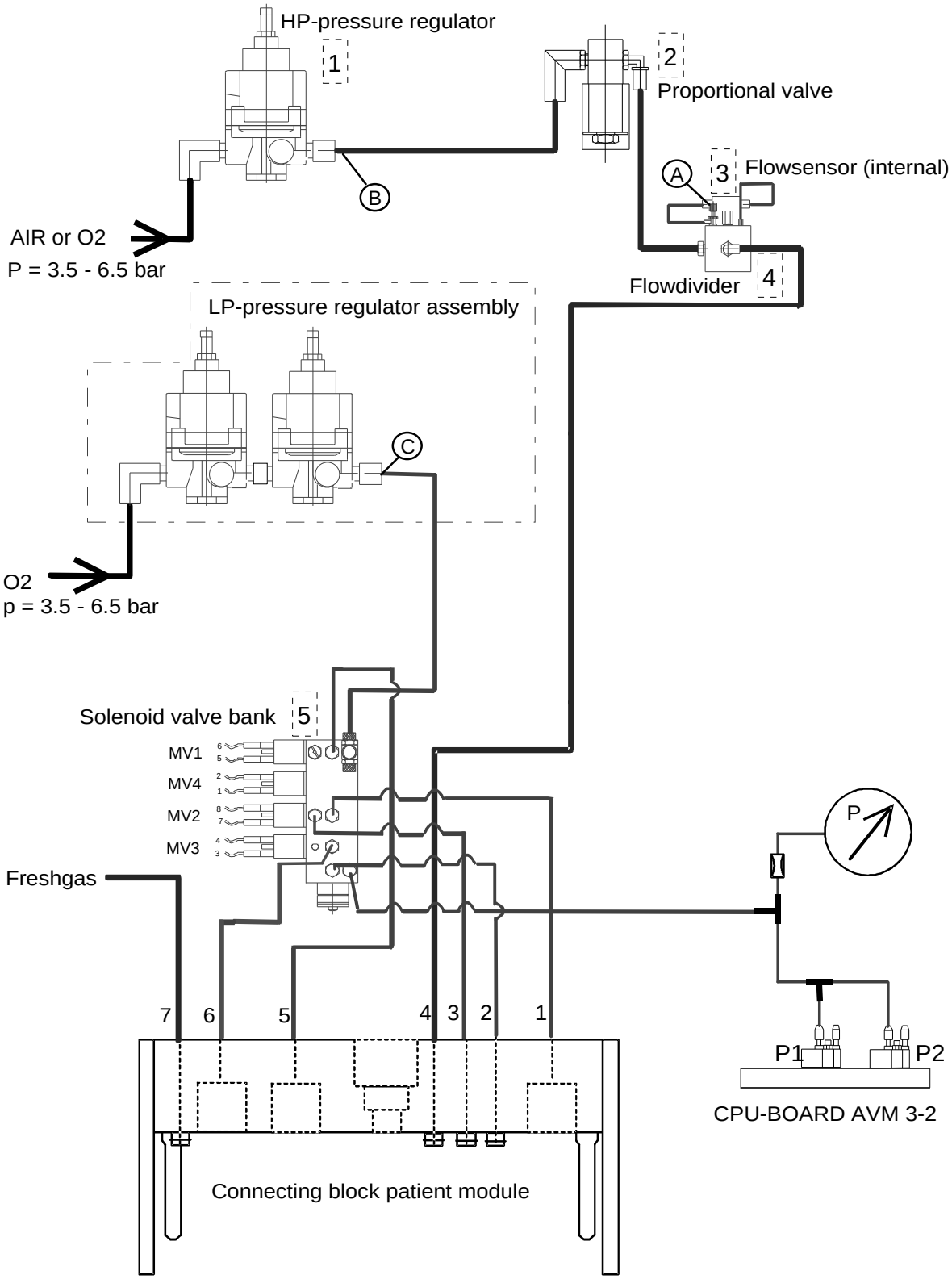


Fig. 6 Ventilator pneumatic

2.14.1 Ventilator pneumatic drive

Air or Oxygen serves as driving gas for the ventilator. In addition to the flow meter block, a pressure reducer, reducing the supply pressure to 200kPa (2 bar; 29 PSI), is supplied by the Air or oxygen connection. This pressure represents the high system pressure of the ventilator. The pressure reducer is named HP pressure reducer.
The HP pressure reducer is placed ahead of the proportional valve that generates the driving gas flow during the inspiratory phase. This flow is led through the flow divider and fills the bellows dome that surrounds the silicone bellow.
In response to the inspiratory and expiratory phases of a respiration cycle, the pneumatic valves (diaphragm valves) of the patient module are activated by solenoid valves.
These solenoid valves, MV1, MV3, and MV2 are supplied by a second pressure reducer assembly (LP- double stage pressure reducer) at the low system pressure, together with MV4, with about 20kPa (200 mbar; 2.9 PSI)// 25kPa (250 mbar; 3,63 PSI).
Cyclic activation of the proportional valve and solenoid valves is steered by the processors of module 2 according to the parameters set on the control panel of the ventilator.
A description of the individual components will be found in the following chapters:

2.14.2 HP pressure reducer

The HP pressure reducer serves for a stabilization of the supply pressure for the proportional valve. The flow generated by the proportional valve thus becomes independent of pressure variations.
The setting of the HP pressure reducer (200 kPa (2 bar; 29 PSI)) at the same time determines the maximum inspiratory flow of 75 +0/-4 L/min with respect to the respirator.

2.14.3 LP- double stage pressure reducer

This pressure reducer assembly is supplied with oxygen in parallel to the measuring tube block or ratio system, respectively. It reduces the input pressure to 20 kPa (200 mbar; 2.9 PSI)// diaphragm valve,
To 25 kPa (250 mbar; 3,63PSI)// membrane valve and is connected to the solenoid valve bank.

2.14.4 Solenoid valves MV1 to MV4

The solenoid valves MV1, MV2, MV3 and MV4 are mounted on a bank behind the patient module docking station to which the tubes to the docking station of the patient module and the LP- double stage pressure reducer are connected.

MV1: This solenoid valve activates, in the CMV mode, the valve for closing the outlet of the bellows dome (bellows control valve) through the line 5, when driving gas flows in for inspiration. It is supplied by the LP- double stage pressure reducer.

MV2: This solenoid valve activates, in the CMV mode, the valve closing the expiratory channel of the patient module (expiratory valve), via MV2 through the line 1. It is supplied by the LP- double stage pressure reducer via MV4.

MV3: This solenoid valve activates, in the CMV mode, the valve for the fresh gas decoupling (decoupling valve) through the line 6. It is supplied by the LP- double stage pressure reducer.

MV4: This solenoid valve is used for internal supply of MV2 with pressure of the LP- reducer.

2.14.5 Pneumatic driving module

The driving module consists of the proportional valve and flow divider with an internal flow sensor. The proportional valve supplied by the HP pressure reducer generates a driving gas flow of 0-75 l/min in relation to the control voltage of the proportional valve of 0 - $5V_{DC}$.

The control voltage of the PV, required for the pre-selected parameter settings, is generated by the CPU board AVM 3-2.

The driving gas flow $Q_{drive\ gas}$ is in the following in relationship with the tidal volume:

$Q_{drive\ gas}$ = Vt/Ti with $Q_{drive\ gas}$ = driving gas flow

Vt = generated tidal volume

Ti = Inspiratory time

2.14.6 Flow metering module

The flow metering module attached to the proportional valve consists of a flow sensor with a measuring range of 0 - 1 l/min and a flow divider. The flow divider splits the total flow in a ratio of 79: 1, and the bypass flow is lead to the flow sensor. A closed loop that allows high accuracy and back up in the generation of the tidal volume results from this configuration via the module 2 CPU-boards.

2.14.7 Tube color coding

Despite the local color coding system, all the pneumatic tubes inside the apparatus will be according to the coding label inside the unit, if it is not according to the local color coding system, next to the flow meter block. Typically it will be according to one of the follow standards.

Gas	**ISO 32 Standard**	**US standard**
O_2	White	Green
N_2O	Blue	Blue
AIR	Black/White	Yellow

On the outside of the apparatus, the coding will be as ordered.

2.15 The patient module (circle system)

2.15.1 Top and back side view on the patient module

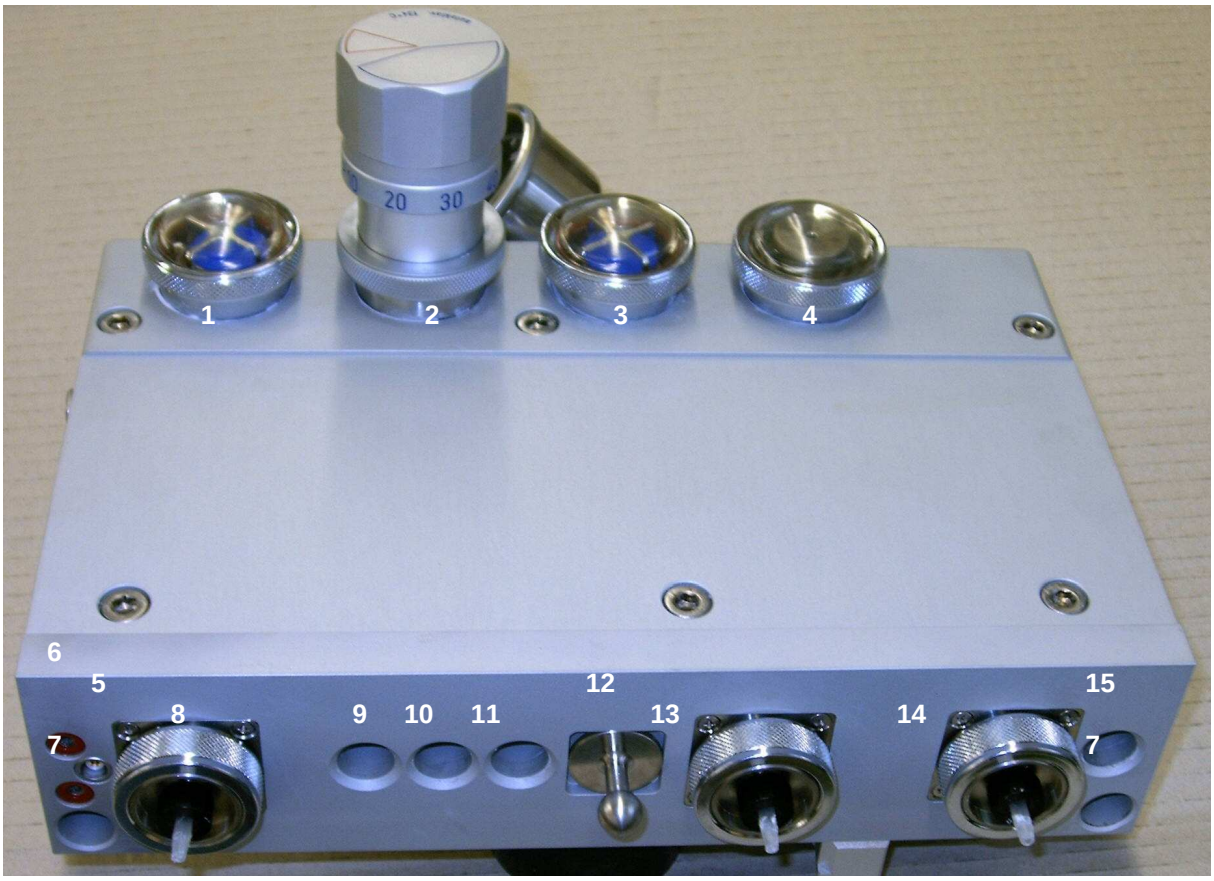


Fig. 7 Top and backside view on the patient module

Pos. Description

1. Expiratory valve (passive)
2. Airway pressure limiting valve (APL)
3. Inspiratory valve (passive)
4. Room air valve, emergency air valve
5. Connector of expiratory flow sensor
6. Connectors of power supply heating blanket
7. Bores for guiding pins of connecting block
8. Expiratory valve (active)
9. Port for pressure measurement
10. Port for expiratory valve activation in the manual mode
11. Port for driving gas
12. Locking bolt
13. Bellows diaphragm valve
14. Decoupling diaphragm valve
15. Port for fresh gas

2.15.2 Bottom and back side view on the patient module

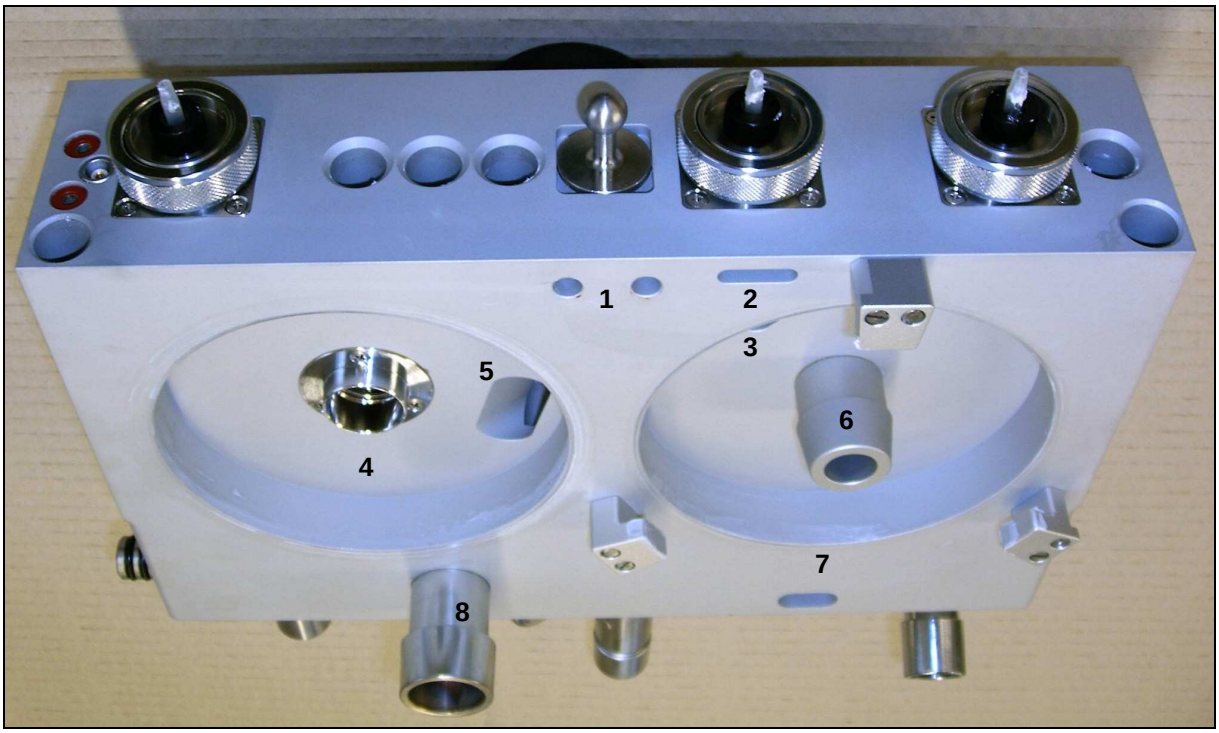


Fig. 8 Bottom and backside view on the patient module

Pos.	Description
1	Fixing screws for locking bolt
2	Exhaust for driving gas
3	Driving gas in- and outlet to bellows dome
4	Thread for CO_2 absorber canister fixing, outlet from patient module to absorber
5	Inlet for re-breathing gas from absorber to patient module
6	Connector for bellows
7	Inlet for ambient air valve / emergency air valve
8	Port for anesthetic gas scavenging tube (30 mm cone)

2.15.3 Functional representations of the patient module

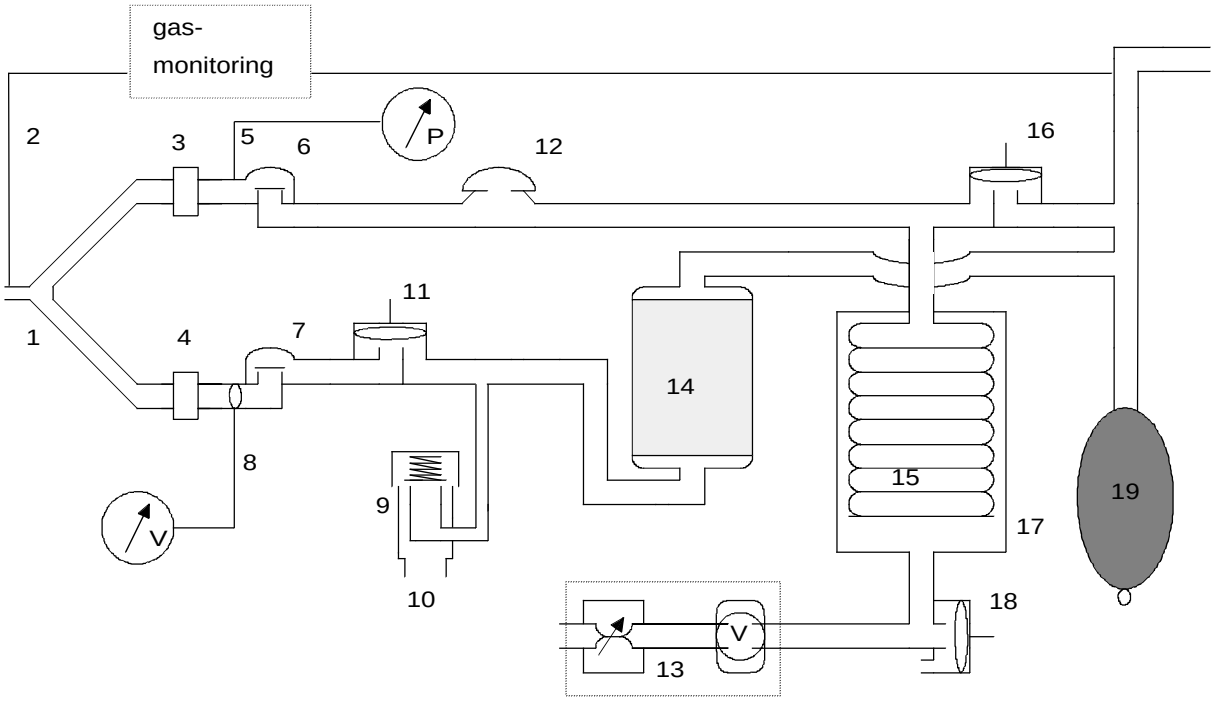


Fig. 9 Survey of the patient module

Pos. Description

1 Patient's y-piece
2 Side stream gas monitor
3 Inspiratory bacterial filter
4 Expiratory bacterial filter
5 Airway pressure monitor connection
6 Inspiratory valve (passive)
7 Expiratory valve (passive)
8 Spirometry sensor
9 Airway pressure limiting valve (APL)
10 Waste gas outlet
11 Expiratory valve
12 Room air valve, emergency air valve
13 Ventilator control pneumatic
14 CO_2 absorber
15 Bellows
16 Decoupling valve
17 Bellows dome
18 Bellows valve
19 Reservoir / manual ventilation bag

2.15.3.1 CMV mode, inspiration

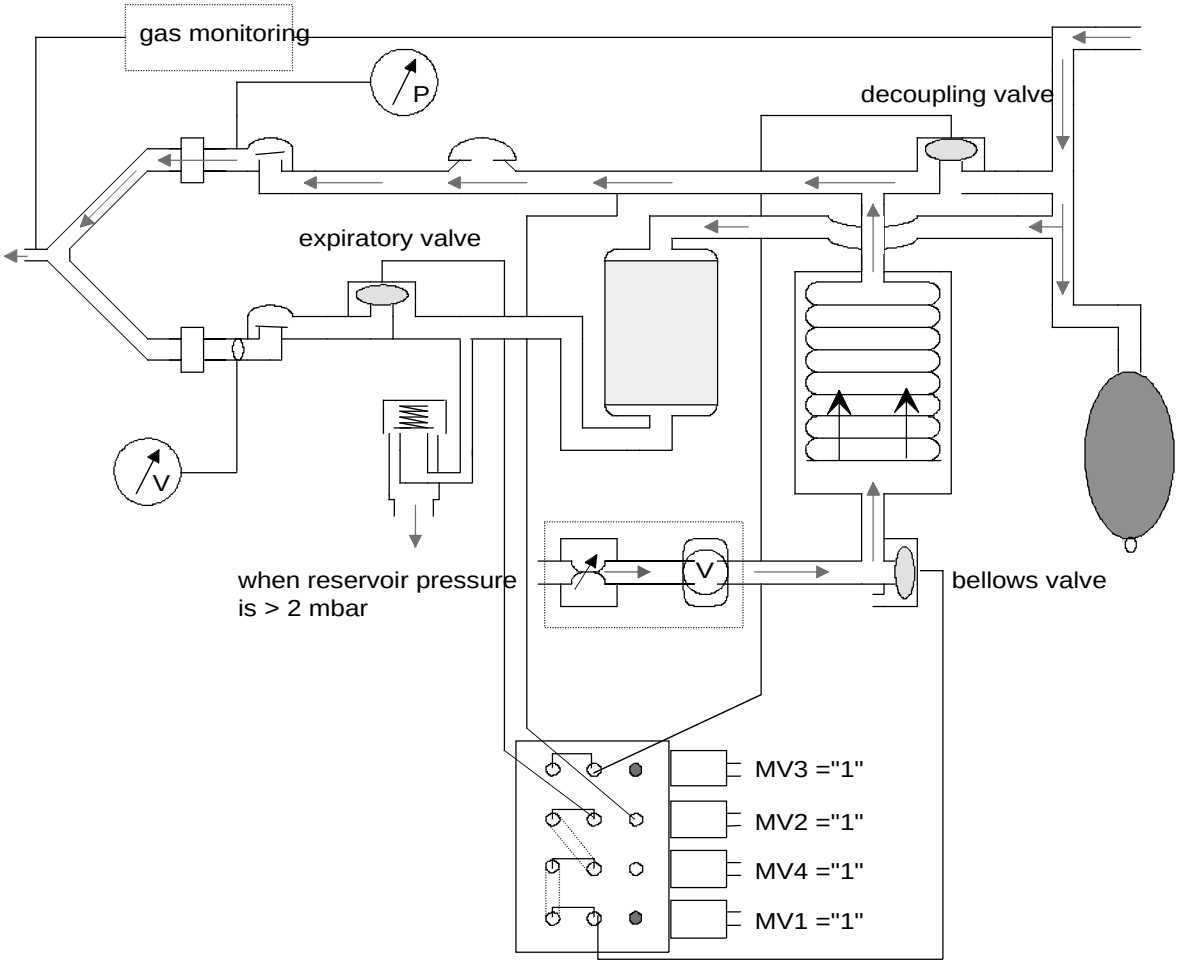


Fig. 10 Survey of the patient module, CMV mode, inspiration

2.15.3.2 CMV mode, expiration

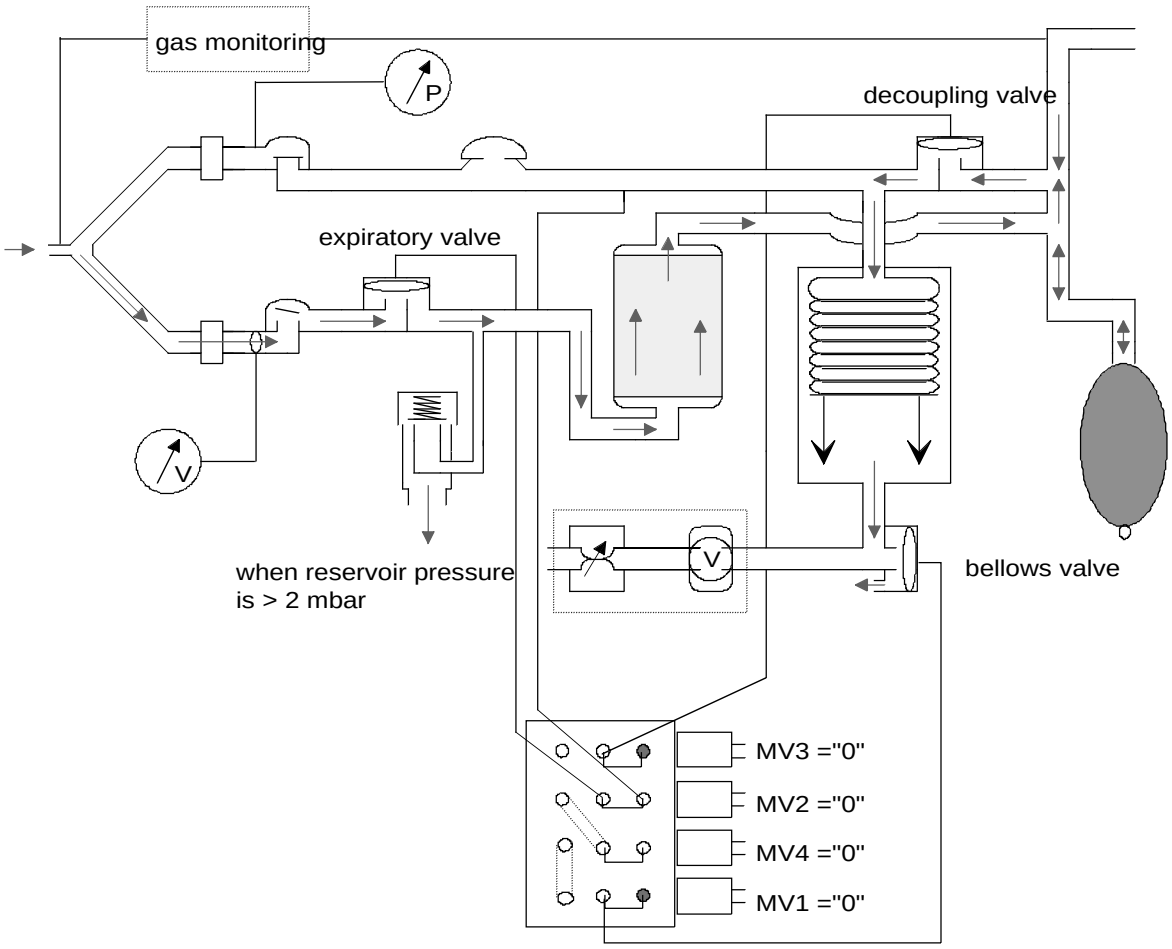


Fig. 11 Survey of the patient module, CMV mode, expiration

2.15.3.3 Manual mode, inspiration

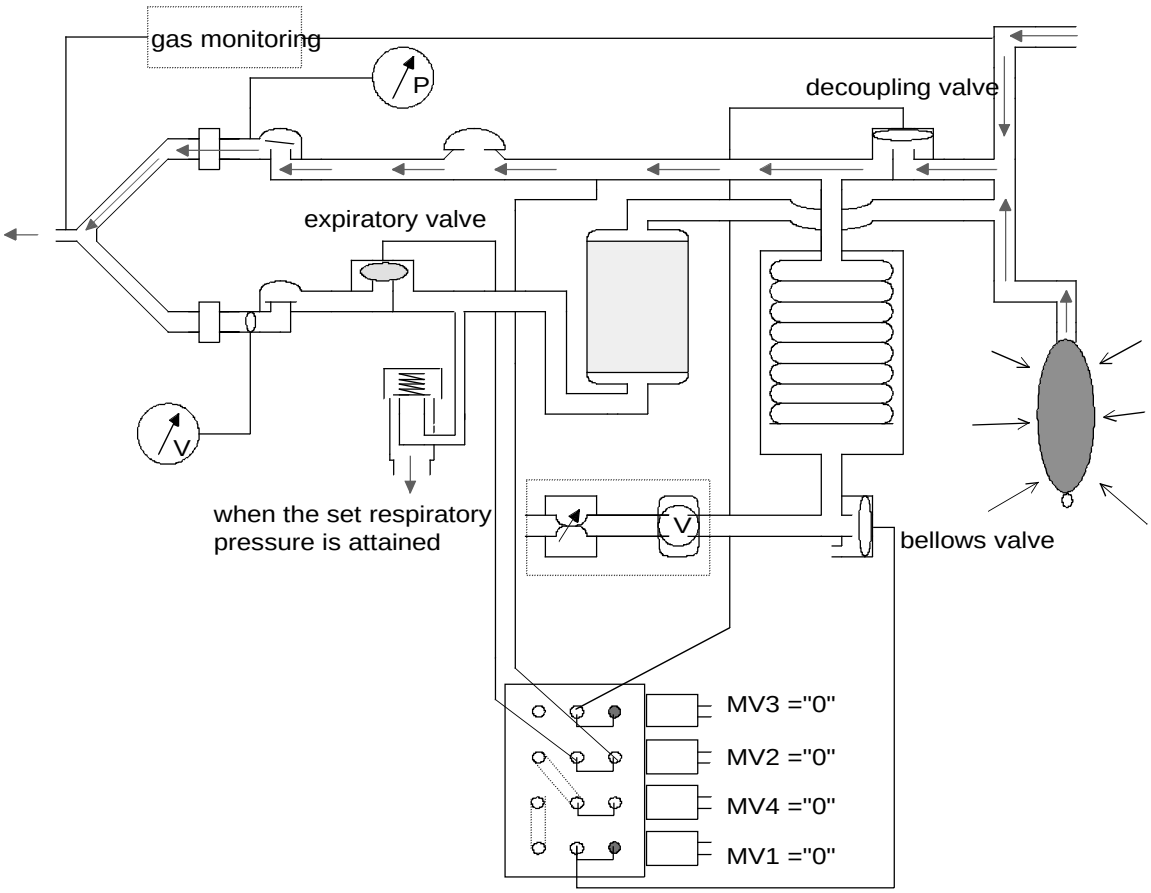


Fig. 12 Survey of the patient module, Manual mode, inspiration

2.15.3.4 Manual mode, expiration

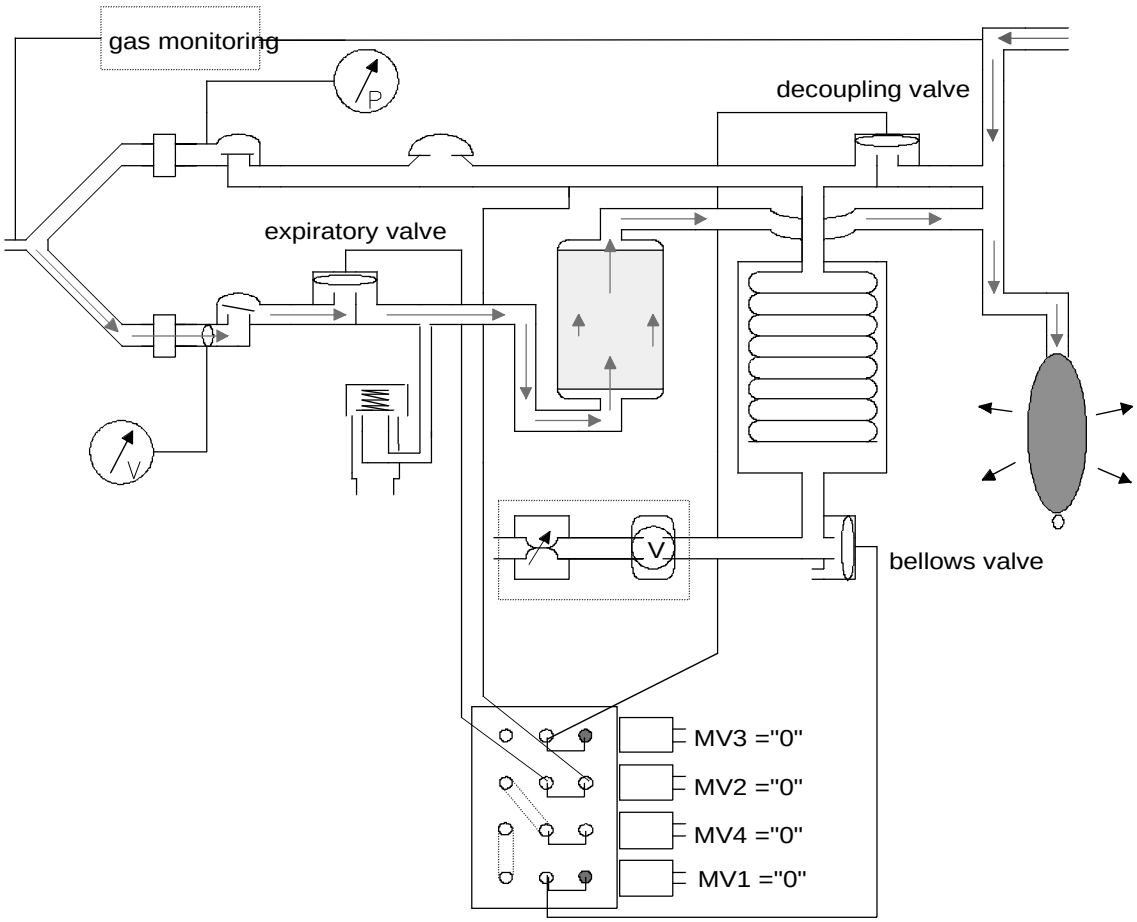


Fig. 13 Survey of the patient module, Manual mode, expiration

2.15.3.5 Spontaneous mode, inspiration

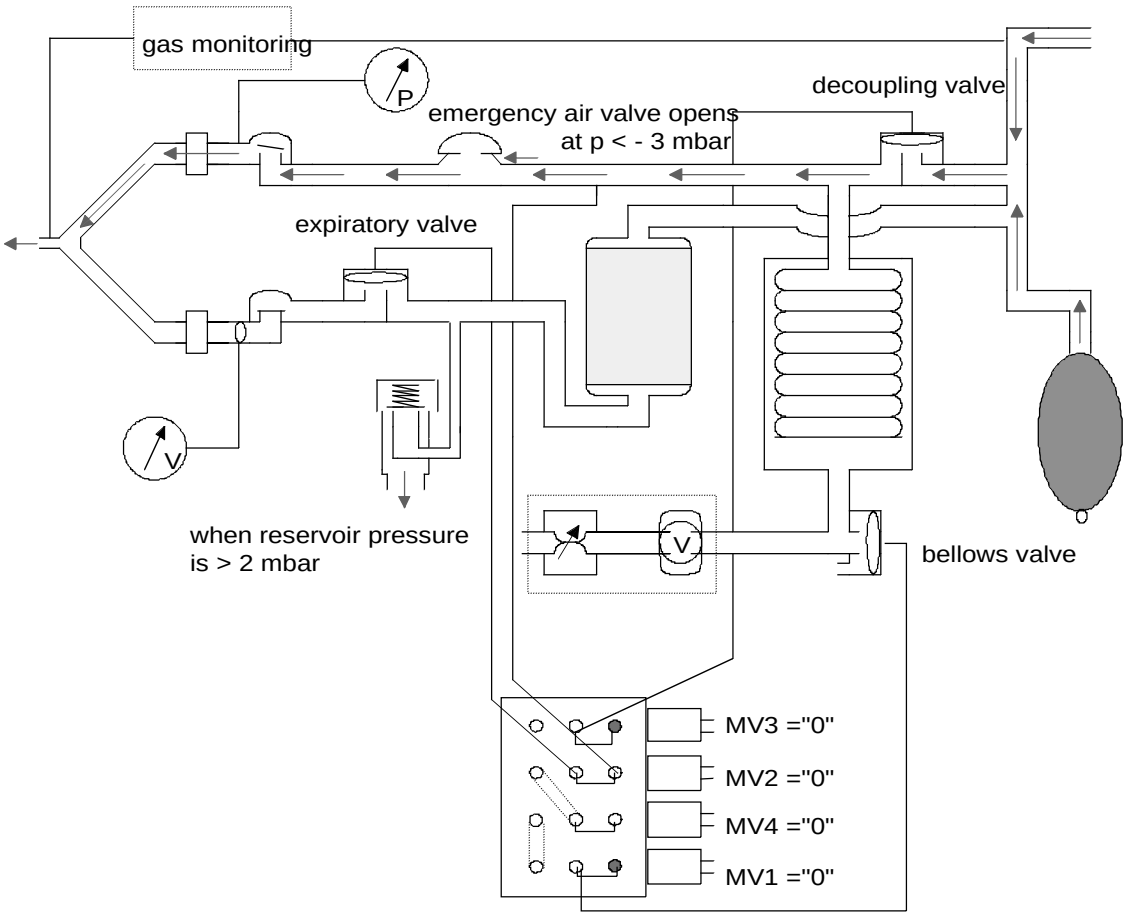


Fig. 14 Survey of the patient module, Spontaneous mode, inspiration

2.15.3.6 Spontaneous mode, expiration

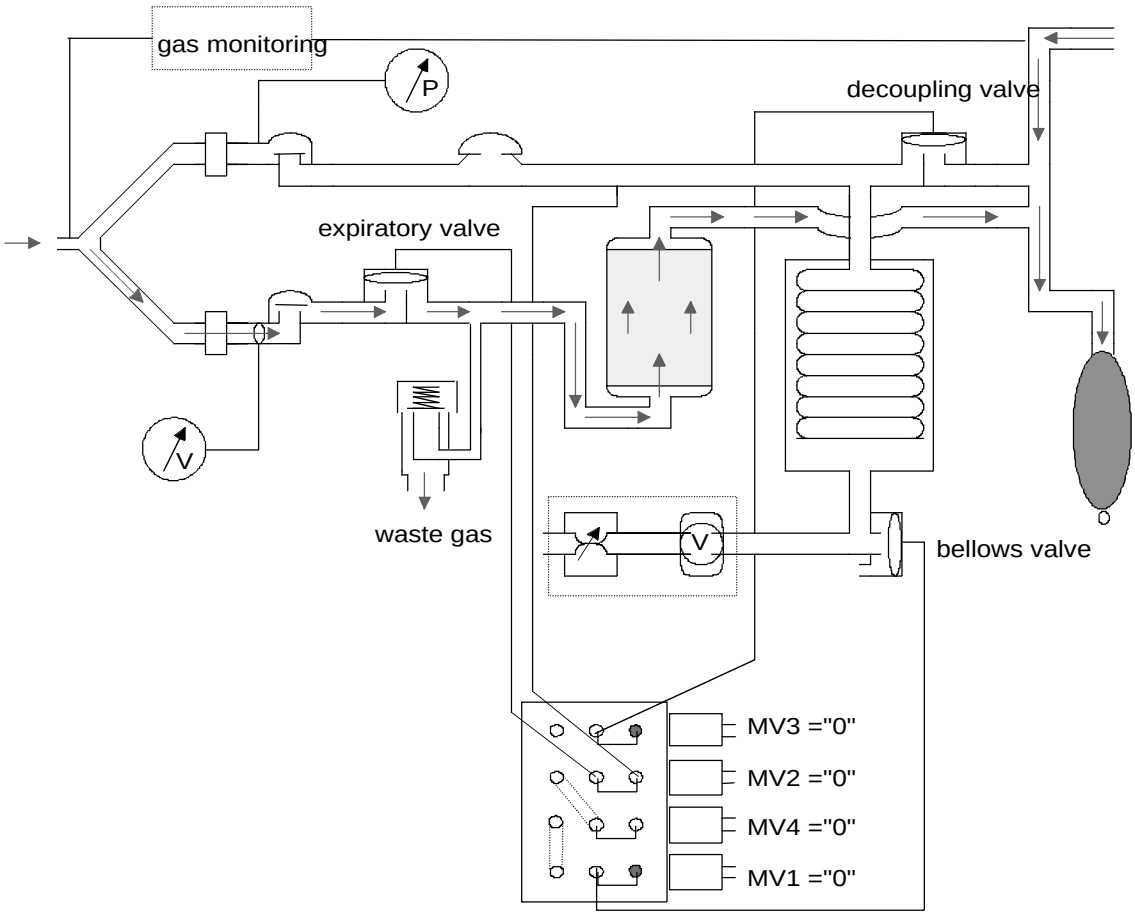


Fig. 15 Survey of the patient module, Spontaneous mode, expiration

2.15.4 Components of the patient module

2.15.4.1 Ventilation bellows system

The ventilator's driving system can be characterized as a constant flow generator. The driving gas of this generator fills the bellows dome to compress the bellows. The breathing gas is pressed out of the bellows into the circuit. Due to the weight of the descending bellows, it is self-filling when the driving gas flow is stopped. The bellows control valve enables the escape of the driving gas.

2.15.4.2 Manual Respiration Bag / Reservoir

In the manual mode this device acts as a normal breathing bag, enabling the user to ventilate the patient manually. In CMV mode this bag acts as a reservoir for fresh gas in the inspiration phase. In the expiratory phase the re-breathing gas and the fresh gas are accumulated in this reservoir. The bag's in- and deflation corresponds to the volume balance of the breathing circuit and the patient. When a volume loss occurs, the bag deflates breath by breath and finally collapses. Such a collapsing breathing bag is an indicator for a leakage. The breathing bag must collapse if the fresh gas flow, reduced by the patient's uptake, is not able to compensate the leakage.

2.15.4.3 CO_2 absorber

The soda lime inside the absorber retains the carbon dioxide from the re-breathing gas. The flow orientation is upstream.

2.15.4.4 Inspiratory and expiratory valves

To ensure the gas flow direction the two one-way-valves in the inspiratory limb and expiratory limb are integrated inside the patient module. These valves are seen activating form the top of the module.

2.15.4.5 Airway pressure relief valve

In CMV position the APL valve closes the re-breathing system towards the scavenging line and limits the reservoir pressure to a constant value of 2 cmH_2O. In manual mode the APL valve acts as a normal spring loaded pressure relief valve, limiting the maximum pressure in the re-breathing system.

2.15.4.6 Room Air valve

Due to the tendency of the descending bellows to refill itself by creating a negative pressure inside the bellows this valve prevents the patient from becoming any negative pressure by opening the diaphragm and allowing ambient air to refill the bellows.

2.15.4.7 Diaphragm / Membrane valves

Inside the patient module diaphragm/membrane valves operate the expiratory line, the bellows dome outlet and the fresh gas decoupling line during the CMV-mode. These valves are controlled by pressured gas to open or close the valve's path. All diaphragm valves are open when not inflated. The power gas for these valves is controlled by the ventilator's valve bank using a supply pressure of about 20 kPa (200 mbar; 2.9 PSI)/ 25 kPa (250 mbar; 3,63PSI) from the ventilator pneumatic.

2.15.2.7.1 Status of the diaphragm/membrane valves:

The diaphragm valves are pneumatically operated by solenoid valves. The following list shows the correspondence between diaphragm valve, solenoid valve and pressure port.

Valve	Bellows valve	Exp. valve		Decoupling valve
controlled by	MV 1	MV 2	MV 4	MV 3
connected to port #	5	1	3	6
wire #	5, 6	7, 8	1, 2	3, 4

In the following the status of the diaphragm valves are shown corresponding to the selected ventilation mode of the ventilator.

2.15.2.7.2 Machine OFF or Ventilator in Standby

Valve	MV 1	MV 2	MV 3	MV 4
Activity	OFF	OFF	OFF	OFF
Pressure on port	5, No	1, No	6, No	no sup. of MV2

2.15.2.7.3 Manual / Spontaneous Mode, INSPIRATION And EXPIRATION

Valve	MV 1	MV 2	MV 3	MV 4
Activity	OFF	OFF	OFF	OFF
Pressure on port	5, No	1, No	6, No	no sup. of MV 2

2.15.2.7.4 CMV Child / Adult Mode, INSPIRATION

Valve	MV 1	MV 2	MV 3	MV 4
Activity	ON	ON	ON	ON
Pressure on port	5, Yes	1, Yes	6, Yes	supply of MV 2

2.15.2.7.5 CMV Child / Adult, EXPIRATION

Valve	MV 1	MV 2	MV 3	MV 4
Activity	OFF	OFF	OFF	OFF
Pressure on port	5, No	1, No	6, No	no sup. of MV 2

2.15.2.7.6 CMV Adult, EXPIRATION And PEEP

Valve	MV 1	MV2	MV3	MV4
Activity	OFF	ON	OFF	ON
Pressure on port	5, No	1, Yes	6, No	supply of MV2

2.15.2.7.7 Compliance Test Patient Module

The compliance test patient module is divided in 3 phases.
Phase 1. Flow into the re-breathing system and test of flow sensors.

Valve	**MV 1**	**MV2**	**MV3**	**MV4**
Activity	ON	OFF	ON	ON
Pressure on port	5, Yes	1, No	6, Yes	no sup. of MV2

Phase 2. Pressure increase up to test pressure 40 cmH_2O, calculation of system compliance.

Valve	**MV 1**	**MV2**	**MV3**	**MV4**
Activity	ON	ON	ON	ON
Pressure on port	5, Yes	1, Yes	6, Yes	supply of MV2

Phase 3. Test of pressure loss.

Valve	**MV 1**	**MV2**	**MV3**	**MV4**
Activity	ON	ON	ON	ON
Pressure on port	5, Yes	1, Yes	6, Yes	supply of MV2

2.15.2.7.8 Leak Test Patient Module and Fresh Gas Module

Valve	**MV 1**	**MV2**	**MV3**	**MV4**
Activity	ON	OFF	OFF	OFF
Pressure on port	5, Yes	1, No	6, No	no sup. of MV2

3 Repair Information

3.1 Introduction

This chapter of the service manual provides the necessary technical information to perform repairs to the instrument. The most important perquisites for effective troubleshooting are a trough understanding of the instruments functions, as well as understanding the principals of operation.

3.2 Warnings and precautions

In the event the instrument covers are removed, observe the following warnings and guidelines

3.2.1 Precautions

1. Do not short components leads together

2. The instrument covers must not be removed by anyone other than qualified technical personnel who have received supplementary instructions regarding maintenance of medical equipment and/or have equivalent experience in this area.

3.2.2 Warnings

1. This device operates using compressed gas at high pressures. When attaching emergency gas tanks, always open tank valves slowly, watching the cylinder gauge indicate the tank pressure. When disconnecting the tanks, always close the valves slowly. Use the Narkomat^{+} flow meters to bleed down the pressure, watching the cylinder gauge indicating the depleting tank pressure, before disconnecting the tank from the yoke. Always open and close tank valves fully.

2. This device operates using compressed gas at high pressures from the hospital central supply. When connecting gas supply lines, attach the hose connection to the machine before connecting the quick disconnect fitting to the hospital source. Disconnect the supply hose from the hospital source connection prior to disconnecting it from the Narkomat^{+} gas connection fittings.

3. Whenever flowing anesthetic gases, nitrous oxide, oxygen, or any hospital gas always use the appropriate agent evacuation system.

4. Never oil or grease any oxygen equipment unless the lubricant used is made and approved for this kind of service. In general, oils and greases oxidize readily, and in the presence of oxygen burn violently.

3.3 Troubleshooting Guidelines

1. **Identify the problem** – Due to the wide variety of potential symptoms, certain problems may be more subtle than others. Following the guidelines of the tests will help determine the problem if one exists.

2. **Avoid shorting component leads together** – During repair procedures, it can be tempting to make a quick series of measurements. Always turn the power off before connecting and disconnecting the test leads and probes. The accidental shorting of leads can easily stress the components and cause a second failure (aside from the safety risk).

3. **Use the proper equipment** – The equipment listed below is suggested to fulfill a wide range of troubleshooting requirements. It is imperative to use the designated equipment in order to ensure proper results of any and all test procedures.

4. **Clean up the repair area** – After any repair, clean off the repair area.

3.4 Troubleshooting Charts

3.4.1 Error Messages during ventilation

Display message	Cause	Corrective action User	Corrective action Service technician
Vent Error: Use Manual Ventilation Call Service	No communication between AVM 3-1 and AVM 3-2 (ventilator microprocessor boards) for more than 8 sec.	Finish the case with manual ventilation; Take the machine out of use; Call Service	Exchange module 2 (ventilator microprocessor boards)
CPU Error: Use Manual Ventilation Call Service	➔ No communication between AVM 3-1 and module 1 (user interface) for more than 20 sec. ➔ System Failure (Module 1) ➔ Watchdog Error (Module 2)	Finish the case with manual ventilation; Take the machine out of use; Call Service	Exchange either the module 2, the module 1 or the communication cable connecting the two modules
Set APL valve to CMV/SP position	AVM3-2 PPEAK is greater than 10 mbar and lowest expiration pressure after the expiration still greater than PPEAK–2mbar ➔ No pressure relief in the expiration	Set APL to the CMV/SP position Reset automatically after pressure relief, Restart of the ventilation after request.	If resetting the APL valve does not solve the problem, check the correct functions of the APL valve, solenoid valves and the diaphragm valves
Flow Error: Use Manual Ventilation Call Service	CMV, PCV After the first five breaths in CHILD resp. after the first three breaths ADULT: Last inspiratory flow is lower than 0,05 L/min, even though more than 2.00 L/min were set at the prop. valve Sensor does not deliver any values	Finish the case with manual ventilation; Take the machine out of use; Call Service	Recalibrate the proportional valve, internal flow sensor and the characteristic of the proportional valve. If that does not solve the problem, exchange the 1. proportional valve 2. internal flow sensor
Valve Error: Use Manual Ventilation Call Service	AVM3-2 CMV The internal actual flow value is measured during the inspiration and may not exceed the following desired value x factor 1.5: AVM3-2 PCV The same as CMV, but other tolerance Prop. Valve faulty	The intermitting tone is reset via the mute button (acknowledgement) Reset the error message via the compliance test	Recalibrate the proportional valve, internal flow sensor and the characteristic of the proportional valve. If that does not solve the problem, exchange the 1. proportional valve 2. internal flow sensor

Display message	Cause	Corrective action User	Corrective action Service technician
Valve Error: Use Manual Ventilation Call Service	AVM3-2 CMV/ PCV The actual internal flow value should be 0 during expiration	Finish the case with manual ventilation; Take the machine out of use; Call Service	Recalibrate the proportional valve, internal flow sensor and the characteristic of the proportional valve. If that does not solve the problem, exchange the 1. proportional valve 2. internal flow sensor
Calibrate Breathing System Perform Compliance Test when convenient	AVM3-2 CMV, PCV Difference between the set and the detected state of each solenoid valve for more than 200 ms	The intermitting tone is reset via the mute button (acknowledgement) Reset the error message via the compliance test	Check the correct voltage supply for the solenoid vales. If that does not solve the problem exchange the according solenoid valve
Pressure Reading out of tolerance Perform Compliance Test when convenient	AVM3-1, AVM3-2 A difference between the two pressure sensors of more than 10 mbar	The intermitting tone is reset via the mute button (acknowledgement) Reset the error message via the compliance test	Recalibrate the pressure sensors and check the according tubing. If that does not solve the problem exchange the module 2
No drive gas; please check	AVM3-1 Monitoring of the pressure switch for the driving gas	Ensure the driving gas supply, restart the ventilation on request.	Check the gas supply, the correct tubing and the correct connection and function of the pressure switch
Flow/Volume Readings not available Replace Flow Sensor – Call Service	AVM3-1 during ventilation External flow sensor is broken or short-circuited	The intermitting tone is reset via the mute button (acknowledgement) Reset the error message via the compliance test	Exchange the external flow sensor
A P N E A	AVM3-1. Manual/ spontaneous Within a period of 15 to 60 seconds a expiration cannot be detected	Create expiration	Ensure the correct function of the circle system
Breathing Circuit Disconnect	AVM3-1 CMV, (S)CMV, PCV The peak pressure PPEAK is lower than 0.5 mbar and lower then the set pressure limit Pmin	Create a pressure increase in the inspiration phase	Ensure the correct function of the circle system and the correct electrical and pneumatic function of the solenoid valves
PEEP greater than Pmin	AVM3-1 CMV, (S)CMV, PCV The end expiratory pressure is greater than the set pressure limit Pmin	Lower the end expiratory pressure or raise the pressure limit Pmin	Check the correct position and function of the APL valve. Ensure the correct function of the circle system
FiO2 lower than FiO2 min	AVM3-1 The measured O2 value is lower than the set O2min limit	Increase the O2 value or raise the limit O2min	Recalibrate and check the correct function of the O_2 cell. Exchange if necessary
Tidal Volume lower than Vt min	AVM3-1 The measured Vt value is lower than the set Vt min limit	Increase the Vt value or raise the limit Vt min	
Peak pressure greater than alarm limit	AVM3-1 The measured Ppeak value is greater than or equal to the set Pmax limit	Decrease the Ppeak value or raise the limit Pmax	
Peak pressure below alarm limit	AVM3-1 The measured Ppeak value is lower than the set Pmin limit	Increase the Ppeak value or lower the limit Pmin	
Minute Volume below alarm limit	AVM3-1 The calculated M.Vol value is lower than the set M.Vol min limit	Increase the ventilation rate or the Vt value or lower the limit Pmin	
PEEP greater than PEEP-Setting	AVM3-1 The measured PEEP value is 5 mbar higher than the set PEEP	Decrease the PEEP value or raise the set PEEP	Check the correct position and function of the APL valve
FiO2 greater than FiO2 alarm limit	AVM3-1 The measured FiO2 value is greater than the set FiO2max limit	Decrease the FiO2 value or raise the set FiO2max limit	Re-calibrate the O2 sensor
Check Vent Dial position	AVM3-1 The selector switch position is monitored An invalid position must be eliminated within two seconds. After this the alarm message appears.	The last detected valid position is maintained until a new valid position is detected, then the message disappears	1. Check the correct function of the Vent Dial

Display message	Cause	Corrective action User	Corrective action Service technician
System Error Cal Required Call Service	EEPROM is checked during the start up and during the sensor test for CRC errors	Take the machine out of use; Call Service	Recalibrate the complete system. If that does not solve the problem exchange the module 2
Temp Sensor readings not available Call Service	AVM3-1 The measured temperature value is out of tolerance	Restore the function of the temperature sensor	Recalibrate the temperature sensor in the service mode. If that does not solve the problem exchange the module 2
Temp Sensor out of tolerance Check Heating System - Call Service	AVM3-1 The over-temperature switch activated or the temperature of the patient module has not increased for 20 min even though heater is switched on	Restore the function of the heating blanket	Recalibrate the temperature sensor in the service mode. Check the correct function of the solid state relay and the according power supply
Fan Error Check Fan - Call Service	AVM3-1 The Fan does not deliver any impulses	Restore the function of the Fan	1. Check for physical obstructions 2. Exchange the fan
AC Power lost, using Battery	AVM3-1 The line power fail signal reports use of battery	Restore the line supply	1. Ensure the correct line voltage 2. Ensure the correct function of the power supply module
Continuous Pressure	AVM3-1 Manual/ spontaneous Over a time of 10 seconds the minimum and the maximum pressure is measured. If the actual pressure is greater than 10 mbar and the difference between the minimum and the maximum pressure is smaller than 5 mbar, the error message is issued	Increase the pressure difference	
Battery running low Use Manual Ventilation	AVM3-1 Battery mode The valid discharge time is over	Restore the line supply	1. Charge the battery 2. Check the capacity of the battery, if necessary, exchange it.
Ambient Air Intake: Check Fresh Gas setting	AVM3-1 CMV, PCV In the expiration phase there is a sub-atmospheric of more than 2 mbar, an error message is issued	Correct the fresh gas flow. When the smallest Pressure zero higher is, the error message disappears	Check the correct calibration of the pressure sensors
Set APL to CMV/SP position	AVM3-1 Controlled ventilation • The measured PEEP value is 5 mbar higher than the set PEEP over a period of 5 ventilation cycles	Set APL to VENT (CMV) position	1. Ensure the correct function of the APL valve. 2. check the breathing circuit for obstructions
	• The controlled ventilation is being started		
Check Settings	AVM3-2 CMV The maximum position of the Proportional valve has been reached	Decrease ventilation frequency or Vt	
30 min. remaining	AVM3-1 Battery mode 30 minutes of battery use left	Restore the line supply	1. Charge the battery 2. Check the capacity of the battery, if necessary, exchange it.
25 min. remaining	AVM3-1 Battery mode 25 minutes of battery use left	Restore the line supply	1. Charge the battery 2. Check the capacity of the battery, if necessary, exchange it.
20 min. remaining	AVM3-1 Battery mode 20 minutes of battery use left	Restore the line supply	1. Charge the battery 2. Check the capacity of the battery, if necessary, exchange it.
15 min. remaining	AVM3-1 Battery mode 15 minutes of battery use left	Restore the line supply	1. Charge the battery 2. Check the capacity of the battery, if necessary, exchange it.

Display message	Cause	Corrective action User	Corrective action Service technician
10 min. remaining	AVM3-1 Battery mode 10 minutes of battery use left	Restore the line supply	1. Charge the battery 2. Check the capacity of the battery, if necessary, exchange it.
5 min. remaining	AVM3-1 Battery mode 5 minutes of battery use left	Restore the line supply	1. Charge the battery 2. Check the capacity of the battery, if necessary, exchange it.
Unable to attain target pressure, Adjust flow or I:E ratio	AVM3-2 PCV The peak pressure PPEAK is lower than the set volume	Increase driving gas flow or lower the plateau	Check the system for leakages
PCV Setting not valid	AVM3-2 PCV Bellow monitor active. additional volume delivery is not possible	Reduce ventilation frequency or increase “I”	
Expiratory time too short	AVM3-2 PCV The calculated expiratory time is greater than 1 second (Adult) resp. 0.5 second (Child)	Reduce ventilation frequency or increase “E”	
Resume Ventilation	AVM3-1 Message to restart the ventilation	Restart the ventilation	
Compliance Test bypassed	The system is started without having performed the compliance test	Perform the compliance test	
CO2 Re-breathing; please check Absorber	The inspiratory CO_2 value is too high	Exchange the soda lime. If all else fails call Service.	Verify the gas module calibration. If else fails, exchange the gas module
Gas Monitor Technical Failure	Internal fault in the gas module	Call Service	Check the internal cable connections. If else fails, exchange the gas module
Sampling Line Occlusion	Due to an improper tube connection, the exact value can not be measured	Check if the sample tube is kinked or obstructed. If else fails exchange the sample tube	Calibrate the sample flow rate in the service mode
No Patient detected; no Breathing	The CO_2 measurement cannot detect any breathing or respiration activities	Check if the sample tube is connected and check the conditions of the patient	Check and if necessary recalibrate the sample flow rate in the service mode
Water trap is full, will be full soon or connection faulty	The water trap is full, nearly full or the water trap is not connected correctly	Check if the water trap is connected correctly or, if full, exchange it	Check and if necessary recalibrate the sample flow rate in the service mode
Gas Monitor NOT ready	Power supply or data communication to the gas module is defective	Call Service	Check for correct power supply and ensure correct cable connections. If else fails, exchange the gas module

3.4.2 Alarm messages during the compliance test, leak test and O2 calibration

Display message	Cause	Corrective action User	Corrective action Service technician
System Resistance too high	**AVM 3-2** If with in 1 sec. after a flow of 12 l/min has been generated, a pressure increase of 10 mbar is measured	Repeat the compliance test	Check the breathing circuit for obstructions
Leak rate too high	AVM 3-2 If after 10 mbar have been reached, 40 mbar are not reached within 2s	Troubleshoot the breathing circuit for leakages	Troubleshoot the breathing circuit for leakages
Compliance out of range	AVM 3-2 The measured compliance has to be between 2.0 and 9.9	Replace bacteria filter and breathing circuit. Use the Compliance test in Standby / OPTIONS to retest. If all else fails call Service.	Replace bacteria filter and breathing circuit. Check the complete breathing system for obstructions.
System Error Cal Required Call Service	AVM 3-2 Data for parameter or alarm limit settings was not saved correctly, the data exchange between the ventilator modules and on-screen display is faulty or the startup test for Internal circuit EEPROM has failed.	Retry function. Reboot machine. If all else fails call Service.	Recalibrate the system. If this fails, exchange the module 2 processor board
Check Diaphragm Valves	AVM 3-2 The PV closes after 40mbar has been reached. If after this a pressure increase of 4 mbar takes place within 4 s	Remove the Breathing circuit from the Docking Station and check the Decoupling and Expiratory valves for intact membranes. Replace as required or call Service.	Remove the Breathing circuit from the Docking Station and check the Decoupling and Expiratory valves for intact membranes. Replace as required
Pressure Reading out of tolerance Perform Compliance Test when convenient	If the pressure sensors measure a difference greater than 3 mbar during the offset comparison, even though the system is pressure relieved.	Take the machine out of use; Call Service	Recalibrate the pressure sensors and check the according tubing. If that does not solve the problem exchange the module 2
Flow Error: Use Manual Ventilation Call Service	Compliance Test • When during the offset calibration a flow of greater than 3 L/min is detected • During the compliance test a flow of 12 L/min is delivered through the prop. valve. If the delivered flow is out of tolerance ➔ Flow Sensor Error	Take the machine out of use; Call Service	Recalibrate the proportional valve, internal flow sensor and the characteristic of the proportional valve. If that does not solve the problem, exchange the 1. proportional valve 2. internal flow sensor
Flow/Volume Readings not available Replace Flow Sensor - Call Service	AVM3-2 Pressure test • Cannot be set to zero via the analogue output • Set DAC value greater than 1,83V • The amplifier circuit is not working correctly	Retry function. Reboot machine. If else fails call service	Exchange the external flow sensor
System Error Cal Required - Call Service	EEPROM is checked during the start up and during the sensor test for CRC errors	Take the machine out of use; Call Service	Recalibrate the complete system. If that does not solve the problem exchange the module 2
Calibrate Breathing System Perform Compliance Test when convenient	The checking of the solenoid valves failed	Retry function. Reboot machine. If else fails call service	Check the correct voltage supply for the solenoid vales. If that does not solve the problem exchange the according solenoid valve
Patient module unlocked	The system does not detect a signal from the stop switch in the docking station	Insert Breathing system, else call service	Test the correct function of the stop switch in the service mode. If the function ids OK, readjust it's positioning. If the function is faulty, exchange the stop switch

Display message	Cause	Corrective action User	Corrective action Service technician
System not pressure less	AVM 3-2 A pressure larger than 10 mbar is measured before the start of the compliance test	Vent the system by opening the Breathing circuit. Monitor system pressure.	Relieve the system pressure, recalibrate the pressure sensors
System vented or drive gas missing	AVM 3-2 During the compliance test or Leak test a pressure higher than 10 mbar is not measured	Check the O2 cell is present, APL valve is set to max (leak test) and breathing circuit is connected properly.	Troubleshoot the breathing circuit for leakages

3.4.2.1 Messages during the system tests

Result	Compliance Test Start Up	Compliance Test	Leak Test	O2 calibration
OK	Compliance Test Passed Leak rate < 300 ml/min Press Enter to continue	Test Passed	Leak Test Passed Set APL Valve to VENT (CMV) position	
OK with a leak of 300ml to 600ml	Compliance Test Complete Leak rate is between 300-600 ml/min Press Enter to continue	Test Complete Leak rate is xxx ml/min Compliance is x.x ml/cmH2O Please check breathing circuit		
OK with a leak of 500ml to 1000ml			Leak Test Complete Leak rate is xxx ml/min Verify that APL Valve is set to Max CO2 absorber, vaporizers locked	
OK with a leak of >600ml/min	Compliance Test Complete Leak rate is higher than 600 ml/min Tighten valve rings Check breathing circuit Press Enter to continue	Test Complete Leak rate is higher than 600ml/min Please check for leaks		
OK with a leak of >1000ml/min			Leak Test Complete Leak rate is higher than 1000 ml/min Verify that APL Valve is set to Max CO2 absorber, vaporizers locked	

Result	Compliance Test Start Up	Compliance Test	Leak Test	O2 calibration
OK				O2Sensor calibration successful
O2 too high				O2 concentration too high Expose Sensor to room air Press Enter to Start
O2 Sensor too old				O2 Sensor is out of rage Replace O2 Sensor Press Enter to Start

3.4.2.2 Symptoms of Fuse Failures

The following table shows the reaction to a failed fuse on the power supply board. The fuses F2, F3, F4, F5 and F6 have been removed from the power supply module and are therefore subject of the production date.

FUSE	Failure during working	Failure during start
F1	Display is black; module 1 and 2 do not work	Display is black; module 1 and 2 do not boot
F7	alarm „Solenoid Valves faulty“, „Fan faulty“ and „Ambient Air Intake“; real time curve shows a zero line	after booting the message „Selected mode is not Standby“ is shown; module 2 does not boot; fan does not work
F8/F9	alarm „AC power lost, using battery“	after the machine has booted alarm „AC power lost, using battery“ is shown
F10/F11	During the ventilation there is no failure; after you have turned the selector switch to Standby the message „Insert patient module“ is shown; during using battery the message disappeared	after the machine has booted the message„Insert patient module“ is shown; during using battery the message disappeared

3.5 Required Tools

Item Number	Part Number	Description	Specification
1	-	Operation manual	**HEYER** specification
2	-	Service manual	**HEYER** specification
3	900-4726	Calibration pump, Pressure sensors	0 – 80 cmH_2O
4	-	Safety analyzer	For electrical tests according to IEC-601-1,B
5	-	Digital Volt Meter	
6	-	Calculator	Standard four function
7	900-4715	Temperature simulator	**HEYER** specification
8	-	Mass flow meter	0 – 80 l/min ± 2% of reading
9	-	Surface cleaner	Standard hospital grade
10	340-3000	Gasket set	**HEYER** specification
11	460-0610	Driving gas test adapter with 1 meter tubing	**HEYER** specification
12	603-4000	Test lung	Adult size
13	-	Test lung	Neonate size
14	-	High pressure gauge	0 – 2.5 kPa x 100(0 – 2.5 bar; 0 – 38 PSI)
15	-	Low pressure gauge	0 – 250 Pa x 100(0 – 250 mbar; 0 – 3.8 PSI)
16	-	Hand tools, calibration tool, flat screw driver, socket and Allen wrench set	Metric standard
17	800-6009	Pressure regulator for verification gas cylinder	
18	800-6004	Verification gas	50% O_2, 43% N_2O, 5.5% CO_2, 1.5% Hal
19			

3.6 Disassembly instructions

3.6.1 Connecting and disconnecting vaporizers

1. To connect the vaporizer, place it carefully onto the vaporizer manifold. The manifold is Selectatec type.
2. Lock the vaporizer with the locking lever ¼ turn to the fully locked position.
3. Only vaporizers with interlock-system may be used with this system.
4. After each exchange of a vaporizer, perform a leak test.

3.6.2 Removing the compressed gas tanks (PIN-Index)

1. Ensure that the tank is closed
2. Rotate the hand tight knob that retains the tank against the port seat.
3. Flip the swiveling yoke collar 180 degrees.
4. Grip the tank firmly and remove it from the yoke.
5. Connect a new tank in reverse order, ensuring a single tank washer is present on the yoke port seat.

3.6.3 Removing the Patient Module

1. Remove the CO_2 absorber dome.
2. Remove the bag in bottle system.
3. Remove the O_2 cell cable from the O_2 cell, if present.
4. Remove the scavenger hose.
5. Remove the breathing circuit.
6. Enter the **OPTIONS** window in the operating **STANDBY** mode. AC power and drive gas are required.
7. Select **UNLOCK** and remove the Patient Module, or
8. Enter the **Misc** screen in the **TEST** menu of the service Program Main menu. AC power is required.
9. Select **UNLOCK** and remove the patient module.

3.6.4 Removing the CO_2 Absorber Canister

1. To release the absorber canister from the patient module, turn the unit counter clockwise. Secure the Canister that it does not fall to the ground when the thread has ended.

Note: The discoloration of the spent soda lime disappears again after some time if it has not been used. If used again, the color discoloration returns. Dry soda lime becomes malsorbant.

3.6.5 Removing the Bellows and Dome System

1. Turn the unit counter clockwise and unscrew the unit ¼ turn.
2. Once released, remove the silicon bellows by pulling it down form the Patient Module fitting.

3.6.6 Removing the Airway Pressure Limiting Valve (APL)

1. Unscrew the union nut. The top section can now be removed.
2. The membrane can be removed from the bottom section and replaced, if necessary.
3. The membrane is placed back into the bottom section with the metal facing upwards.
4. Replace the top part of the Airway Pressure Limiting valve by lining up the index line in its correct orientation.
5. Secure with union nut.

Caution: The spring in the top of the APL valve may not be stressed. After removal from the bottom section place the top section to one side, taking care that the spring is not unduly loaded.

3.6.7 Inspecting/replacing the Decoupling, Bellow and Expiratory Valves

1. To replace the Patient modules rear side valves' membrane, undo the coupling nut.
2. After removing the valve assembly, undo the black nut securing the valve.
3. Inspect and /or replace the valve, ensuring no hole or deformity that would cause a leak.
4. Assemble in reverse order

CAUTION: During transportation of the patient module, transportation protection should be applied at the rear to protect the valves.

3.6.8 Disassembling the Room Air, Inspiration and expiration valves

1. To dismantle the valves, the coupling ring must be unscrewed from the valve body. The valve cover can now be removed.
2. The O-ring and the metal baskets in the expiration or inspiration valve can now be removed. The valve plate can be removed. Assemble in reverse order.
3. The membrane of the room air valve can be carefully removed from the valve body after removing the coupling ring and the valve cover. Assemble in reverse order.
4. The O-rings of the valve bodies have only to be exchanged if the valves were pulled out of the Patient Module's top.

3.6.9 Removing the Gas Block Module

1. Disconnect all sources of pressurized gas.
2. Remove the screws holding the rear access panel.
3. Remove the internal access panel containing the Gas Block.
4. Remove the screws and nuts holding the gas block to the enclosure.
5. Disconnect the gas lines running to the various connections.
6. Remove the Gas Block as a single module.
7. Reinstall the Gas Block in reverse order. Apply gas pressure and test prior to final button-up.

WARNING: An error in the tubing can lead to a serious health damage or death of the patient. Reinsure the correct connection of the gas lines before the unit is put back to use.

3.6.10 Removing the flow tubes

1. Remove the Gas Block Module
2. Remove the spring-loaded flow tubes by pushing it up and removing from the bottom.
3. Reinstall in reverse order.

3.6.11 Removing the pressure gauges

1. Remove the Gas Block Module
2. Remove the metal compression fittings from the gauge.
3. Remove the gauges from the front panel enclosure.
4. Reinstall in reverse order
5. Connect gas supplies at each gauge. Observe and test compression fittings for leaks.

3.6.12 Removing the Module 2 Circuit Board Set

1. Disconnect AC power.
2. Remove the cables connecting the Module 2 circuit boards to the rest of the Narkomat^{+}.
3. Remove the two nuts holding the Module to the housing.
4. Remove the Module 2 circuit as a module.
5. Reinstall in the reverse order.

3.6.13 Removing Module1 Circuit Board Set

1. Remove the display cover and open module 1 housing by unscrewing the screws on the top.
2. Remove the cables connecting the Module 1 circuit board to the rest of the Narkomat^{+}.
3. Remove the screws holding the Module 1 to the button of the housing.
4. Remove the Module 1 circuit boards as a module
5. Reinstall in the reverse order.

3.6.14 Removing the Power Supply Module

1. Disconnect AC power
2. Remove the housing cover of the power supply module.
3. Remove cables connecting the power supply module to the rest of the Narkomat^{+}.
4. Remove the screws holding the board/module to the access panel.
5. Remove the power supply as a module.
6. Reinstall in reverse order.

3.6.15 Removing Internal Regulators, Proportional Valve and Flow Divider

1. Disconnect all sources of pressurized gas.
2. Remove vaporizers.
3. Remove the screws of pneumatic drawer and pull it out.
4. Disconnect each gas hose and electric cable running through each section.
5. Remove the drawer exposing the internal regulators and proportional valve. Replace the targeted component. Replace each hose and cable.
6. Reconnect hoses and cables to the new component.
7. Rebuild in reverse order.
8. Apply gas pressure and power to functional test prior to final button-up

4 Maintenance and Calibration

4.1 Introduction

The Narkomat^{+} maintenance and calibration is comprised of four distinct activities:

1. Inspecting and/or replacing consumable parts
2. Adjusting individual potentiometers
3. Functional testing
4. Programming coefficients into stored memory

Consult the Preventive Maintenance chapter of this manual to determine the appropriate interval for inspection and replacement of consumables, mechanical and electronic adjustments, testing and programming.
Ensure that all testing materials, including gas drive, breathing circuits, test fixtures, tools and documents are available and in good working order prior to beginning test procedures.
Testing and programming requires utilizing internal service software. A password is provided by **HEYER.**

4.2 Calibration Warnings and Precautions

WARNING: **The Narkomat^{+} Anesthesia Machine operates on line voltage and at high pressure. Therefore, an electric shock hazard may exist when the backside panel covering the power supply boards is removed. Repair and calibration procedures should only be preformed by qualified personnel who follow proper servicing techniques. Warnings are given in appropriate location.**

WARNING: **Possible fire hazard. Fuses (i.e., additional sockets) must only be replaced by fuses of the same type with the same rating.**

WARNING: **Possible electrical shock hazard. The machine may only be opened by HEYER authorized service personnel.**

CAUTION: **Refer to the maintenance intervals in the preventive maintenance section for guidance on which steps are preformed when.**

CAUTION: **Use surgical gloves whenever touching or disassembling valves or other components of the patient module.**

CAUTION: **Ensure that the gas supply of the machine always complies with the technical specification.**

CAUTION: **If the machine should show faults during the initial calibration or testing, the machine should not be operated until the fault has been repaired by a qualified service technician.**

CAUTION: **After servicing, functional, compliance and leak tests must be carried out before clinical use**

CAUTION: **Failure to connect device to a grounded mains out may elevate leakage current in excess of permissible values.**

CAUTION: **During transportation of the patient module, transportation protection should be applied to the rear to protect the diaphragm valves**

CAUTION: The spring in the top of the APL valve may not be stressed. After removal, ensure that the APL valve is in position "CMV" and place to one side, taking care that the spring is not unduly loaded.

CAUTION: Use cleaning agent sparingly. Excess fluid could enter the machine, causing damage.

4.3 Test Procedure

4.3.1 General

1 Ensure that the Service Manual and Operation Manual are present.

2 Ensure there is no external damage to machine and accessories by visual inspection.

3 Ensure all accessories are complete and functional by visual inspection.

4.3.2 Inspecting/replacing consumable parts

1 Remove the patient module from the Narkomat^{+}

a Turn the lever below the docking station counter clockwise to unlock the patient module..

b Pull out the patient module slightly and verify that the patient module stops.

c Remove the patient module.

d Verify that the diaphragm valve connectors are not damaged..

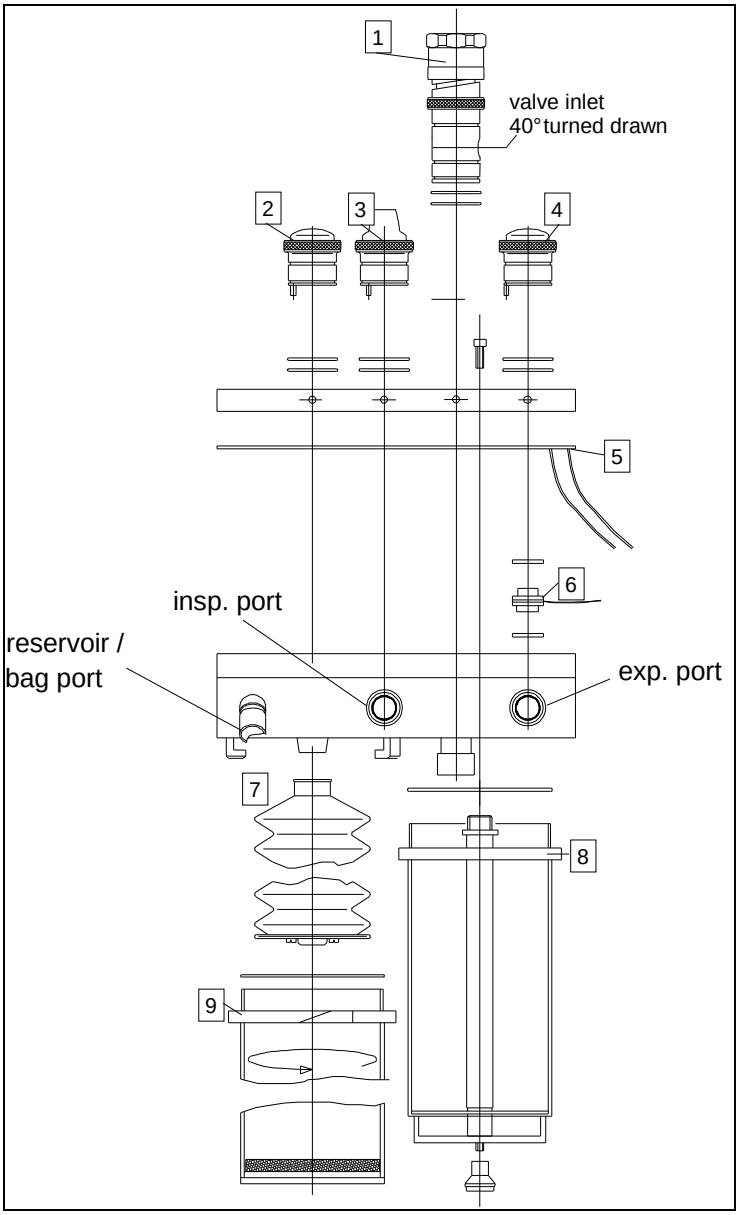


Fig. 16 Patient module, front view

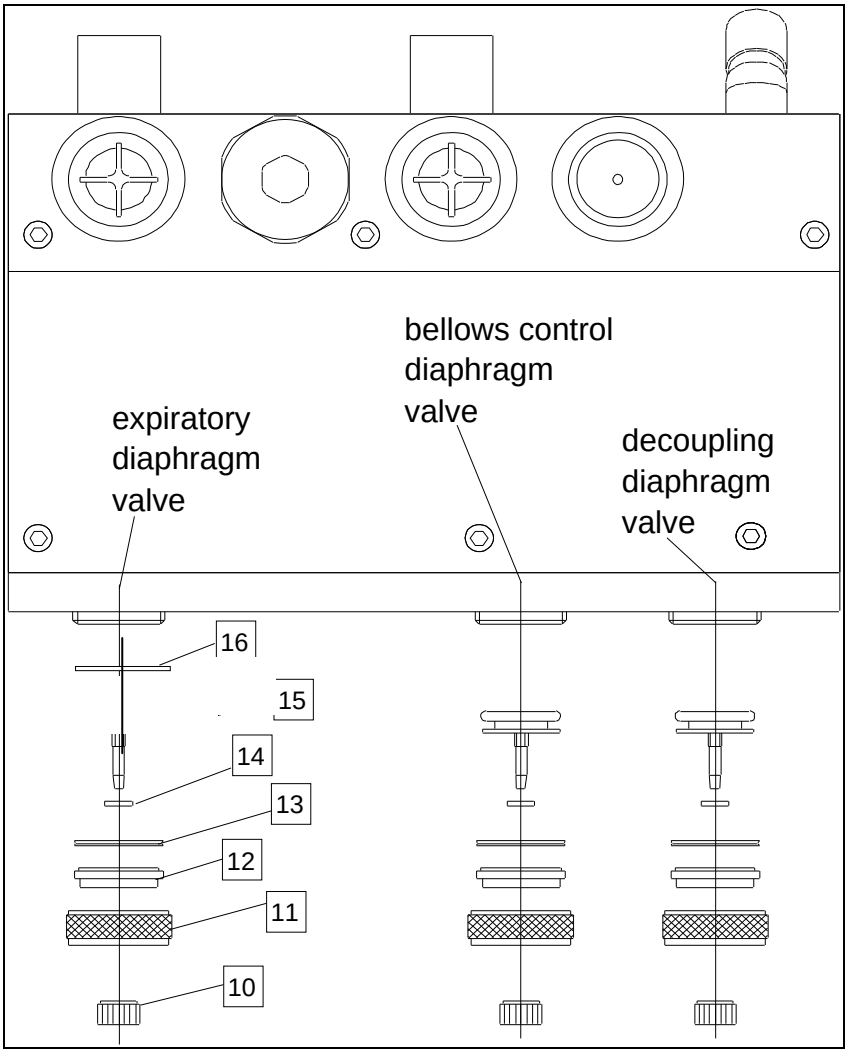


Fig. 17 Patient module, top view (diaphragm version)

Pos. No.	Description	Order No.
1	Airway pressure relief valve, cpl.	323-0095
2	Emergency air valve, cpl.	323-0098
3	Inspiratory valve, cpl.	323-0096
4	Expiratory valve, cpl.	323-0097
5	Heat blanket, cpl	323-0314
6	Flow sensor, cpl.	323-0220
7	Ventilation Bellow	323-0158
8	Absorber vessel	323-0046
9	Bellow dome	323-0045
10	Fixing nut diaphragm valve	323-0294
11	Bessel diaphragm valve	323-0110
12	Ring plate diaphragm valve	323-0042
13	O-ring 28.3x1.78	323-0292
14	Gasket 13x6.5x2	980-1170
15	Diaphragm valve body	323-0100

2 Ensure that the O-ring (323-0147) and the packing ring (980-1170) of the CO_2 absorber are intact.

3 Ensure that the O-ring (323-0147) on the ventilator bellow is intact.

4 Ensure that the O-ring (049-3182) on each vaporizer mount is intact.

5 Check O-rings (049-3052) of the docking station ports (located between the patient module and its docking station).

   a Replace O-rings at recommended interval

6 Inspect O-ring washer (980-1174 for O2 and N2O) between tank and yoke connection. Replace if necessary.

7 Ensure the inspiratory valve (610-3156) is intact, replace if necessary.

8 Ensure the expiratory valve (610-3156) is intact, replace if necessary.

9 Ensure the APL valve (323-0310) is intact, replace if necessary.

10 Ensure the Room air valve (323-0099) is intact, replace if necessary.

11 Ensure that the inspiratory and expiratory valve O-rings (610-3157) are intact, replace if necessary.

12 Ensure the Fresh gas decoupling, Driving gas and expiratory diaphragm valves (323-0100) are intact, replace if necessary.

13 Check gas supply inlet filters (370-0017) and water traps (340-0344).

   a Verify that minimal to no condensation or dirt are present in the inlet filter and bottles. Drain any liquid from bottles.

   b Clean and/or replace the contaminated inlet filters and O-rings, if necessary.

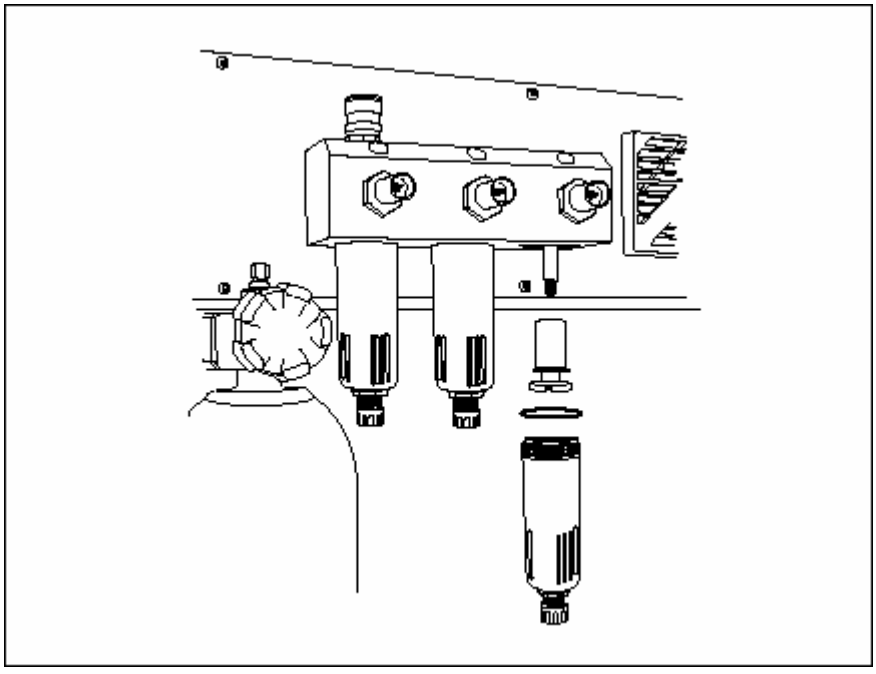


Fig. 18 Supply inlet filters and water traps

14 Reassemble the patient module and install back into the docking station.

15 Turn off the Narkomat^{+} power switch.

16 Verify O_2 and N_2O tank check valves. *

a Connect and open a full gas tank on each yoke

b Withdraw the gas connecting coupling from the supply outlet.

c Verify the check valves prevent gas from escaping through the open supply outlets.

d Verify there is no external damage to the gas connecting coupling

17 Verify O_2, N_2O and AIR supply check valves.

a Remove the tanks and reconnect the gas connecting couplings to the supply outlets.

b Verify the check valves prevent gas from escaping through the open tanks yokes.

c Verify there is no external damage to the gas tank or yoke pins.

* Subject of configuration

4.3.3 Power supply checks

1 Remove the screws from the lower panel and keep the panel at it's position. Carefully remove the panel.

Warning: AC voltage is present

2 Adjust P1 on the power supply board for +5.2 VDC. Use the ground pin located to the right as meter ground.

3 Adjust P2 on the power supply board for +12.5 VDC. Use the ground pin located to the right as meter ground.

4 Verify that the V54 LED is illuminated, indicating -12 VDC.

5 Reinstall the panel.

4.3.4 Functional Tests

4.3.4.1 Pneumatic tests

1 Perform automatic compliance test.

a Turn on the Narkomat$^+$ and ensure adequate drive gas is present

b Attach a breathing circuit the patient module.

c Seal the Y-piece by attaching the open port to the parking place on the side of the patient module.

d Turn off the fresh gas flow.

e Select **START** to start the test. The test calibrates the ventilator for tubing compliance at 40 Pa x 100 (40 mbar; 40 cmH_2O) and performs a leak test on the patient circuit pneumatics between the decoupling valve and the expiratory valve.

f Verify successful completion and that no leaks are indicated.

2 Perform automatic leak test.

a Turn on the Narkomat$^+$ and ensure adequate drive gas is present. Enter the Leak Test via the Options menu.

b Attach a breathing circuit the patient module.

c Connect the y-piece to the hose end where the reservoir bag normally is connected.

d Turn off the fresh gas flow.

e Set the APL valve to max (fully closed)

f Select **START** to start the test. The test pressurizes the system the pneumatic system all the way back to the spindle valve of the flow meters.

g Verify successful completion and that a minimal leak (less than 300 ml/min at 40 cmH_2O) is indicated.

3 Perform the manual pressure test.

a With the selector switch of the Narkomat$^+$ turned to the manual position, attach a breathing circuit to the patient module.

b Connect the y-piece to the hose end where the reservoir bag normally is connected.

c Set the APL valve to max (fully closed).

d Rotate the O_2 or AIR spindle until 60 Pa x 100 (60 mbar; 60 cmH_2O) is observed on the screen.

e Reduce the gas flow by counter rotating the spindle until the pressure stabilizes at 60 Pa x 100 (60 mbar; 60 cmH_2O)

f The gas flow indicates the Narkomat$^+$'s leak rate. If the automatic Compliance and Leak test have passed, this test will indicate a leak in the drive gas system, or may be used to troubleshoot system leaks at a higher-pressure level.

4 Verify APL Valve accuracy.

a Attach a breathing circuit the patient module.

b Connect the y-piece to the hose end where the reservoir bag normally is connected.

c Set a fresh gas flow of 5 l/min.

d Set the APL valve to each pressure graduation (10, 20, 30, 40 and 50 Pa x 100 (mbar; cmH_2O))

e Compare the valves on the pressure gauge with the valve settings. Deviations from pressure indication and setting must not exceed ±20% of the set value or 10 Pa x 100 (10 mbar; 10 cmH_2O), whichever is greater.

4.3.4.2 Alarm Tests

1 Turn on the Narkomat$^+$ and ensure adequate driving gas is present.

2 Perform the Compliance test.

3 Verify the Vt min (low alarm), Peak pressure (high and low alarms), M.Vol (low alarm) and O_2 (high and low alarms).

a Ventilate a test lung in the CMV mode.

b Set each parameter's alarm limit one at a time, to violate it's high and low alarm setting.

c Verify that alarm indications function.

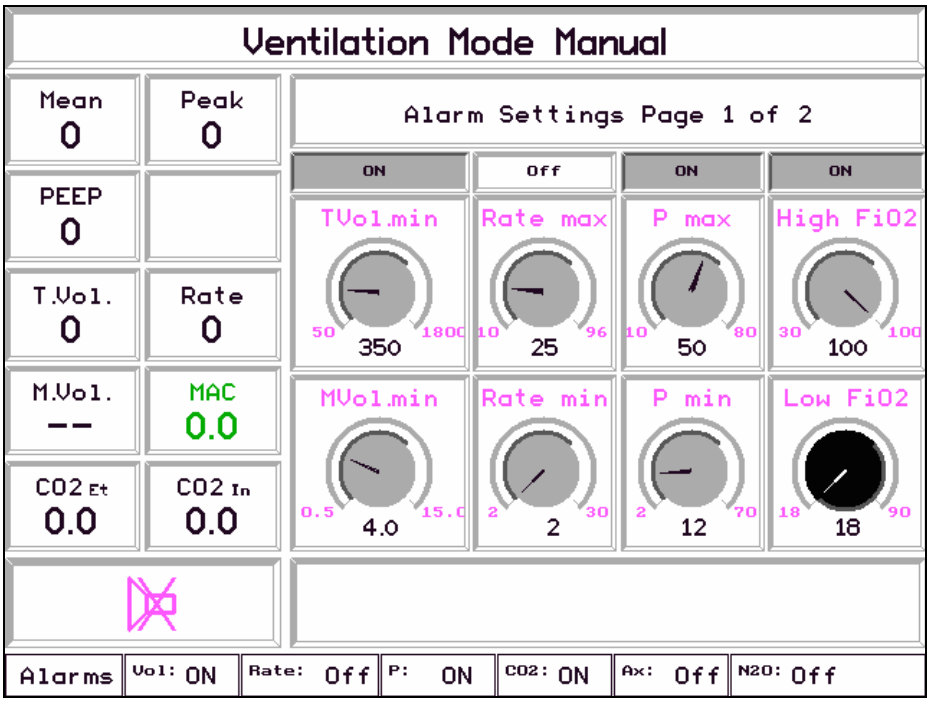


Fig. 19 Alarm screen

4 Verify O2 pressure loss alarm (whistle) and N2O cutoff.

a Ventilate a test lung in the CMV mode.

b Set the AIR/N_2O switch to N_2O

c Flow 1 l/min O_2 and 1 l/min N_2O using the flow meter spindle valves.

d Interrupt the O_2 supply to the Narkomat$^+$.

e Verify the O_2 pressure loss alarm whistle for approximately 7 seconds, and the flow of nitrous oxide lowers to 0 l/min. If O_2 is the ventilator drive gas, an electrical alarm and message will also activate.

f Verify at the same time, Air is available by adjusting the AIR spindle valve. AIR flow will be available regardless of the position of the AIR/N_2O switch position. Air flow can be increased by rotating the Air flow spindle.

g If necessary, adjust the time and loudness level of the O2 deficiency whistle by setting the screw adjustment next to the Whistle reservoir.

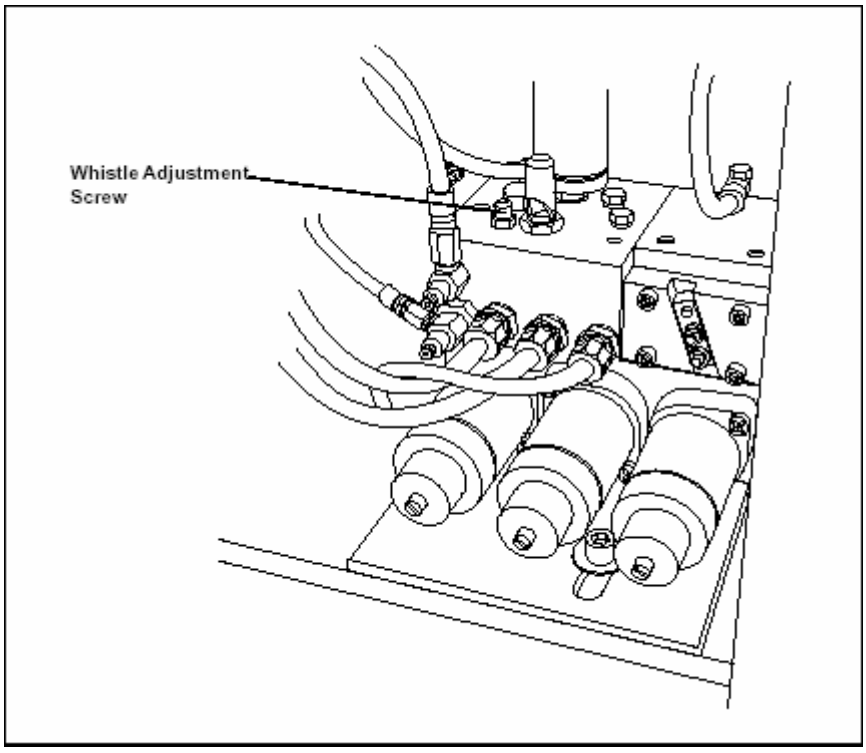


Fig. 20 O2 Whistle adjustment (appearance may differ due to different configuration options)

5 Verify line voltage alarm.

a Interrupt AC line voltage while the respirator unit is in manual/spontaneous, or automatic ventilation mode.

b Verify that the line power alarm sounds and that the AC connector icon appears on the display. The alarm is reset when reconnecting the line power supply.

c Verify the battery icon appears on the screen after AC reconnection. This indicates battery charging.

6 Verify N_2O:O_2 ratio system.

a Set the O_2 and N_2O valves to minimum.

b Rotate the N_2O valve throughout its range from 0.5 to 10 l/min.

c Using the readings from the flow tube, verify that no less than 25% ± 5% O_2 can be achieved at any N_2O flow rate.

4.3.4.3 Electrical Tests

1 Check convenient AC outlets.

a Verify AC voltage is present at each AC outlet with the Narkomat$^+$ Mains switch in the ON or OFF position.

CAUTION: Perform the following electrical safety inspection as the last step after completing a repair or after routine maintenance.

2 Conduct electrical safety inspection.

Test of electric safety according to IEC 601-1:

Test the protective conductor resistance.

For the measurement, use a test set according to IEC 601-1.

The maximum protective conductor resistance must not exceed 0.1 Ohms.

Enter the result into the test protocol.

Test the leakage current.

For the measurement use a test set according to IEC 601-1.

Before the measurement of the leakage current, withdraw the power supply cable of all units form the convince receptacles at the rear side of the apparatus.

The maximum leakage current must not exceed 500µA (0.5 mA).

Enter the result into the test protocol.

Test the insulation resistance.

For the measurement, use a test set according to IEC 601-1.

The insulation resistance must be higher than 70 MOhms.

a Enter the result into the test protocol.

5 Service Software

How To Start The Service Software
Turn off the main switch. The ”INSP. PAUSE” and ”EXP. PAUSE” control panel keys must be pressed while turning on the main switch, the keys have to keep pressed 3 seconds longer than the LED’s are lit. The PC now starts the service software.

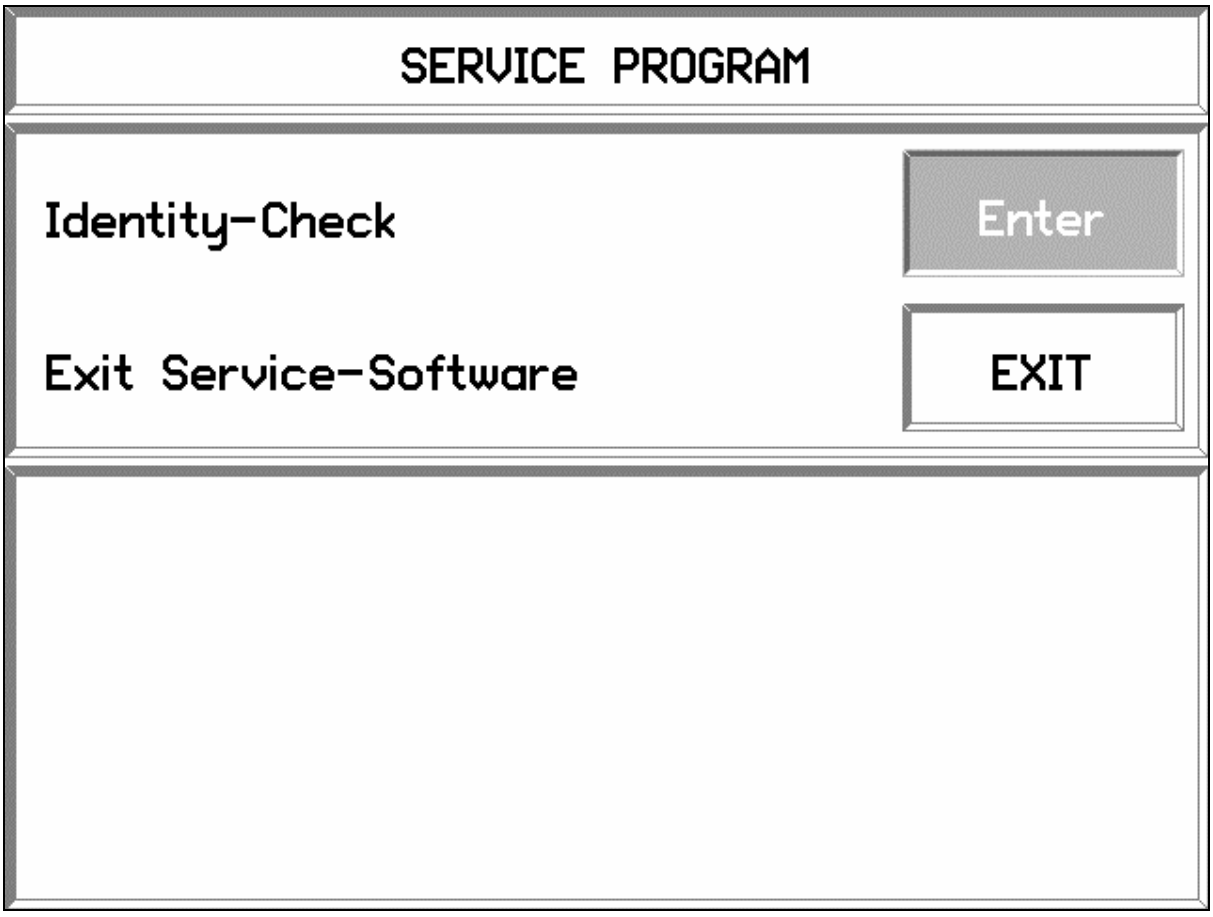


Fig. 1 **Start Window**

5.1 Identity Check

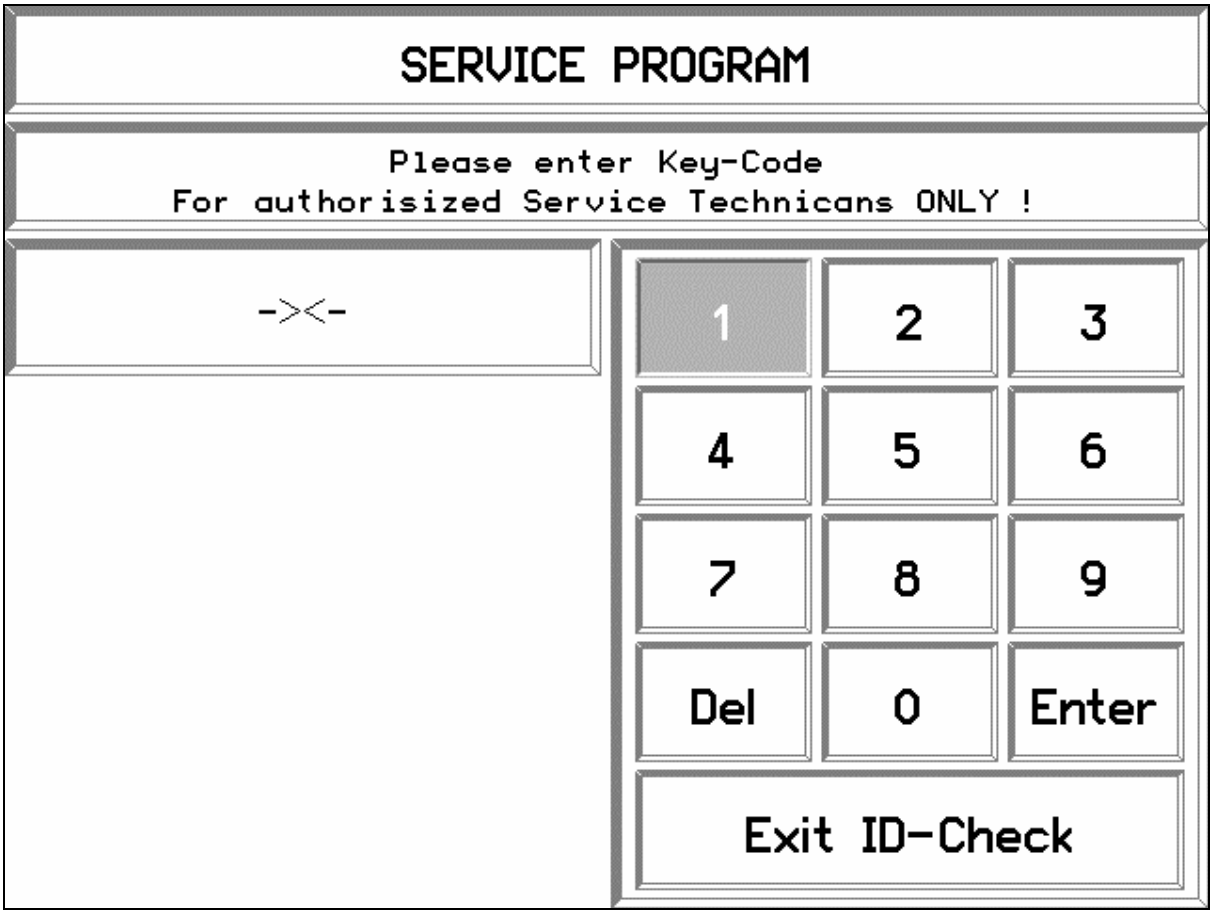


Fig. 2 Identity Check

- Enter a valid key-code to execute the service software.
- Leave this window with ”Enter”.

5.2 Main Menu

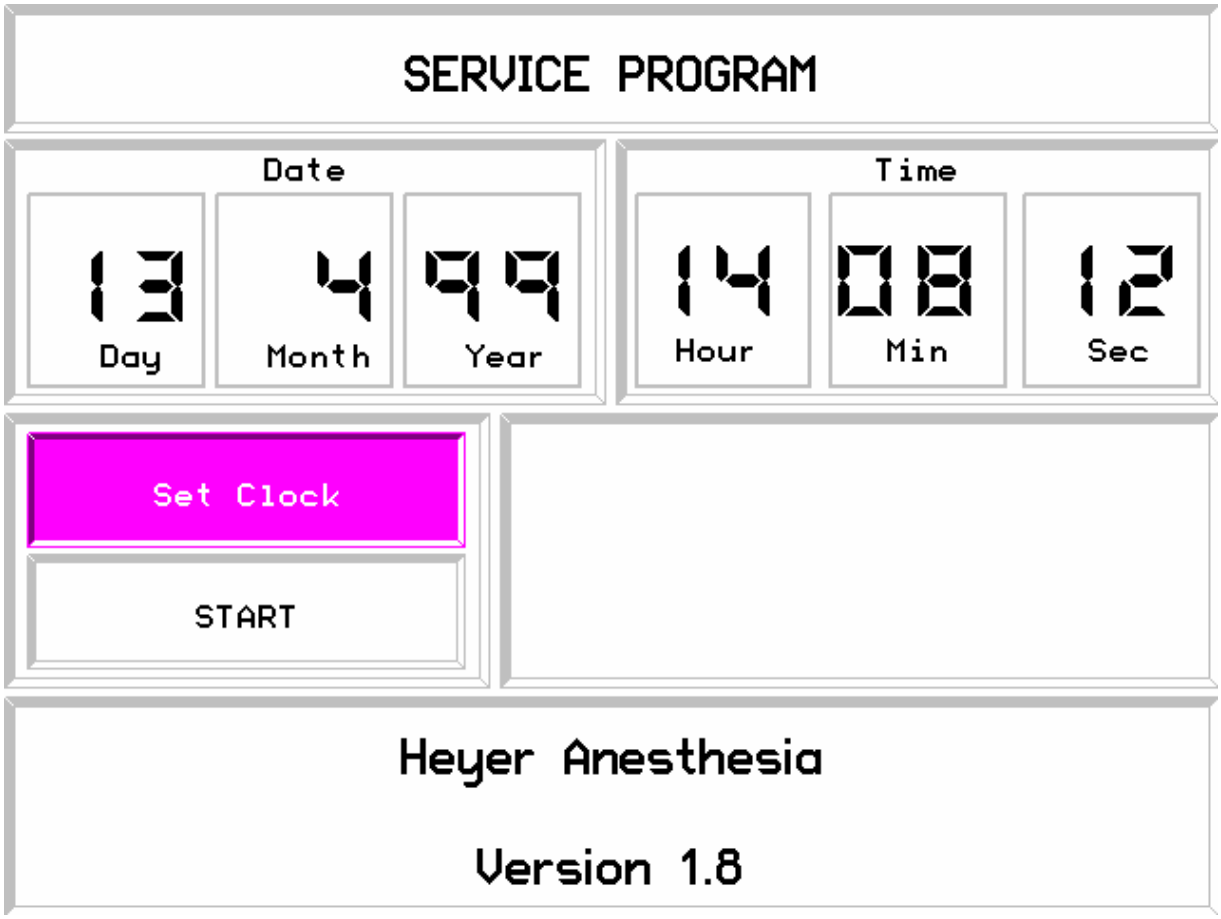


Fig. 3 Main Menu

- Choose the next application by operating one of the buttons.

5.3 Set Date and Time

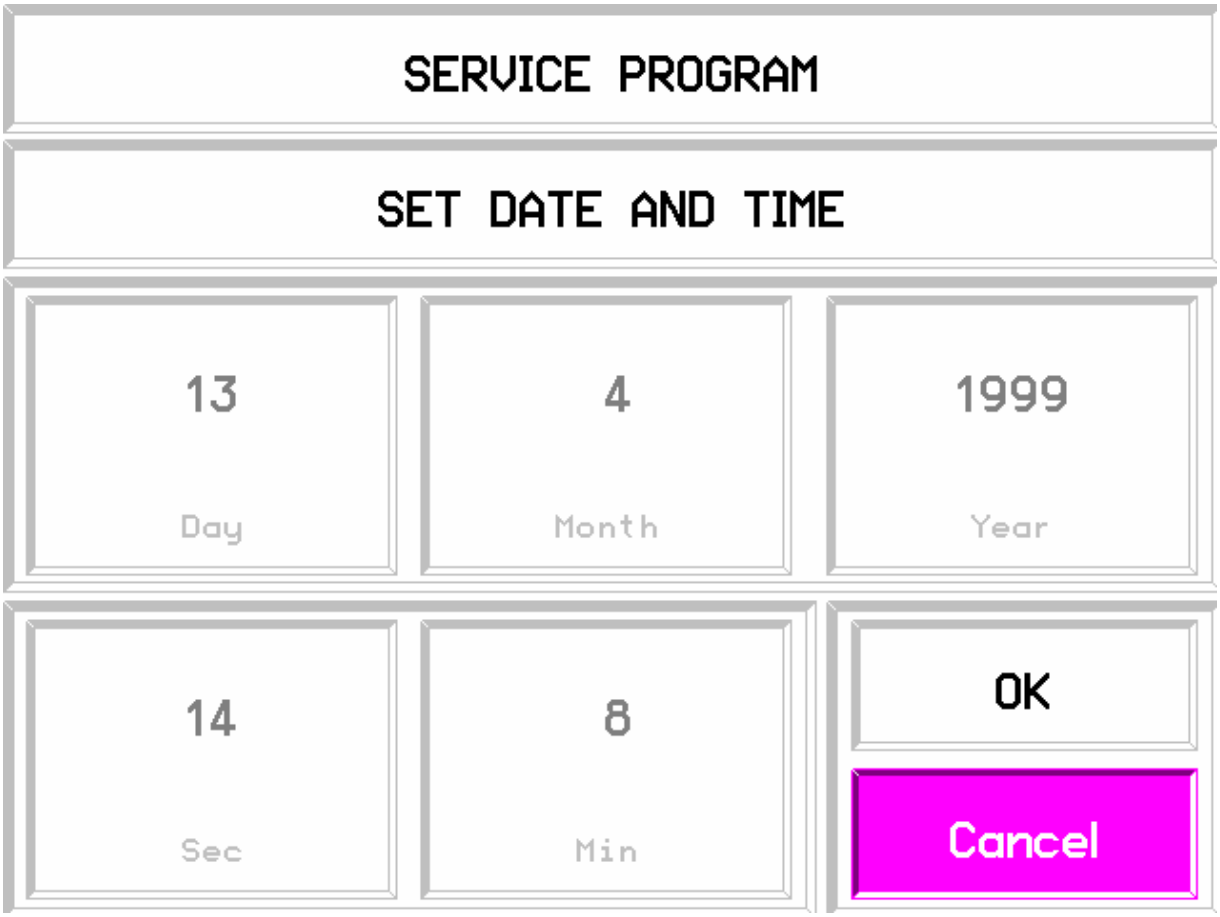


Fig. 4 Set Date and Time

- First check the date and time, if it is necessary, set the clock.
- Change date or time by moving the display pointer to the corresponding button, change the value by turning the encoder knob to the right or to the left. Press the encoder knob to leave the display button.
- When clock is set, save the information and turn back to the main menu by validating the “Cancel” button. If the change should not be saved, quit the application to turn back to main menu.

5.4 Choose Service

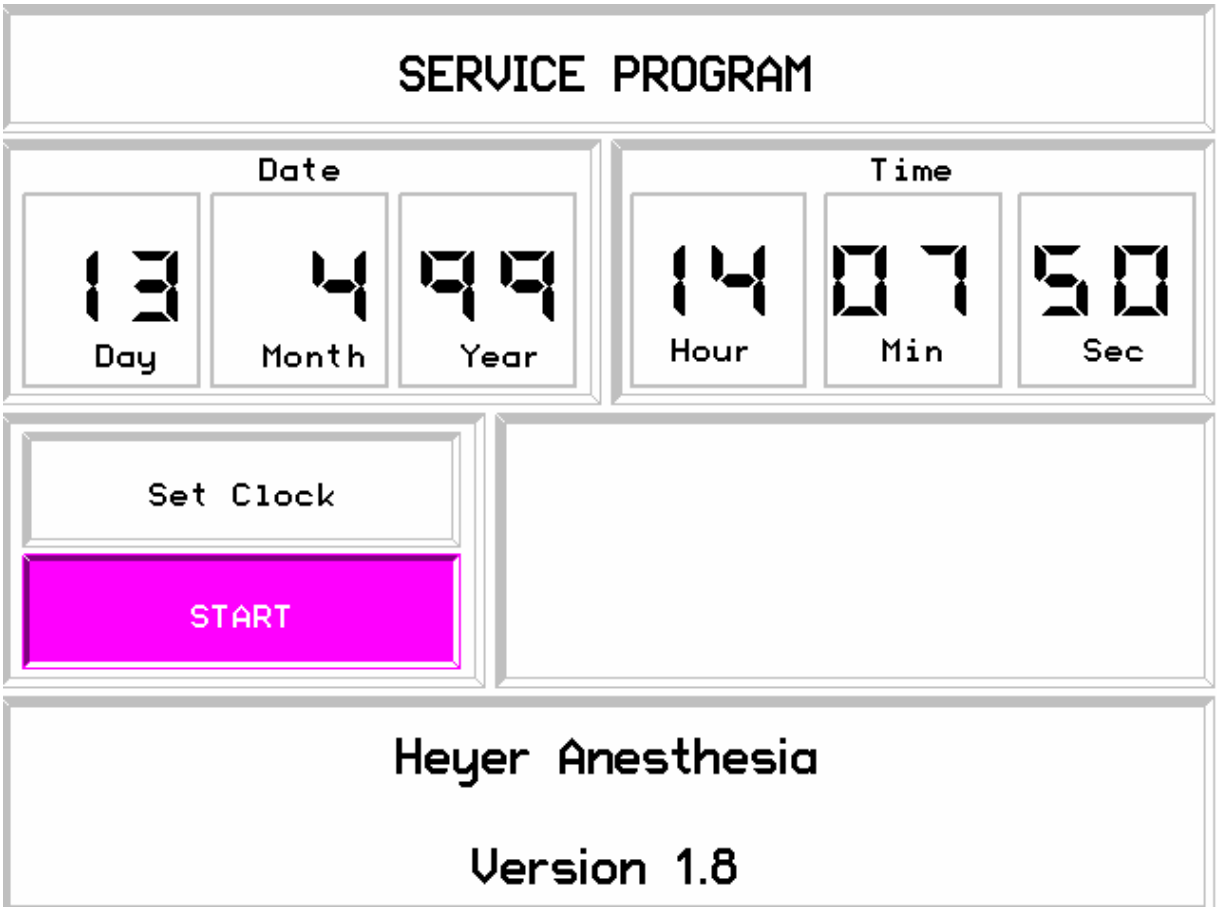
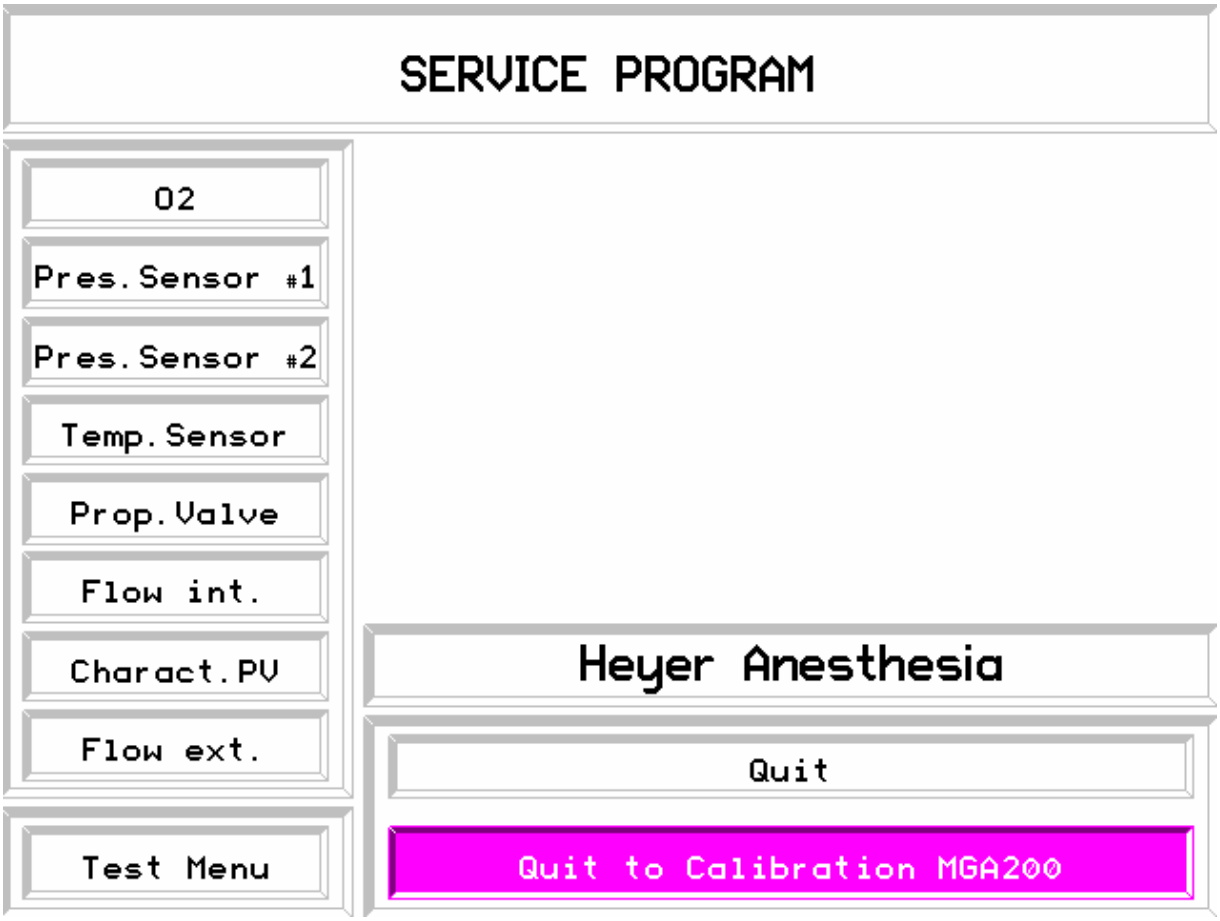


Fig. 5 Choose Service

- Press the ”Start” button at the main menu to open the calibration routines window.



5.5 Calibration Routines

Fig. 6 Calibration Routines

- Choose from the service menu the sensor to calibrate. In case of a complete calibration it's recommended to perform the calibration step by step in order of the menu.
- To exit the service software operate the "Quit" button of this window. Two acoustic signals are indicating the correct end of the service software and a new boot procedure of module 2.

Caution: Shut down the complete unit each time you have finished the service software.
Warning: Perform a Sensor Test and the System Tests after you have finished the service software.

5.5.1 O_2 Sensor ADC Calibration*

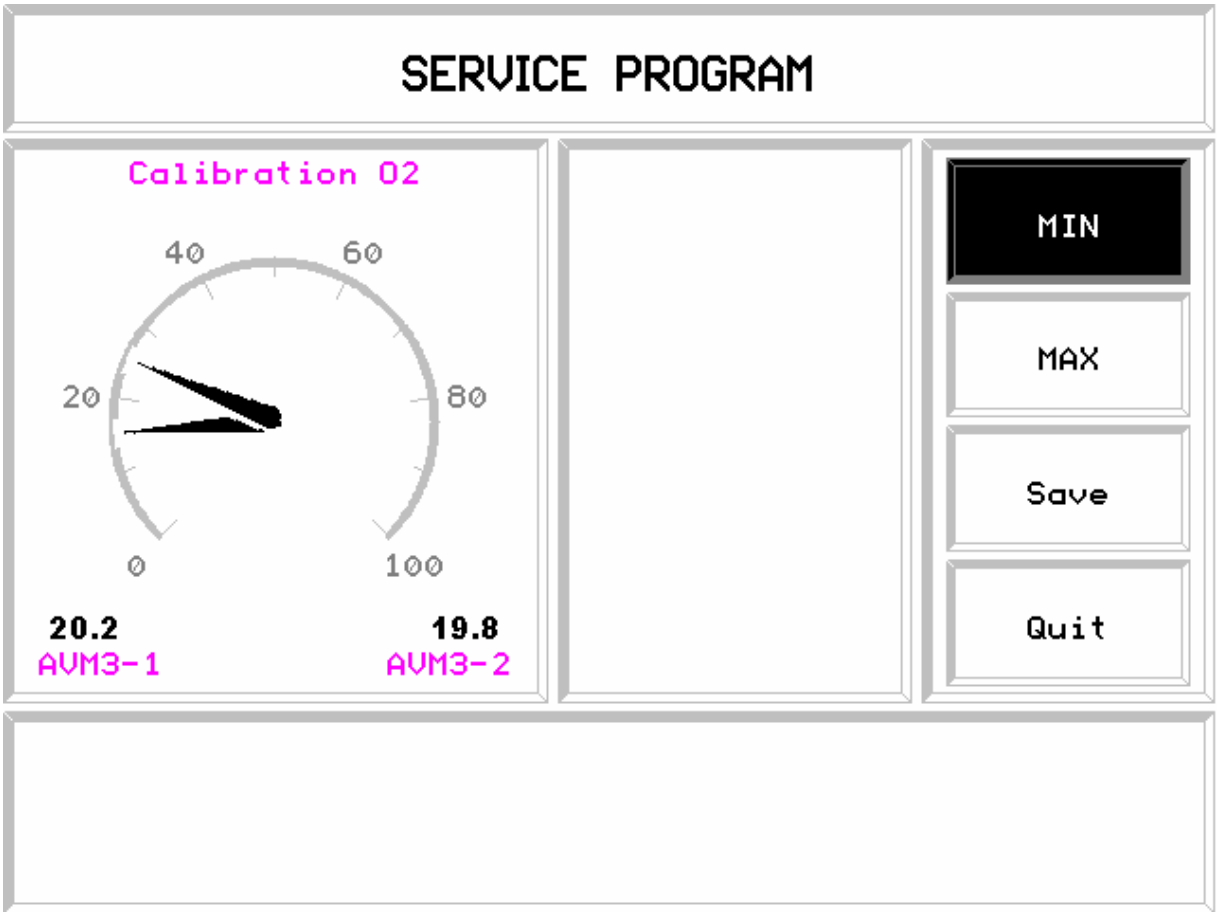


Fig. 7 O_2 Sensor ADC Calibration 1

- Place oxygen sensor into the test adapter in ambient air.
- Turn offset potentiometer screw O_2 OFFS (P5, AVM3-2) until the pointer at the screen shows $20^{\pm 1}$
- Operate the ”MIN” button.

*Not valid with the gas measuring unit

O_2 Sensor ADC Calibration , cont.*

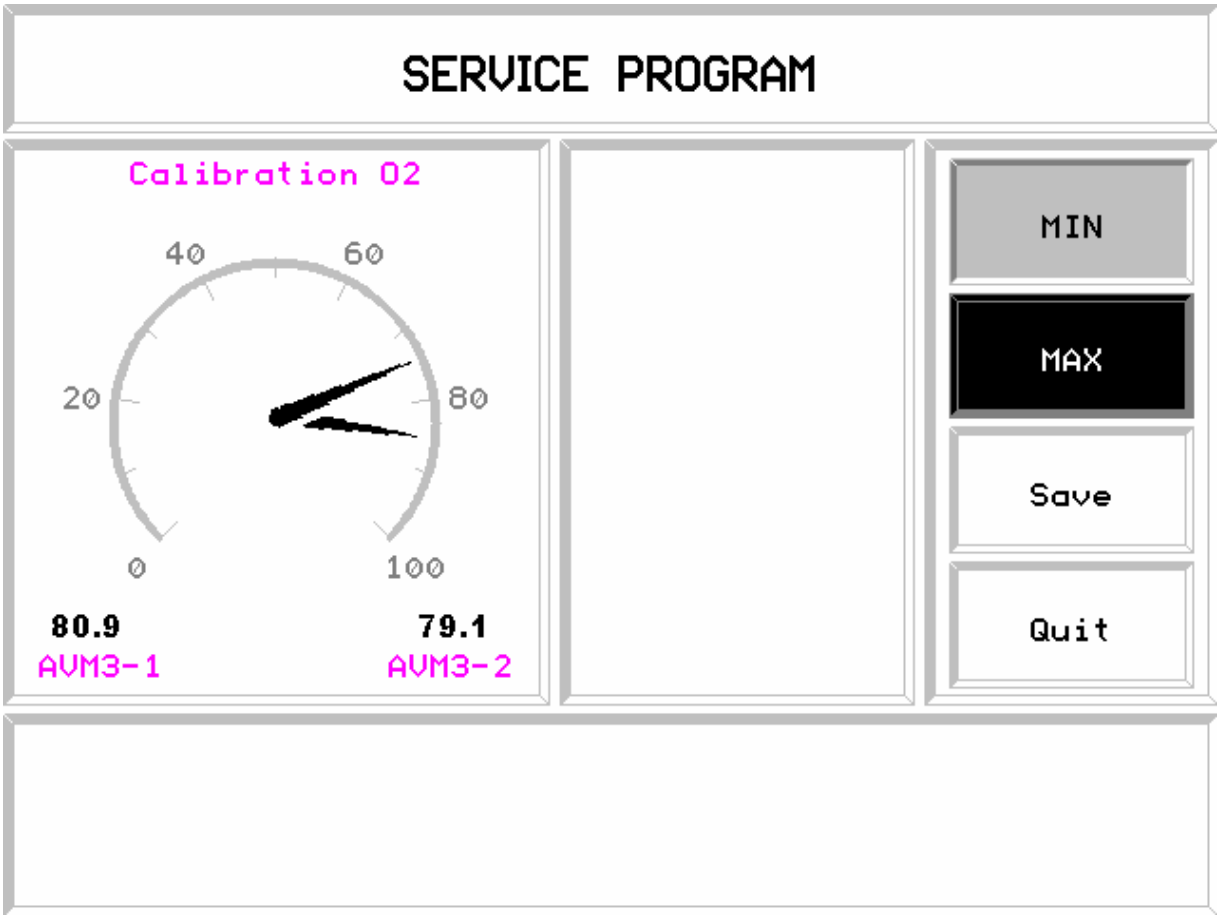


Fig. 8 O_2 Sensor ADC Calibration 2

- Put the oxygen sensor into 100% O_2.
- Open the Y-piece and apply an oxygen flow of 5 l/min for some minutes.
- Turn gain potentiometer screw O_2 GAIN (P6, AVM3-2) until the pointer at the screen shows $80^{\pm 1}$.
- Operate the ”MAX” button.
- Check both of the values alternately for correctness and readjust if necessary. When both of the calibration points are correct within a tolerance range +/-1.0, operate the ”Save” button.
- By operating ”Quit” turn back to calibration menu.

*Not valid with the gas measuring unit

5.5.2 Pressure Sensor #1 ADC Calibration

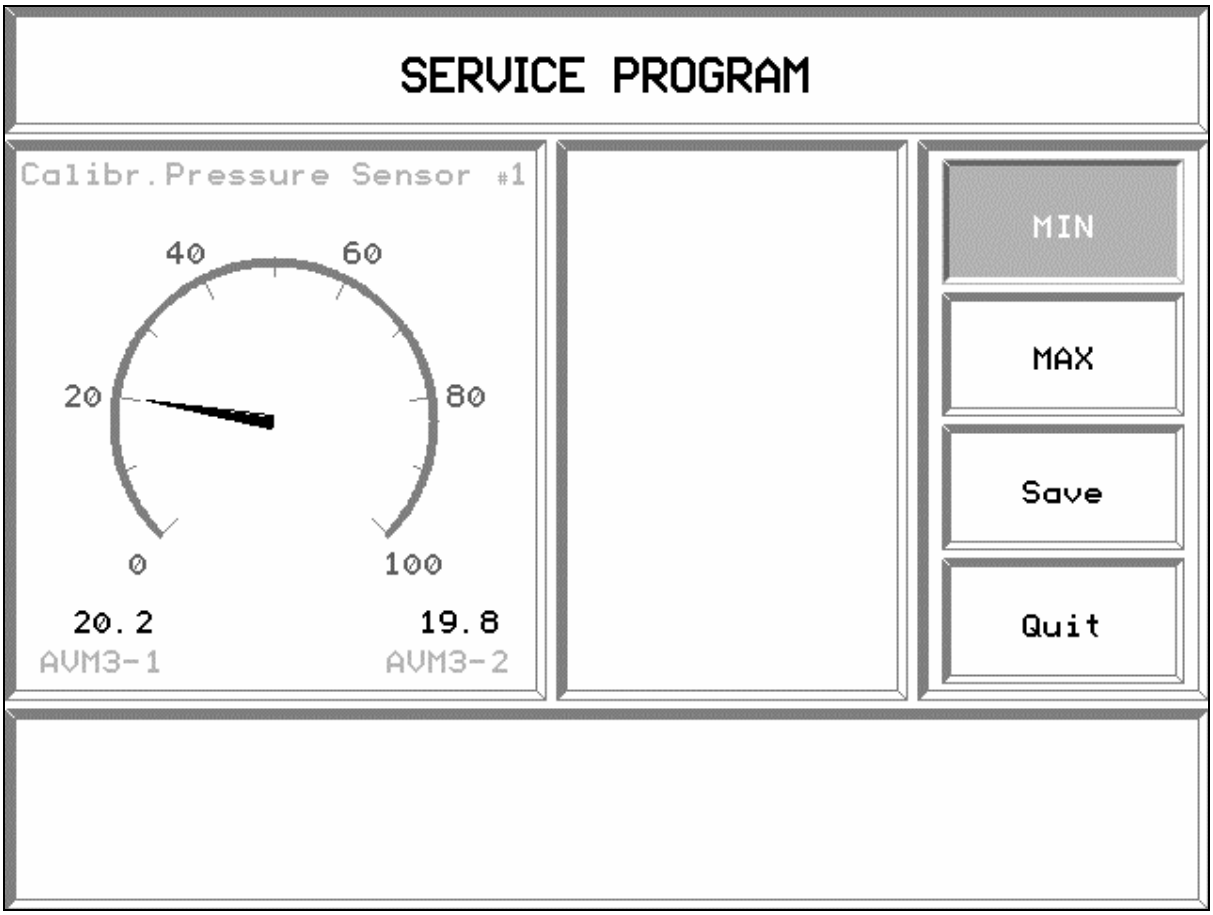


Fig. 9 Pressure Sensor #1 ADC Calibration 1

- Connect a pressure gauge and a pressure applicator to the pressure gauging line.
- Apply ambient pressure.
- Turn offset potentiometer screw P1 OFFS (P11, AVM3-2) until screen pointer shows 20.
- Operate the ”MIN” button.

Pressure Sensor #1 ADC Calibration , cont.

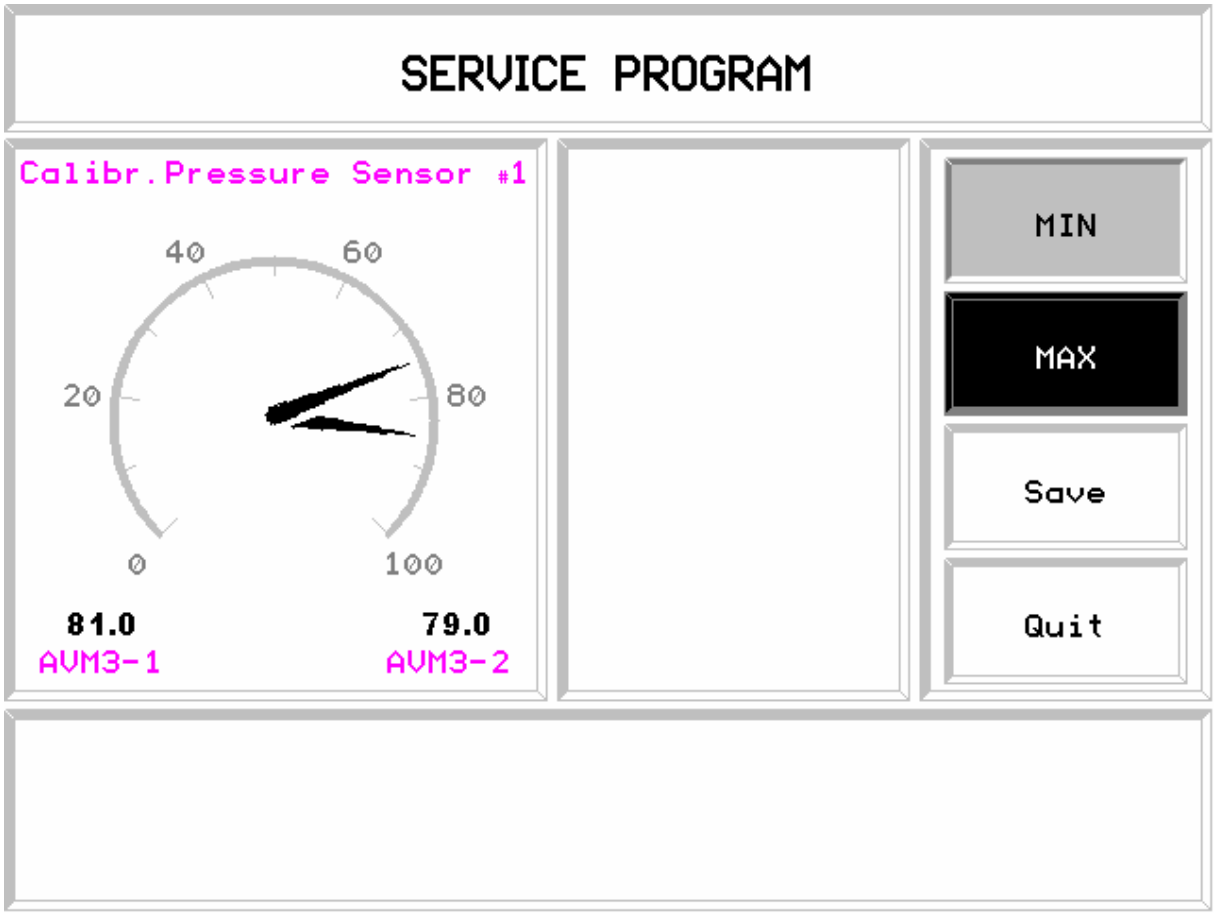


Fig. 10 Pressure Sensor #1 ADC Calibration 2

- Apply a pressure of 80 mbar to the gauging tube.
- Turn gain potentiometer screw P1 GAIN (P10, AVM3-2) until screen pointer shows 80 and operate ”MAX” button.
- Check both of the values alternately for correctness and readjust if necessary. When both of the calibration points are correct within a tolerance range +/-0.2, operate the ”Save” button.
- By operating ”Quit” turn back to calibration menu.

5.5.3 Pressure Sensor #2 ADC Calibration

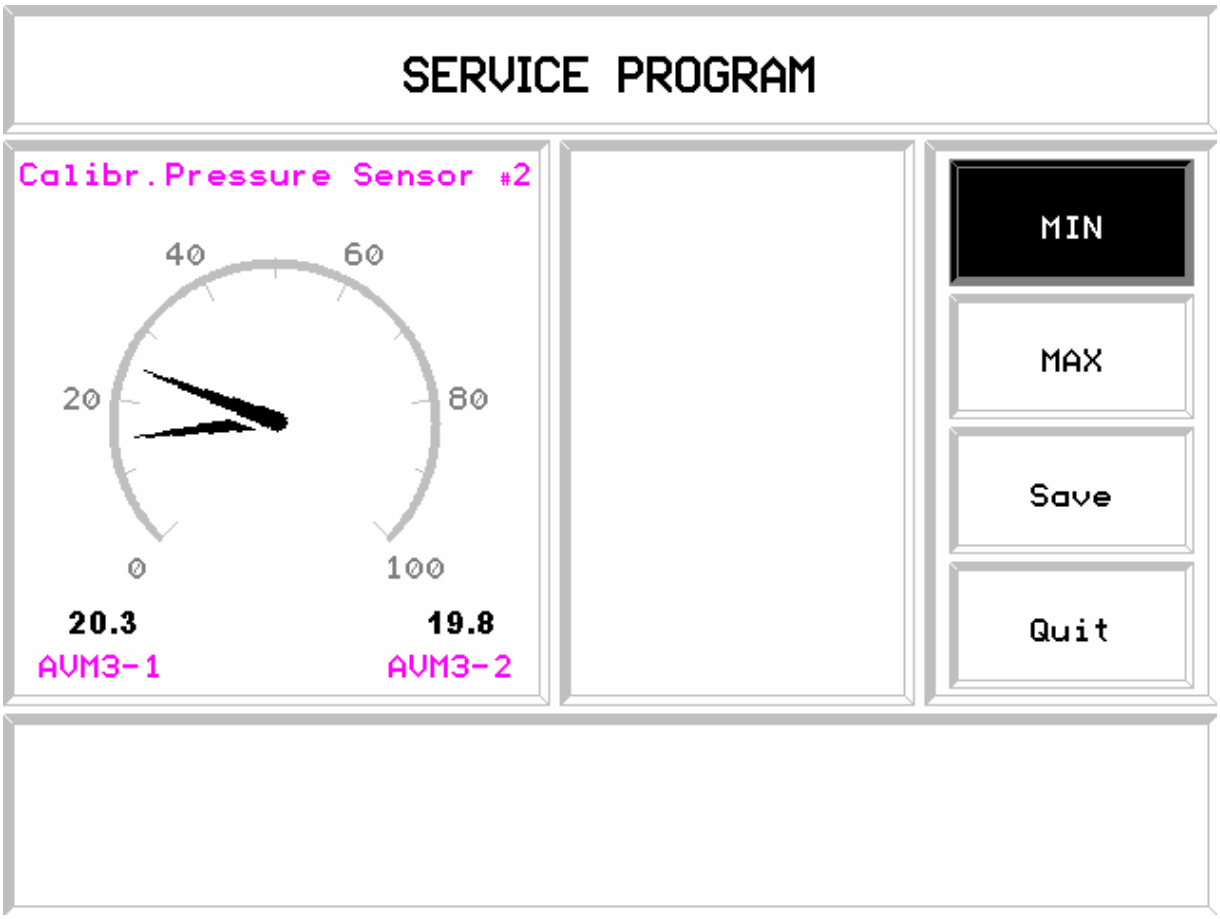


Fig. 11 Pressure Sensor #2 ADC Calibration 1

Perform the same calibration procedure like in case of pressure sensor P1.

- Apply ambient pressure.
- Turn offset potentiometer screw P2 OFFS (P8, AVM3-2) until screen pointer shows 20 and operate the ”MIN” button.

Pressure Sensor #2 ADC Calibration , cont.

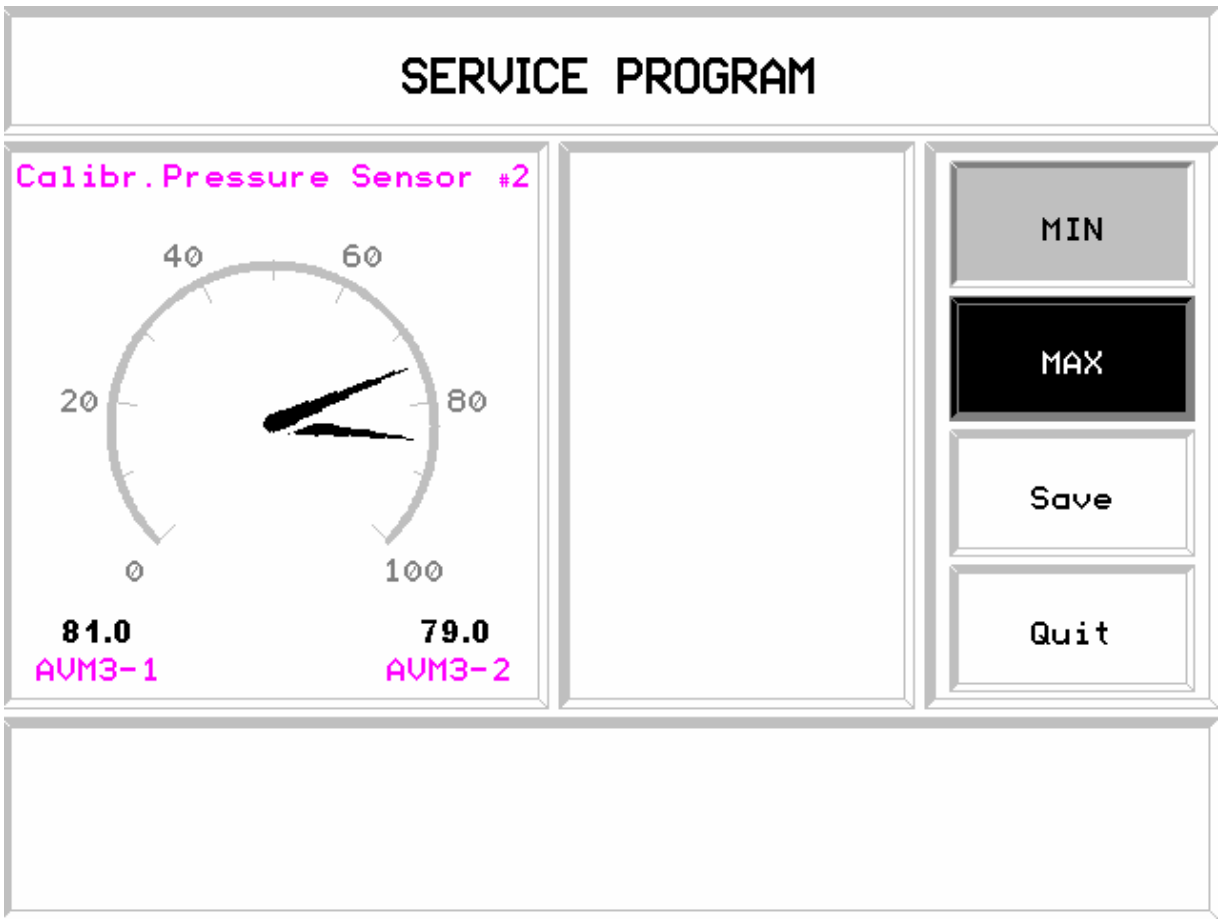


Fig. 12 Pressure Sensor #2 ADC Calibration 2

- Apply a pressure of 80 mbar to the gauging tube.
- Turn gain potentiometer screw P2 GAIN (P7, AVM3-2) for gain calibration until screen pointer shows 80 and operate ”MAX” button.
- Check both of the values alternately for correctness and readjust if necessary. When both of the calibration points are correct within a tolerance range +/-0.2, operate the ”Save” button.
- By operating ”Quit” turn back to calibration menu.

Caution: Avoid differences in adjustment between pressure sensors P1 and P2.

5.5.4 Temperature Sensor Calibration

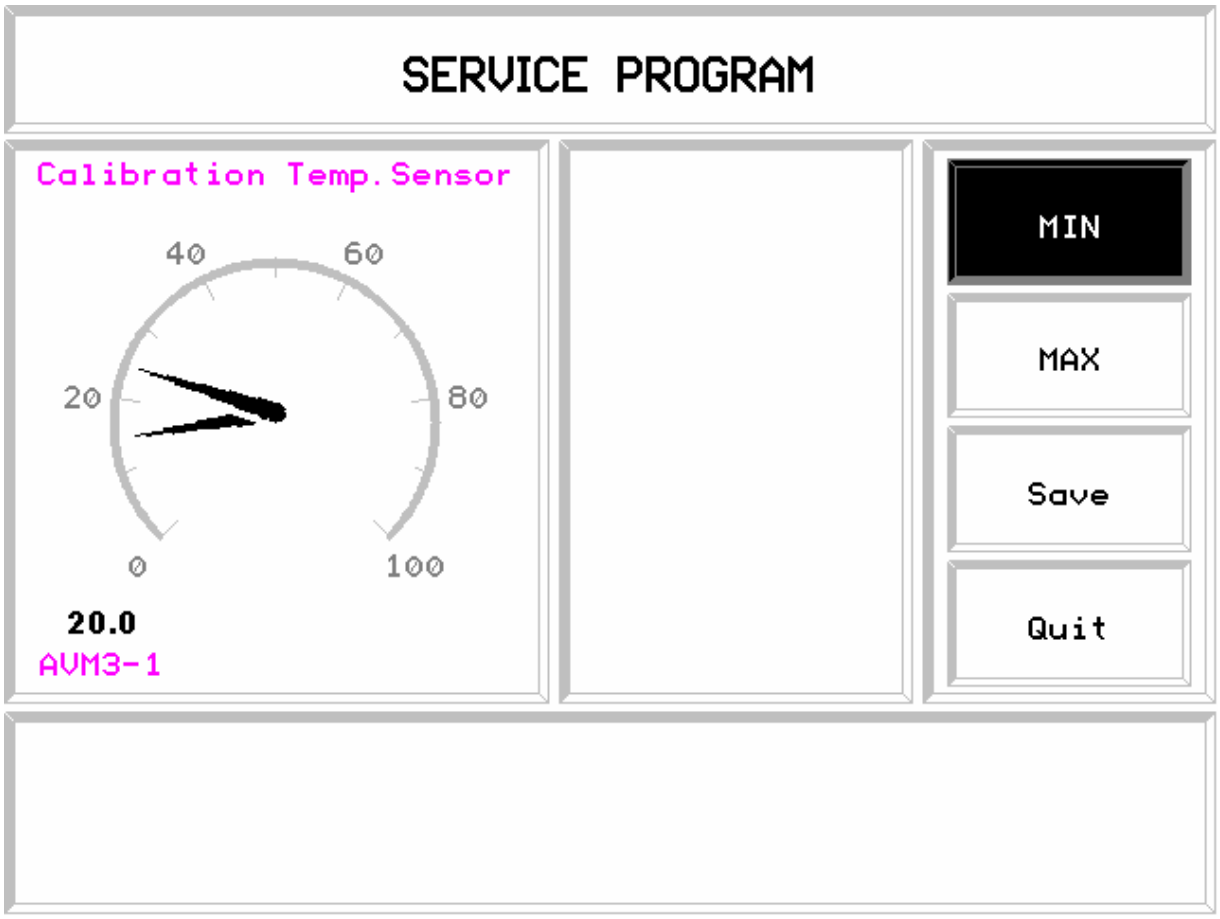


Fig. 13 Temperature Sensor Calibration 1

- Connect a Pt-100 simulator to the connector of the docking station, or directly to the board AVM3-1 of ventilation module 2 (X7).
- Apply a simulated temperature of 0 ℃.
- Turn the offset potentiometer screw (P1, AVM3-1) until the screen pointer show 20 and operate the “MIN” button.

Temperature Sensor Calibration , cont.

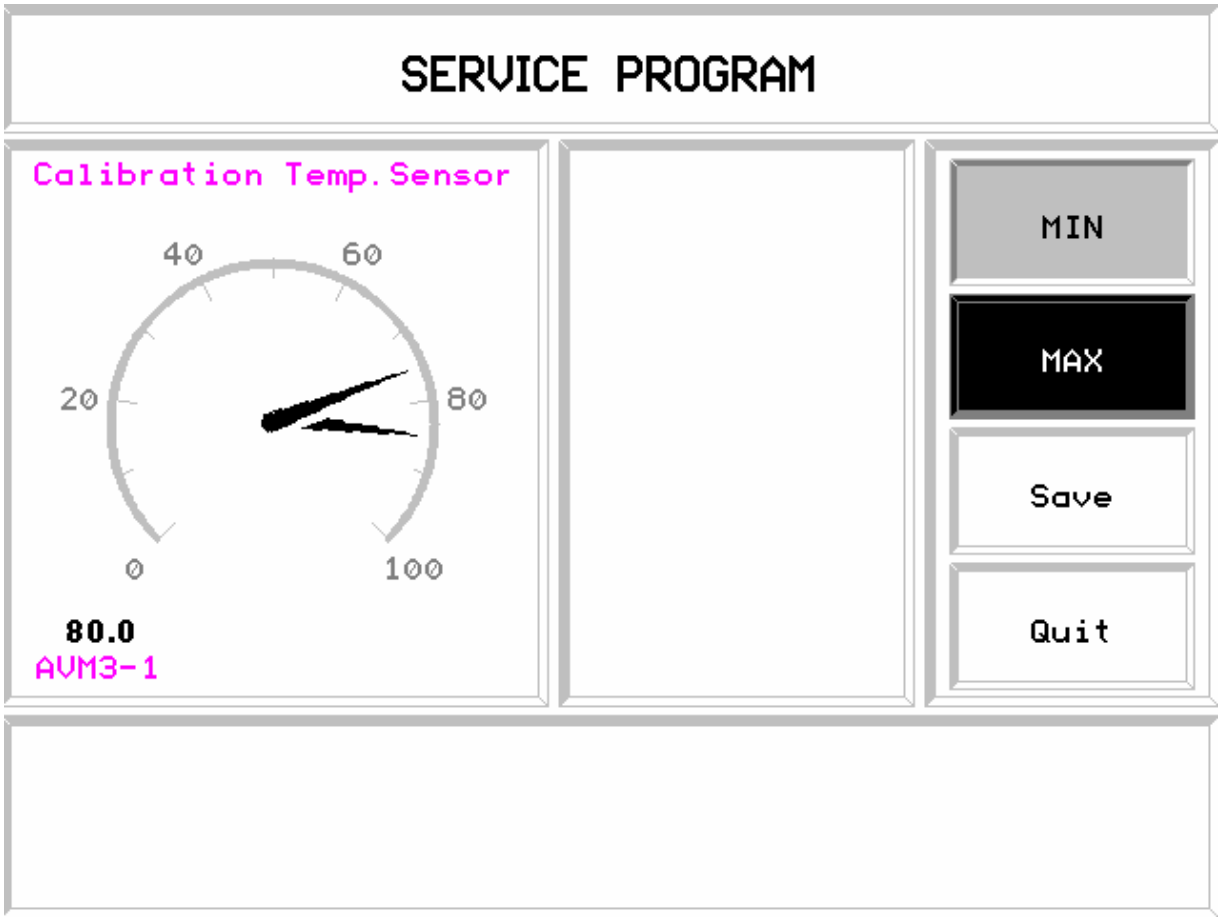


Fig. 14 Temperature Sensor Calibration 2

- Apply a simulated temperature of 60 ℃.
- Turn the gain offset potentiometer screw (P2, AVM3-1) until the screen pointer show 80 and operate the “MAX” button.
- Check both of the values alternately for correctness and readjust if necessary. When both of the calibration points are correct within a tolerance range +/- 0.2, operate the ”Save” button.
- By operating ”Quit” turn back to calibration menu.

5.5.5 Calibration Of Proportional Valve ADC

Caution: The three procedures “Proportional Valve Calibration”, “Internal Flow Sensor Calibration” and “Characteristic of The Proportional Valve” **must** always be performed together in the order as in the manual, never individually.

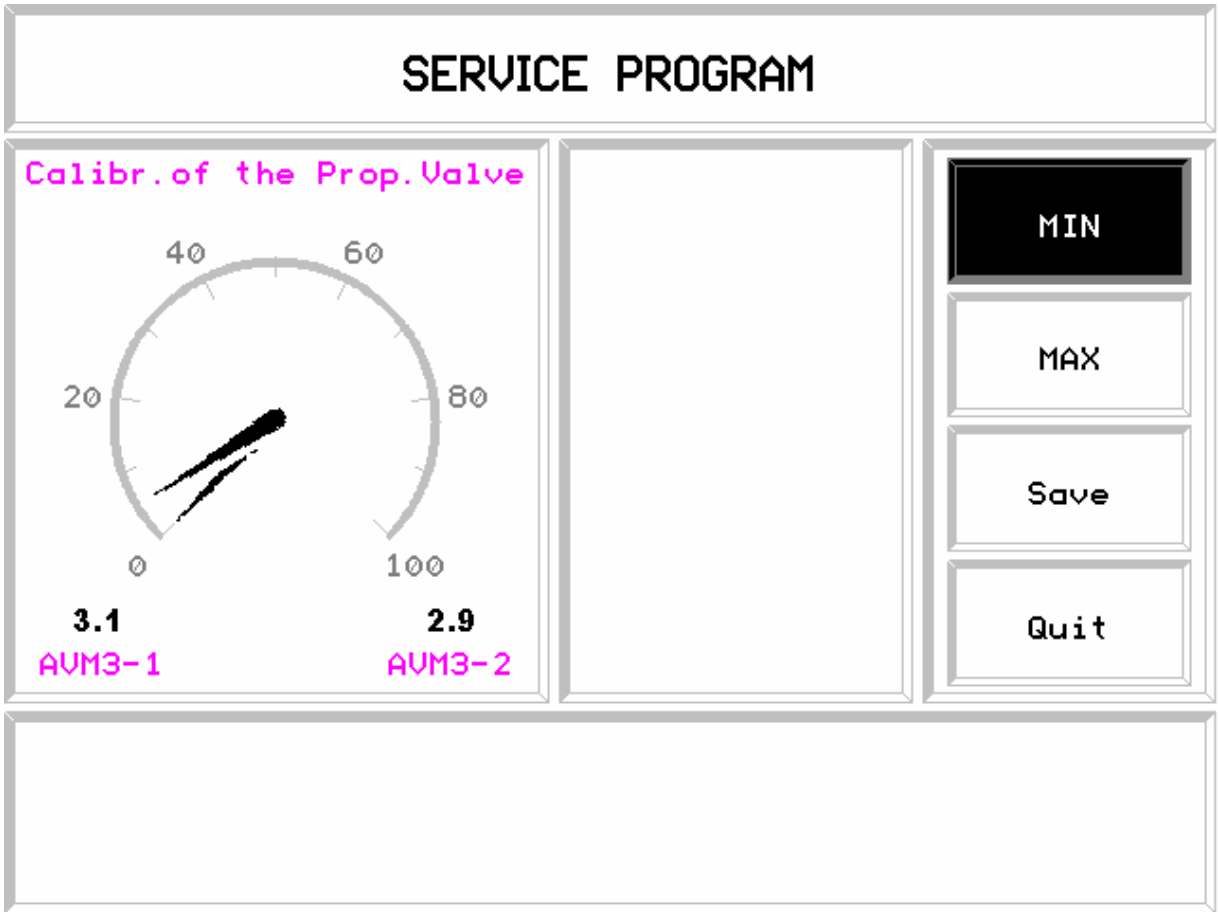


Fig. 15 Calibration Of Proportional Valve ADC 1

- Operate the ”MIN” button to close the proportional valve.
- Turn the offset potentiometer screw PV OFFS (P1, AVM3-2) until screen pointer shows $3^{\pm 1}$.
- Operate the ”MIN” button a second time to store the value.

Calibration Of Proportional Valve ADC , cont.

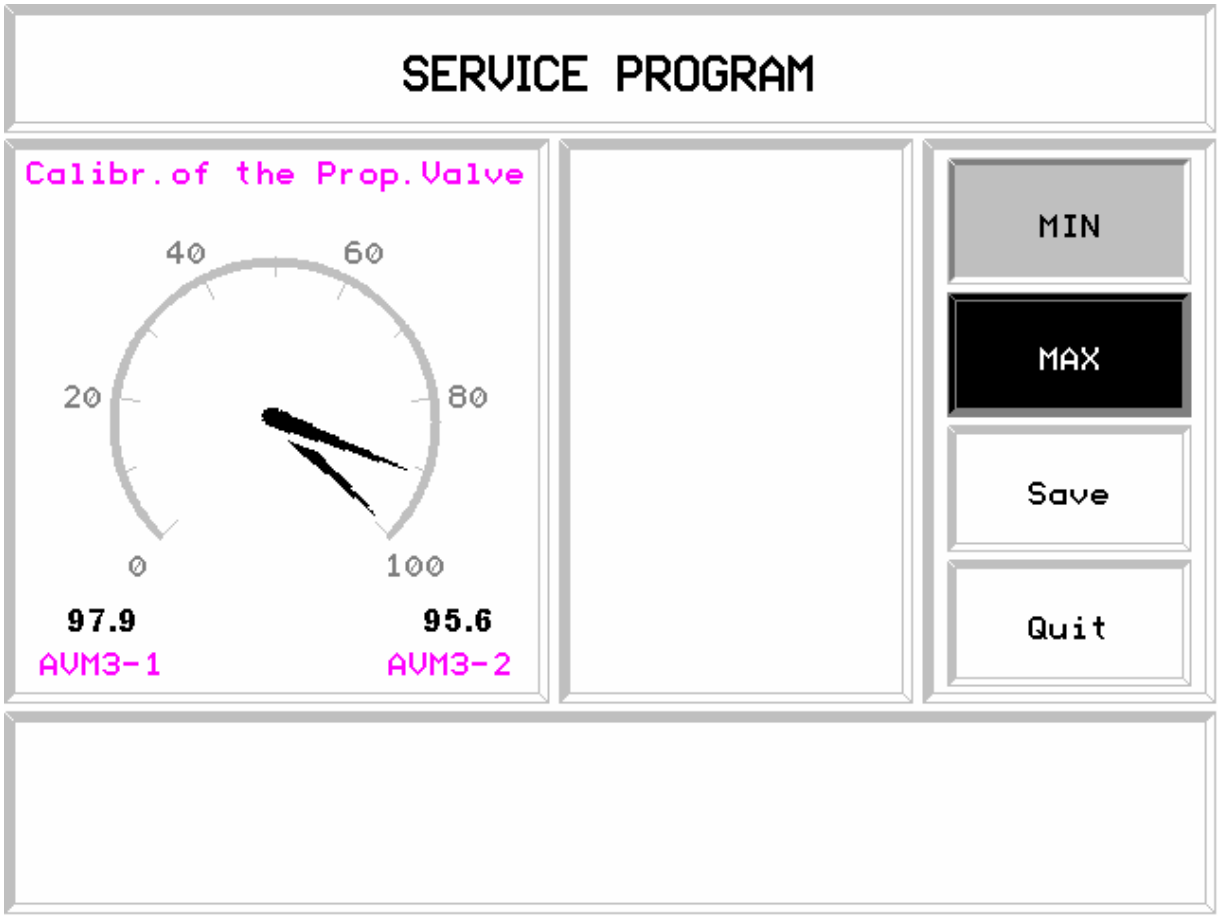


Fig. 16 **Calibration Of Proportional Valve ADC 2**

- Operate the ”MAX” button to open the proportional valve.
- Turn the gain potentiometer screw PV GAIN (P2, AVM3-2) until the screen pointer shows 97 $^{\pm 2}$.
- Operate the ”MAX” button a second time.
- Check at this point the driving gas flow by measurement at the driving gas outlet of the docking station. The flow should be in a range of 80 +0/-5 L/min. If necessary check the adjustment of the pressure regulator of the proportional valve. The supply pressure of the proportional valve should not exceed 2.1 bar. Check the signal of the internal flow sensor by measurement on connector X5 (IF) on board AVM 3-2. The flow signal for max. flow measured at X5-3 and X5-1 should be in a range of 4,6 +/- 0,1 Volts. If necessary adjust by turning the restrictor at the flow splitter.
- Check all of the values alternately for correctness and readjust if necessary. When the calibration points are correct within a tolerance range of +/- 2, operate the ”Save” button.
- By operating ”Quit” turn back to calibration menu.

5.5.6 Calibration Of Internal Flow Sensor

Caution: The three procedures “Proportional Valve Calibration”, “Internal Flow Sensor Calibration” and “Characteristic of The Proportional Valve” **must** always be performed together in the order as in the manual, never individually.

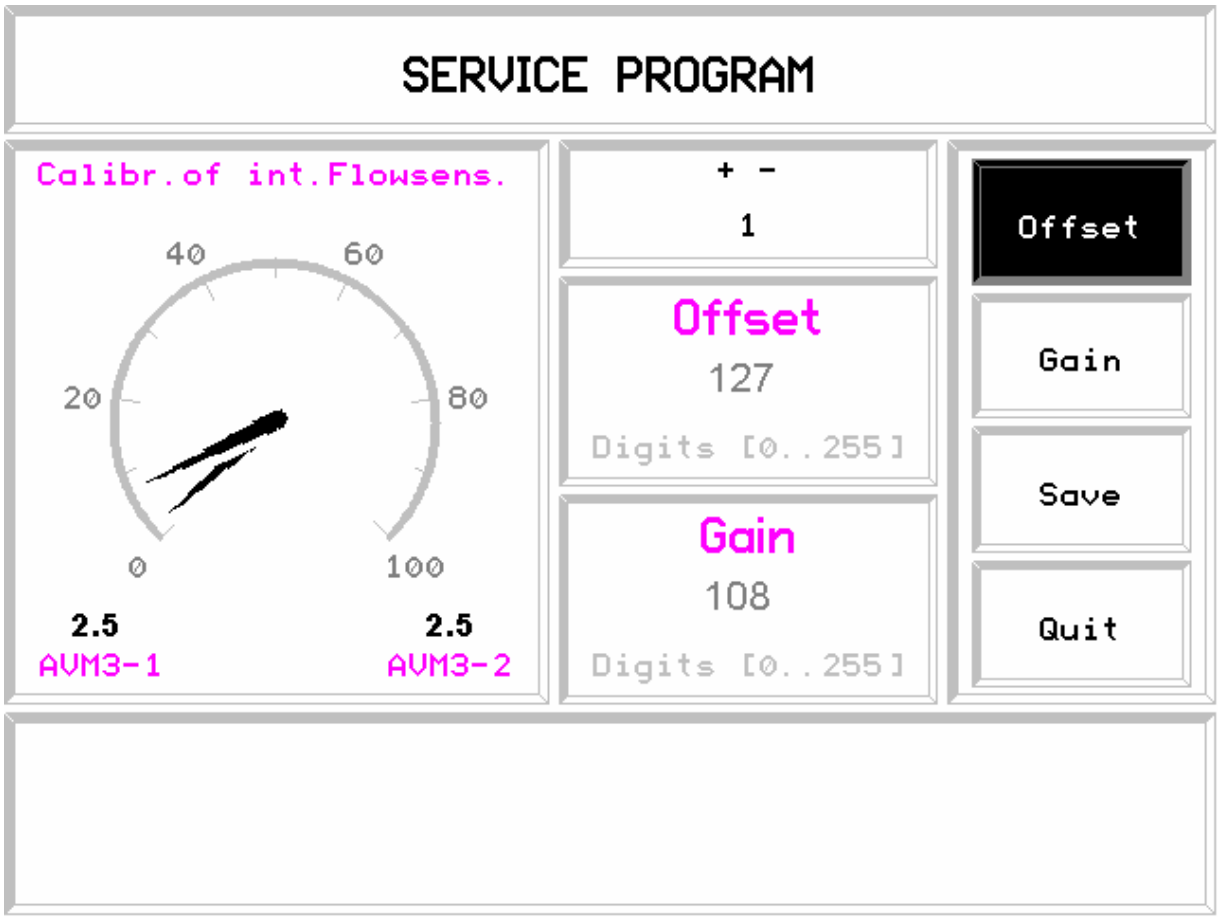


Fig. 17 **Calibration Of Internal Flow Sensor 1**

- Operate the ”OFFSET” button to apply a zero flow.
- Change the offset value by rotary mouse until pointer shows 2.5 $^{\pm 1}$. A typically value for the offset is about 127. To change the moving range of the DAC setting values use the ”MENU” and ”GRAPHICS” control panel keys.
- Operate the “ OFFSET “ button again to store the value.

Calibration Of Internal Flow Sensor , cont.

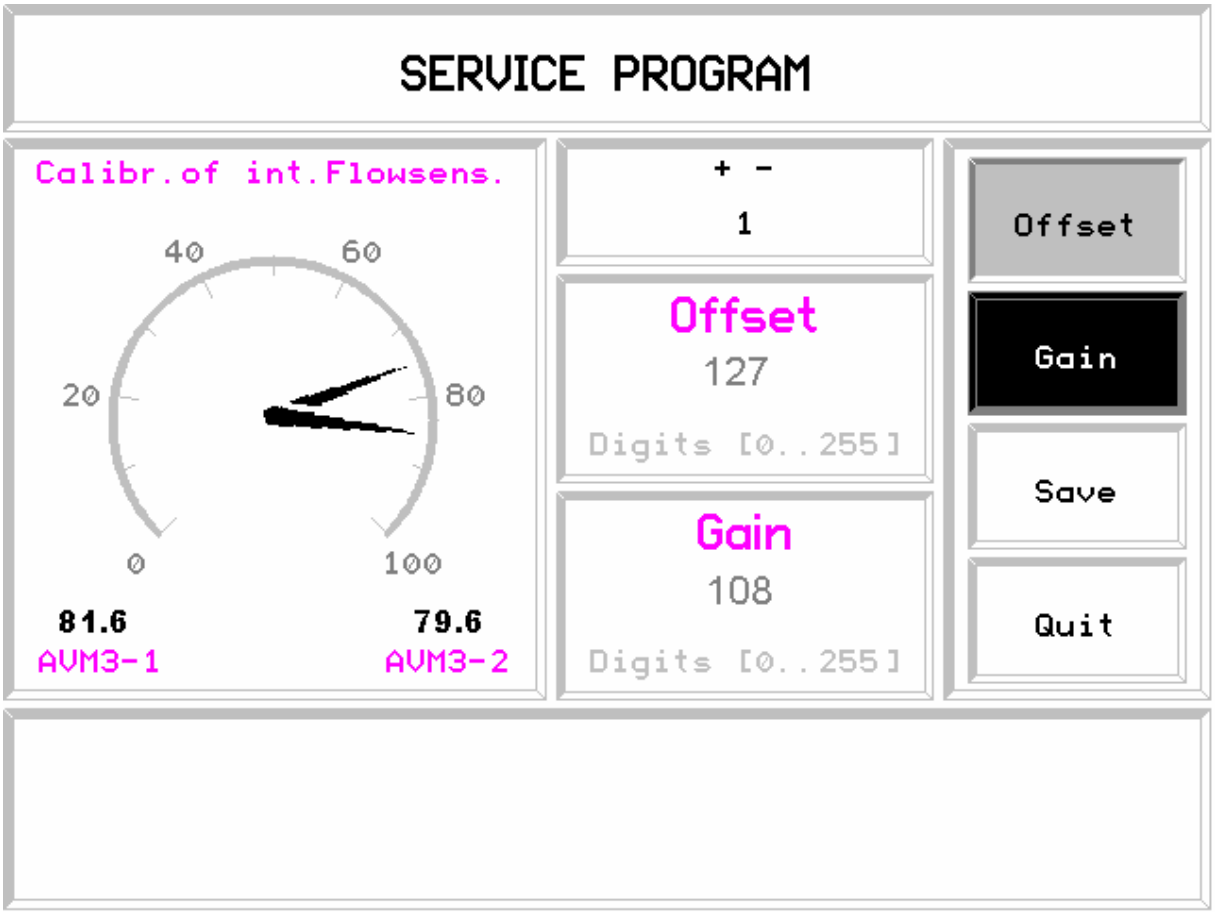


Fig. 18 **Calibration Of Internal Flow Sensor 2**

- Operate the “GAIN” button to apply a maximum flow.
- Change the gain value until pointer shows 80, a typically value is about 108 for the gain setting.
- Operate the “ OFFSET “ button to close the valve and check the offset value. If necessary correct the offset adjustment.
- Operate the “ OFFSET “ button again to store the adjustment.
- Operate the “ GAIN “ button to open the valve.
- Operate the “ GAIN “ button again to store the adjustment.
- Operate the “Save” button to memorize the stored values for gain and offset adjustments.
- By operating ”Quit” turn back to calibration menu.

5.5.7 Fixing Of Calibration Characteristic Proportional Valve

Caution: The three procedures “Proportional Valve Calibration”, “Internal Flow Sensor Calibration” and “Characteristic of The Proportional Valve” **must** always be performed together in the order as in the manual, never individually.

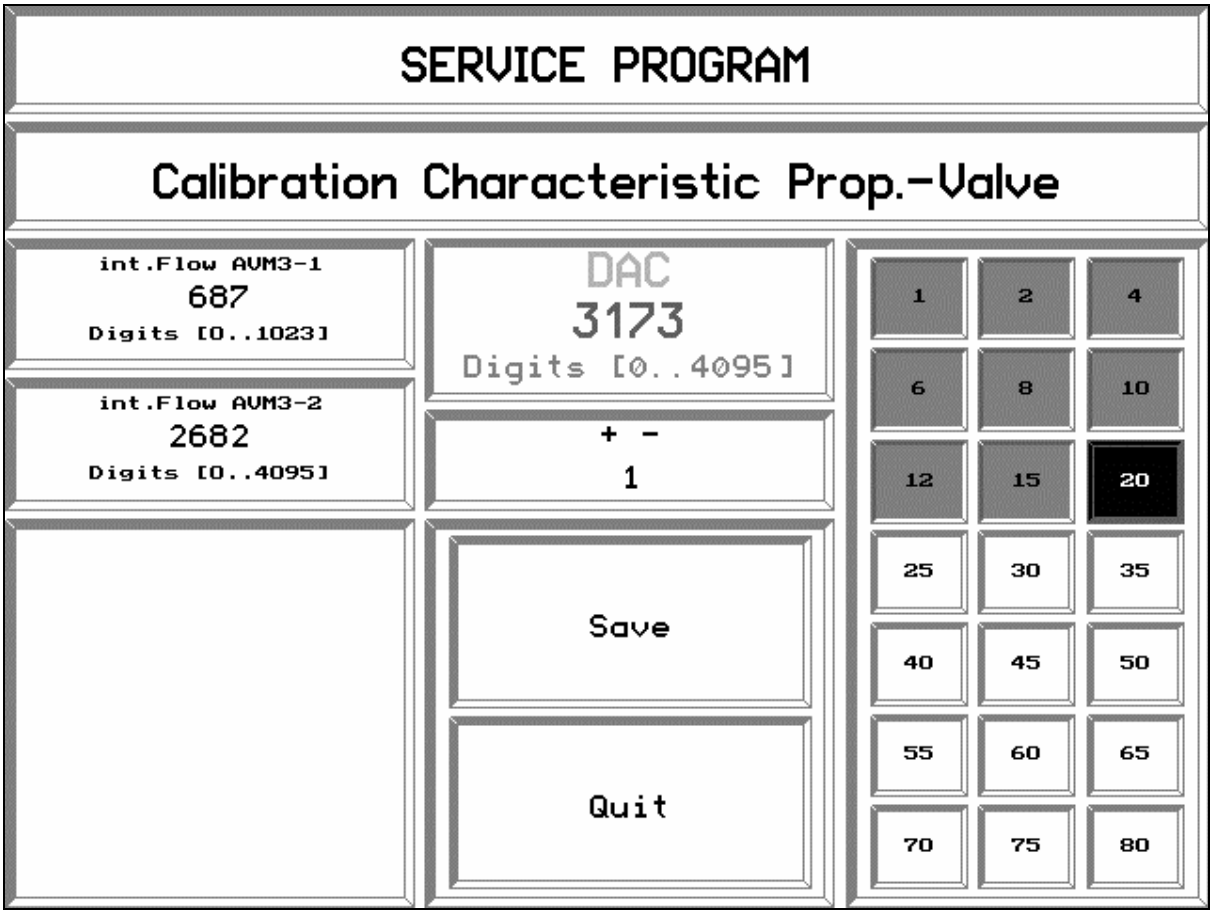


Fig. 19 Fixing Of Calibration Characteristic Proportional Valve

- Connect a flow meter to the driving gas outlet.
- Operate the 1 l/min button. Change the DAC value by rotary mouse until a flow of 1 l/min is applied and operate the rotary mouse again to store the value. To change the moving range of the DAC setting values use the ”MENU” and ”GRAPHICS” keys. The ”OPTION” key reduces the DAC value of 256.
- Increase the DAC value until a flow of 2 l/min is applied and operate the rotary mouse again.
- Continue this procedure until 80 l/min are reached.
- Operate the ”Save” button with a pause of about 30 seconds to store the calibration curve.
- Turn back to calibration menu by operating the ”Quit” button.

Note: If a flow of 80 l/min cannot be reached with the DAC value of 4095, interpolate the last three values to ensure a steady increase of the values and to avoid a calculation fault.

Tolerance range for the flow values:

1 l/min:	+0 / - 0.1	35 l/min:	+0 / - 0.4
2 l/min:	+0 / - 0.1	40 l/min:	+0 / - 0.4
4 l/min:	+0 / - 0.1	45 l/min:	+0 / - 1
6 l/min:	+0 / - 0.1	50 l/min:	+0 / - 1
8 l/min:	+0 / - 0.1	55 l/min:	+0 / - 1
10 l/min:	+0 / - 0.2	60 l/min:	+0 / - 1
12 l/min:	+0 / - 0.2	65l/min:	+0 / - 1
15 l/min:	+0 / - 0.2	70 l/min:	+0 / - 1
20 l/min:	+0 / - 0.4	75 l/min:	+0 / - 5
25 l/min:	+0 / - 0.4	80 l/min:	+0 / - 5
30 l/min:	+0 / - 0.4		

5.5.8 Calibration Of External Flow Sensor

Calibration routine for ventilator software AVM3nVer. 1.3.n:

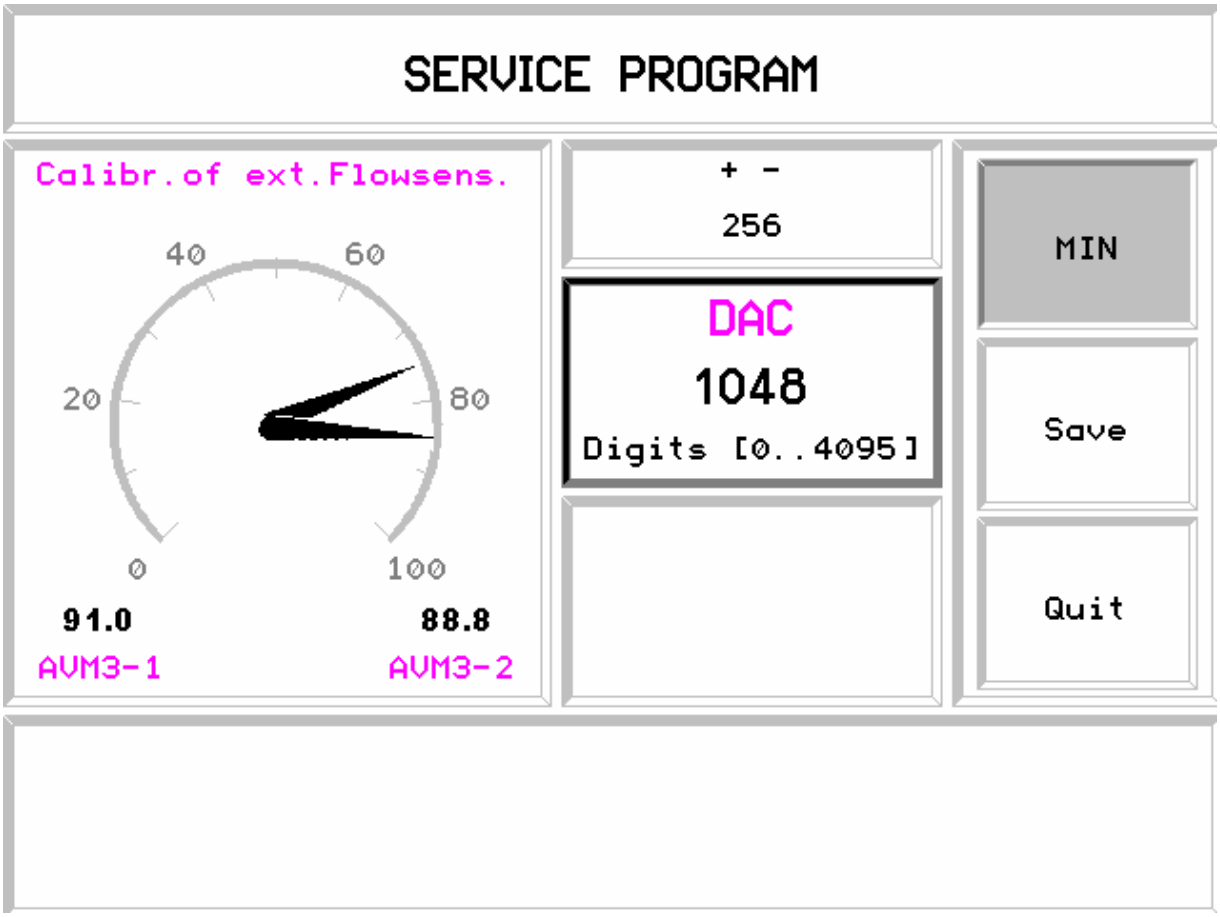


Fig. 20 Calibration Of External Flow Sensor 1

- Connect the patient block to unit, if necessary. Disconnect the breathing tube from breathing gas inlet at the patient block to ensure that there is no flow via external flow sensor.
- Calibration with warmed-up patient module, for preparation disconnect the plug of ext. flow sensor on board AVM 3-2, connector X7, EF.
- Set DAC to 1024 and turn gain potentiometer (P3) on AVM 3-2 until the pointer shows 90.
- Connect the plug of ext. flow sensor to connector EF on AVM 3-2 and press the “MIN” button.
- Press “Save” button.
- Leave this window with “Quit”.
- Start the unit in CMV-Adult mode with default settings to ventilate a test lung.
- Check the measured values for tidal volume and adjust the gain potentiometer (P3) to the values externally measured, respectively the settings of tidal volume on the ventilator (500 ml). Switch during adjustment of P3 sometimes to Standby mode, that the automatic offset calibration is performed. Check the measured values of the external flow sensor again in CMV-Adult mode. Start the sensor test., if a message “ext. flow sensor out of range appears”, turn the gain potentiometer (P3) smoothly until the test will be passed.

Calibration Of External Flow Sensor, cont.

Calibration routine for ventilator software AVM3nVer. 1.4.1:

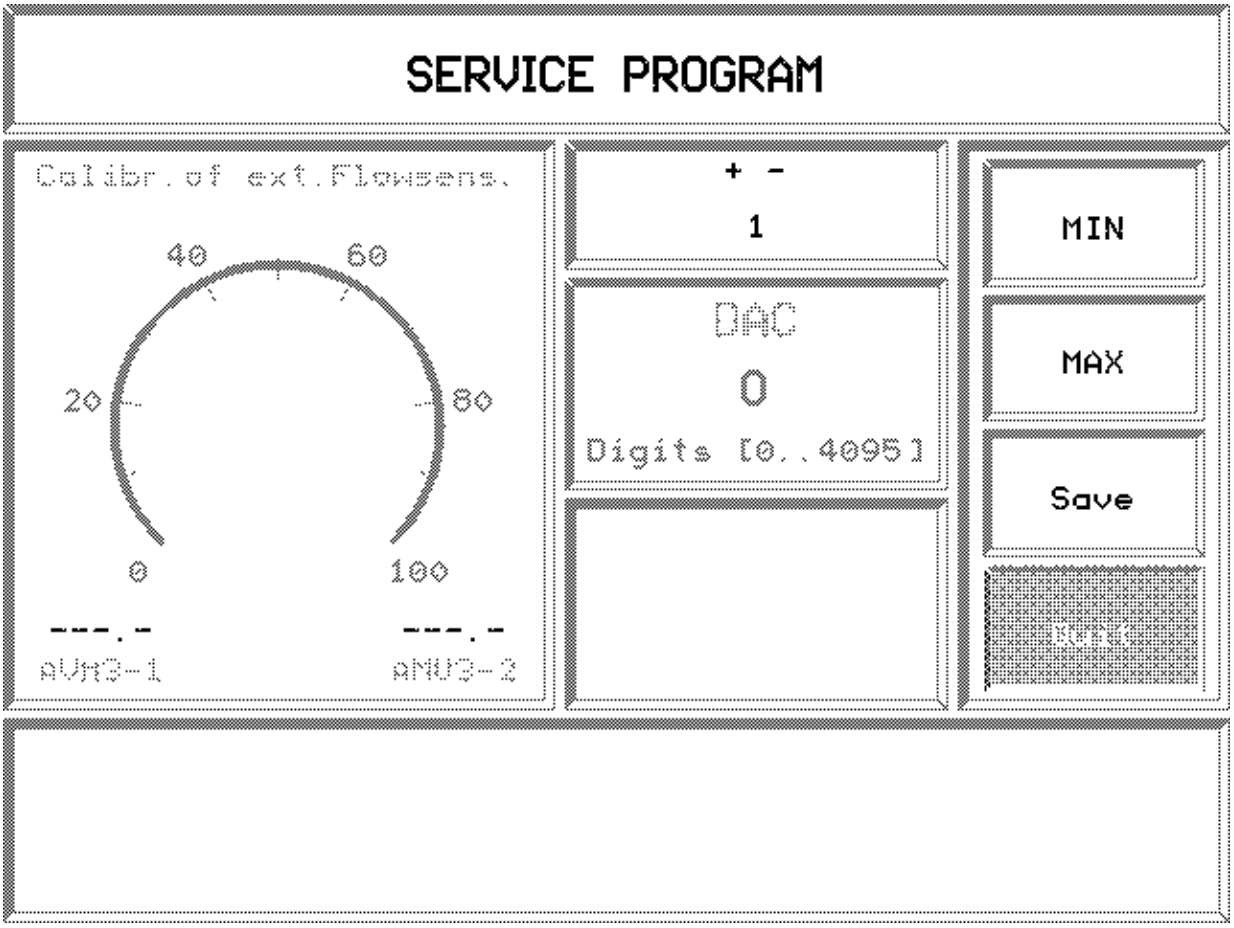


Fig. 21 **Calibration Of External Flow Sensor 2**

- Calibration with warmed-up patient module. Disconnect the breathing tube from breathing gas inlet at the patient block to ensure that there is no flow at external flow sensor.
- Increase the DAC value until the pointer for AVM 3-2 shows 50.0 +/- 0.2
- Don't change the DAC value setting after this.
- Measure the voltages U1 and U2 (see page 2 for measurement points of this voltage) and make a note of the values.
- U1= -(Pin 8 of V13) to +(GND PIN), U2 = -(GND PIN) to + (between R35-R19)
- The voltages U2 must be 1.4 times of the voltage U1.
  Example: U1 = 1.448V , U2 = 1,901V
  U2/U1 = 1.313, This value is to low. The value has to be in a range of 1.39 to 1.41.
- Connect the voltmeter to measure U2 and increase the value by turning on potentiometer P3. Check U1 and U2 again for correct relation of U1 * 1.4 = U2. Repeat adjustment of P3 if necessary. Finally seal the potentiometer and leave the calibration routine be pressing QUIT.

Calibration Of External Flow Sensor, cont.

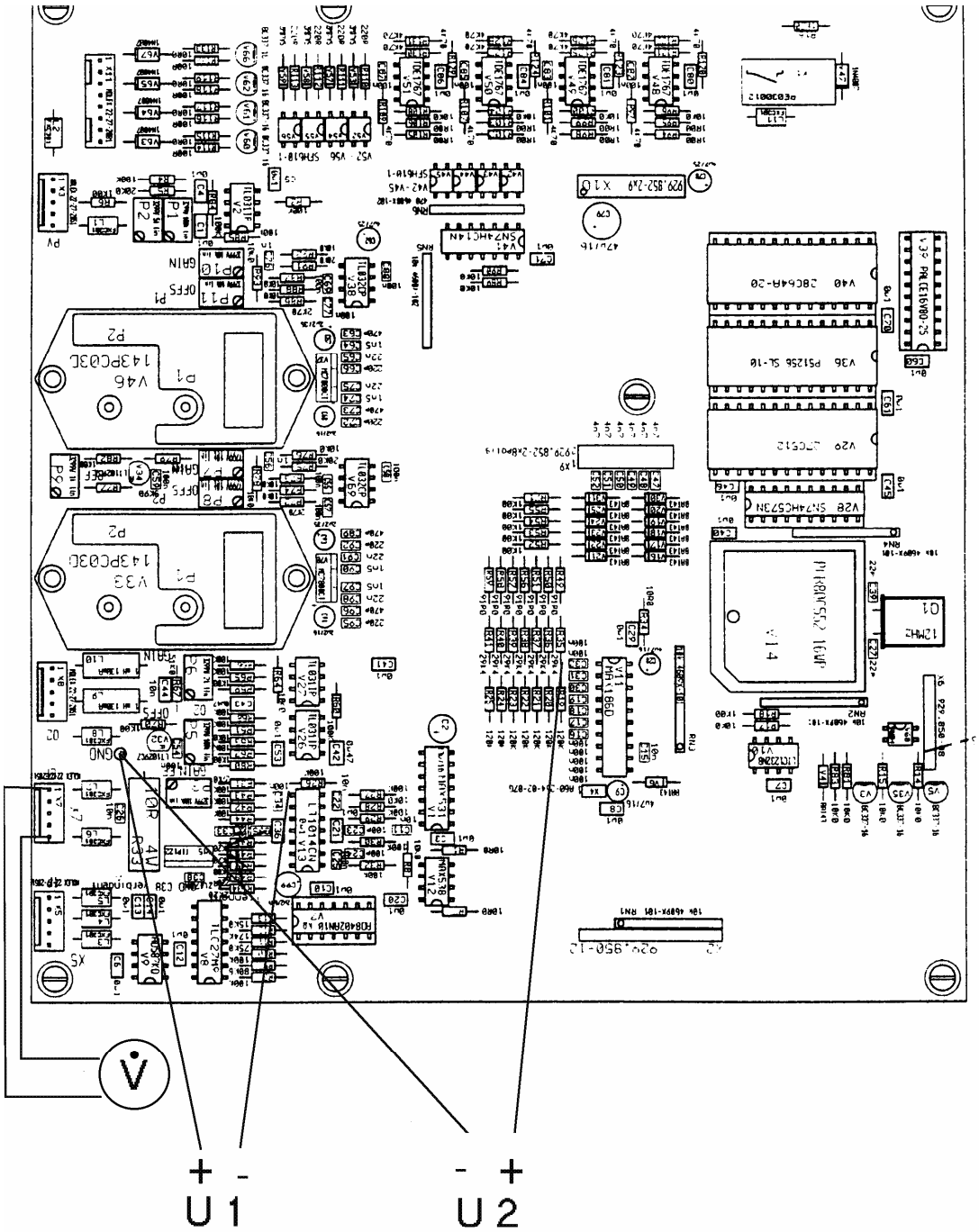


Fig. 22 How to measure the voltages U1 and U2

5.5.9 Test Menu Routines

For testing the sensor calibrations or check different functional tests open test menu and choose the wanted application.

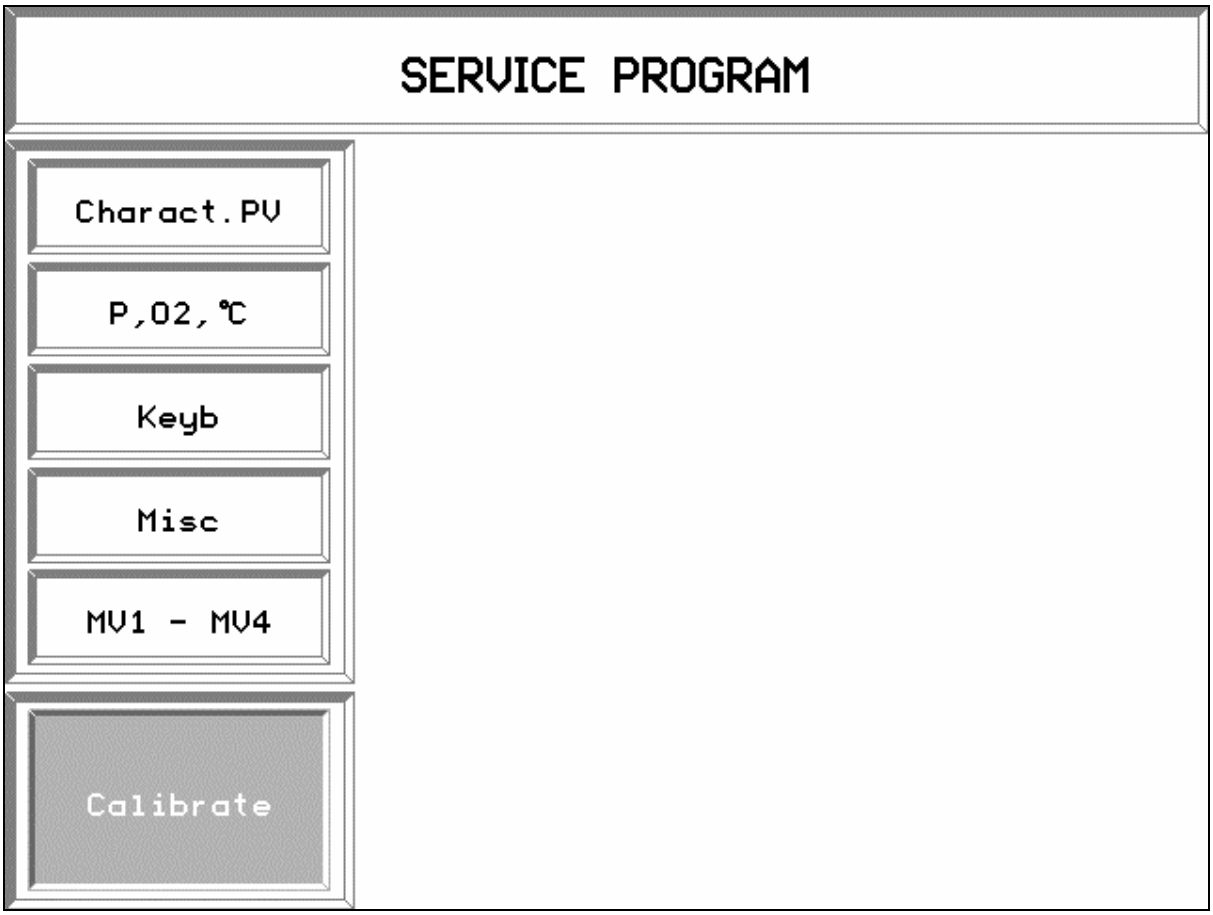


Fig. 23 Test Menu Routines

5.5.10 Test Characteristics Proportional Valve

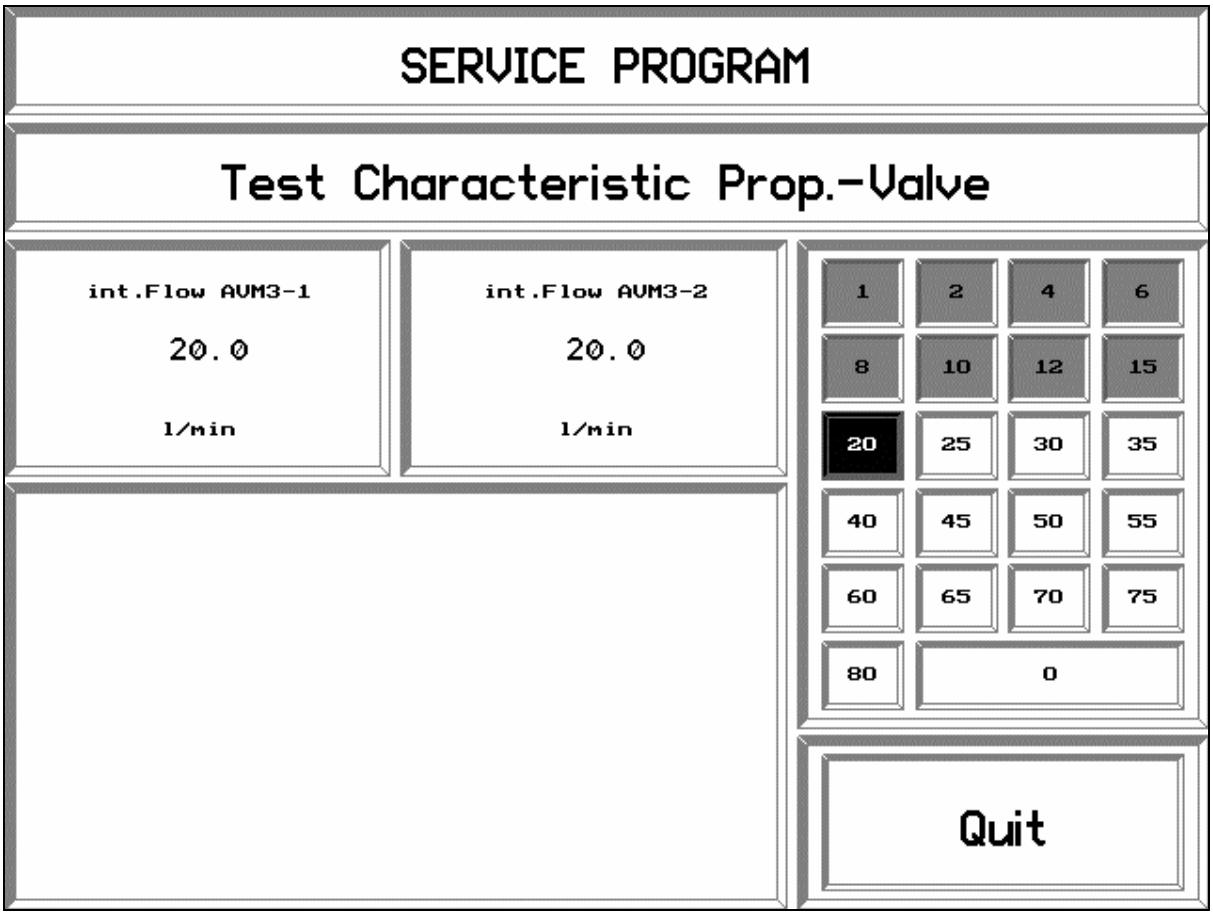


Fig. 24 Test Characteristics Proportional Valve

- By operating a flow button the chosen flow is set by the proportional valve. The measured flow values of proportional valve at the internal flow sensor are shown and can be checked with an external flowmeter.
- By operating the ”0” button the flow is switched off.
- “Quit” returns to the test menu.

5.5.11 Pressure, Oxygen and Temperature-Sensors

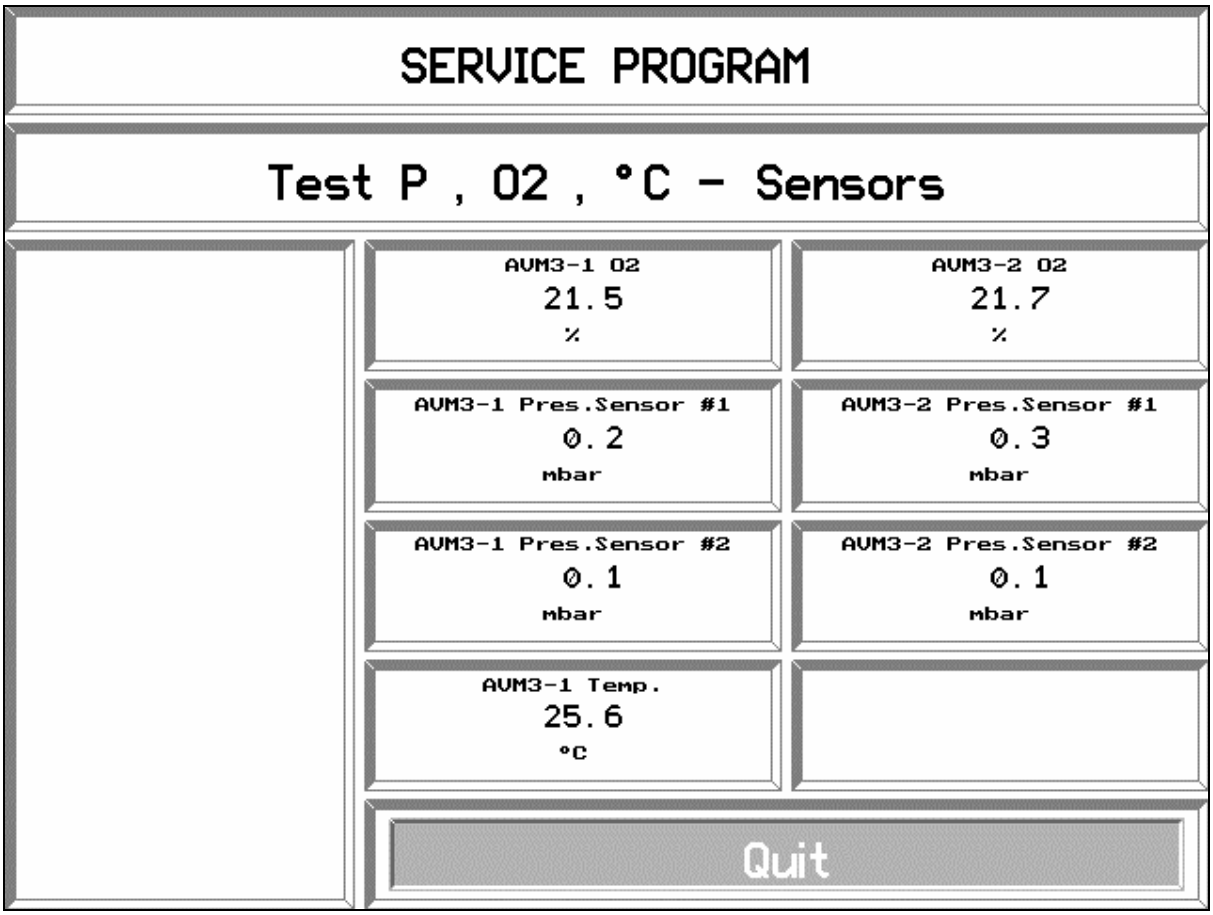


Fig. 25 Pressure, Oxygen and Temperature-Sensors

- Measured values of the oxygen sensor are shown in %O2.
- Pressure sensor values of the transducers P1 and P2 are shown in mbar.
- The measured temperature sensor value is shown in C.
- The adjustment of the sensors can be checked in the window.

5.5.12 Keyboard Test

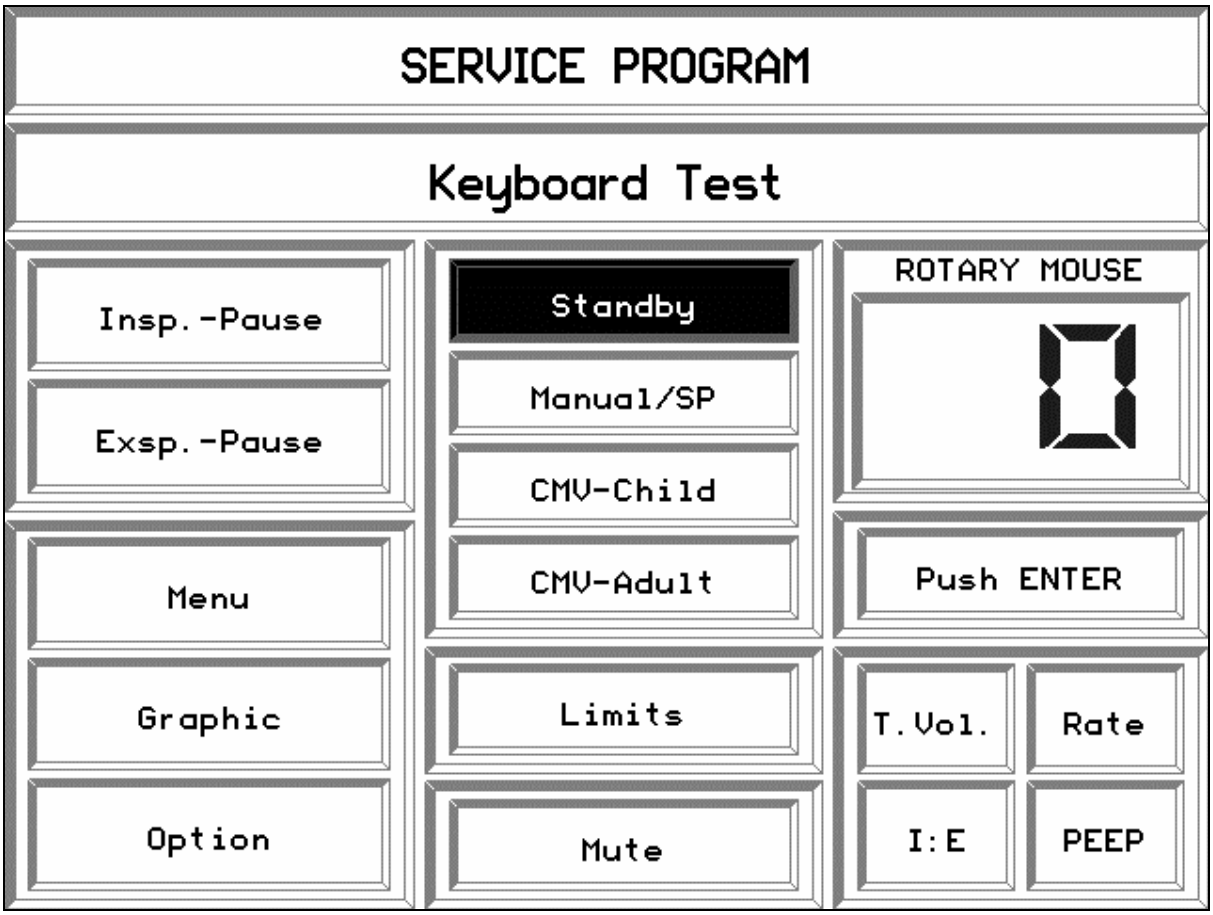


Fig. 26 Keyboard Test

- Control panel keys and the rotary mouse may be tested.
- To close the application operate the ”confirm” function of encoder, rotary mouse.

5.5.13 Miscellaneous Functions

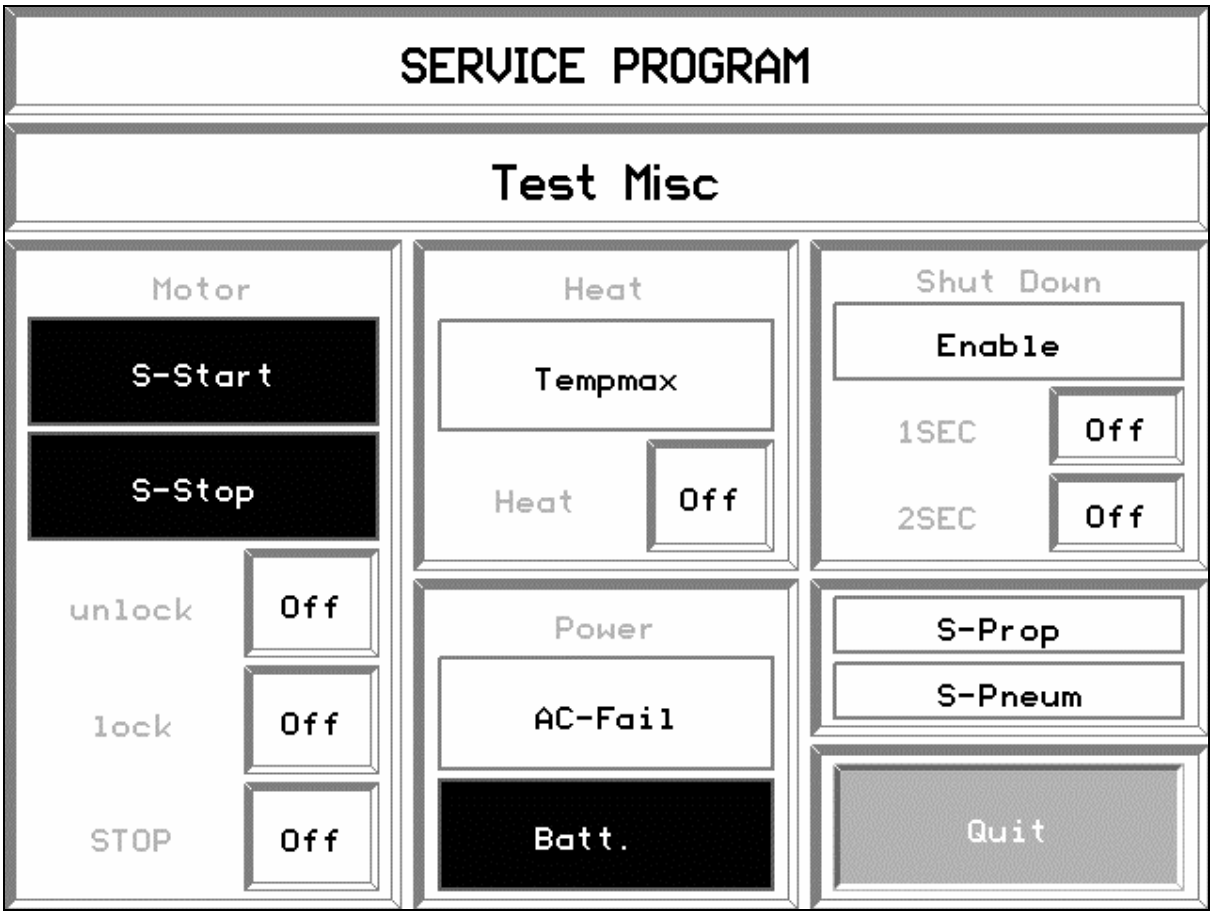


Fig. 27 Miscellaneous Functions

- The ”unlock”, ”lock” and ”STOP” buttons may be operated to test the patient module draw-in facility(if available).
- By operating the Heat ”Off” button heating is switched on and off when operating button again.
- Operating the 1 SEC and 2 SEC ”Off” buttons cause a test of the ”shut down” signals of µP1 and µP2.
- The Motor and Power windows show the status of the appropriately elements.
- The S-Start and S-Stop button are showing the status of the micro switches for motor drive control.
- The power button AC-Fail indicates AC power supply fail. The Batt. button is showing the charging of the battery.

5.5.14 Solenoid Valves MV1 - MV4

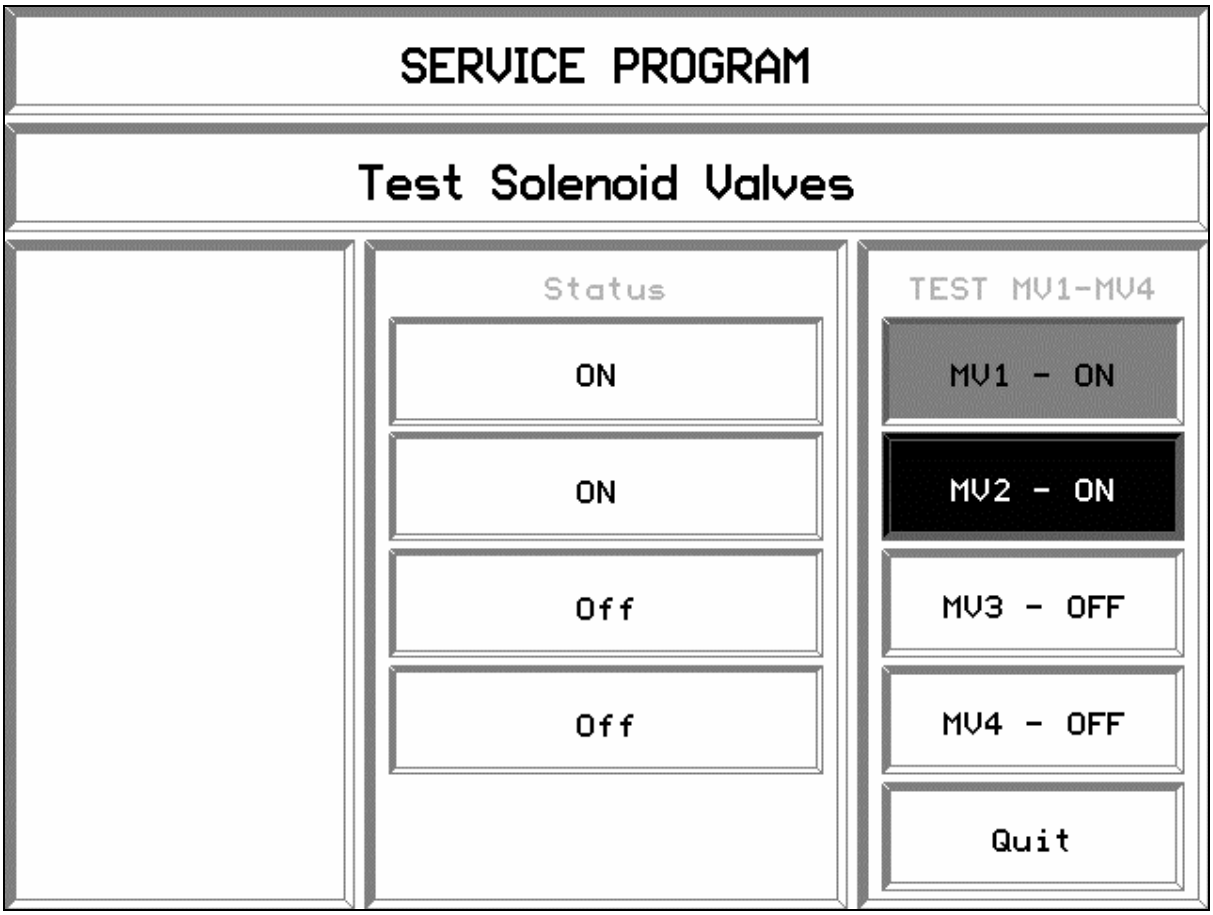


Fig. 28 Solenoid Valves MV1 - MV4

- This application enables the test of the solenoid valves.
- Result of this test are the messages ”ON” , ”OFF” or “Faulty” for each of the four solenoid valves.

6 Preventive Maintenance

The following is a list of activities required for periodic maintenance of the **HEYER** Narkomat$^+$ anesthesia system. Physical inspection, replacement of consumables and performance checks should be periodically performed per the schedule listed below. Certain calibration adjustments are only required only after replacing one or both of the active devices. **HEYER** is not responsible for component failure or loss resulting from the use of stated consumables beyond their recommended replacement interval. These are noted in the Preventive Maintenance Checklist on the following pages.

6.1 6 Month Service Interval

- Ensure operators manual is present
- Ensure preoperative Checkout list is attached
- Check unidirectional valves operate by visual inspection
- Check low O_2 pressure alarm whistle
- Check “No driving gas” alarm
- Check the function of the N_2O cutoff incase of O_2 pressure loss
- Check the function of the N_2O / AIR switch
- Check the differentiation of the flow meters knobs
- Check the function and correct flow of the O_2 flush.
- Check that all flow meters work throughout their range
- Check the function of the Hypoxic Guard
- Check the function of the back light illumination
- Perform the compliance test at power up
- Perform Leak Test (Options Menu) without vaporizers
- Perform Leak Test (Options Menu) with vaporizers
- Perform O_2 Cell calibration (Options Menu)
- Perform Manual tightness test
- Check the function and the accuracy of the APL valve in the manual mode
- Check the O_2 display, 21% in room air, >95 in 100% O_2
- Check the correct function of the of the individual ventilation alarms
- Check the correct function of the Mute button
- Check the correct function of the Alarm LEDs
- Check that all cylinder and pipeline supply pressure gauges operate
- Inspect the line power cord
- Inspect/Clean water traps and filters
- Verify the gas tank check valves*
- Verify the pipeline supply check valves*
- Verify line voltage interruption alarm message
- Verify battery operation
- Verify the 115/230 volts AC at the convenient outlets
- Perform ventilation performance check
- Replace the O-rings on the vaporizer manifold (4 x 049-3182)
- Replace the APL valve membrane (323- 0310)

- Replace O-rings on the docking station (4 x 049-3052)
- Replace O-rings between tanks and yokes (N_2O 800-5947; O_2: 800-5946)*
- Replace the O-ring of the CO_2 absorber (323-0147)
- Replace the flat seal of the CO_2 absorber (980-1170)
- Replace the O-ring of the Patient dome (323-0147)
- Replace the O-rings of the O_2 Cell (609-3021 + 049-3074)
- Replace the fan filter (800-5580)
- Check the threaded insert for the CO2 absorber
- Check the correct function of the brakes
- Test of electric safety according to IEC 601-1

*Subject of the configuration

6.2 12 Month Service Interval

- Perform all the points of the 6 Month Service Interval
- Inspect and if necessary, replace the spindle nut of the patient module
- Examination of the internal hose connection
- Replace the o rings gas pipeline inlet block (1 x 980-1170; 2 x 980-1174)
- Replace the silicon valve plates (2 x 610-3156)
- Replace the O-rings of the in-and expiratory valve seat (2 x 610-3157)
- Replace the diaphragm valves (3 x 323-0100)
- Replace the diaphragm valve O-rings (3x 323-0292)
- Replace the flat rings at the bellows valve screw fitting (3x 980-1170)
- Replace the O-rings of the APL valve (3 x 323-0272)
- Replace the O-rings of the valve seatings (3 x 2 x 323-0272)
- Replace the O-rings for the valve seating screws (4 x 960-1036)
- Replace the O-rings of the test adapter (2 x 049-3052)
- Enter the service software
- Check and if necessary calibrate the O_2 sensor
- Check and if necessary calibrate the Pressure sensors P1 and P2
- Check and if necessary calibrate the temperature sensor
- Check the 2 kPa x 100 (2 bar; 30 PSI) pressure reducer for the driving gas
- Check the 200 Pa x 100 (200 mbar; 3 PSI) pressure reducers for the solenoid valve block
- Check the electrical and pneumatic function of the solenoid valves MV1 to MV4

6.3 36 Month Service Interval

- Perform all the points of the 12 Month Service Interval
- Replace the internal battery (340-2020)
- Replace the room air valve membrane (323-0099)

6.4 Cleaning

6.4.1 Cleaning and disinfecting the apparatus

Before cleaning, switch off apparatus and disconnect from mains
The apparatus housing can be cleaned with a cloth moistened with a liquid cleaning agent. To avoid abrasion, the cloth must be moist. A surface-disinfecting agent may be used. Use cleaning agent sparingly. Excess fluid could enter the apparatus causing damage.

6.4.2 Cleaning and sterilizing the Patient Module

The Patient Module can be autoclaved at a temperature of up to 134℃. Always autoclave the patient module with the protection cover connected to avoid a damage of the diaphragm valves.

Before sterilizing the Patient Module, remove the bellows dome, bellows, CO_2 absorber and APL valve. The patient module requires no further dismantling.
Autoclave the APL upper part and the APL membrane, as separate parts together with the patient module.

The bellows dome cannot be autoclaved! It does not come in contact with patient gas. If soiled, they can be cleaned with water and liquid cleaning agent. **Do NOT use alcohol**!
The silicon bellows and the CO2 absorber canister can also be autoclaved at 134℃. To enhance the life of sealing materials, a temperature of 121℃ i s recommended.

6.5 Battery Replacement and Maintenance

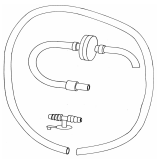
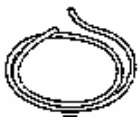
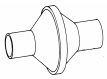
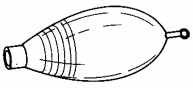
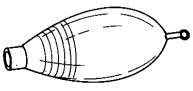
6.5.1 Battery replacement

1. Open the access door (located at the rear of the Narkomat$^+$)
2. Remove the old battery
3. Ensure the new battery is electrically connected and secured in the same manner as the original one.
4. Close battery access door
5. Use only **HEYER** Battery (340-2020)

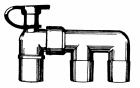
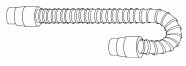
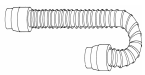
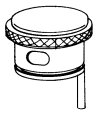
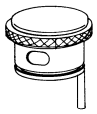
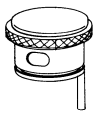
6.5.2 Battery Maintenance

Due to the self-discharging characteristics of this battery type. It is imperative that it is charged after three months of storage (or when not in use). If not charged, a permanent loss of capacity may occur as a result of sulfation.
The batteries used in the Narkomat$^+$ are of sealed lead acid construction. This battery type may be subject to local regulations regarding disposal. At the end of the battery life, dispose of batteries in accordance with the local regulations.

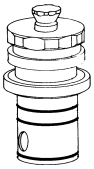
7 Order information

	Ord. No.	Description
	**606-2400**	Suction set universal (includes bacteria filter and finger tip)
	**016-2410**	Finger tip
	**022-3645**	Plastic adapter, angled, for secretion collecting jar
	**034-2950**	Silicone tube ϕ 6 x 2 for suction
	**556-2955**	Bacteria filter for suction set
	**323-0094**	Bacteria filter
	**603-3240**	Breathing bag 2.3 l **Latex**
	**603-3241**	Breathing bag 2.3 l **Silicone**

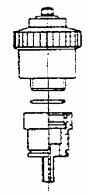
Order information, cont.

	Ord. No.	Description
	**800-5191**	Connector for breathing bag
	**800-4853**	M-Connector
	**800-4854**	Y-piece, right angled
	**323-0092**	Respiratory tube, silicone, 1.5m
	323-0091	Respiratory tube, silicone, 1.2 m
	323-0084	Respiratory tube, silicone, 1.1 m
	**323-0093**	Respiratory tube, silicone, 0.9 m
	323-0089	Respiratory tube, silicone, 0.6 m
	**323-0096**	Inspiration valve, cpl.
	**323-0097**	Expiration valve, cpl.
	**323-0098**	Emergency air valve, cpl.

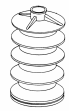
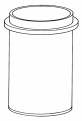
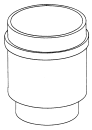
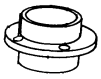
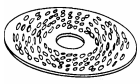
Order information, cont.

	Ord. No.	Description
	**323-0095**	Ventilation pressure valve (APL valve), cpl.
	**323-0310**	Ventilation pressure valve membrane
	**323-0099**	Emergency air valve membrane
	**323-0313**	Sealing set valve body, cpl.
	**323-0159**	Coupling ring valve body
	**610-4020**	Valve cover
	**610-4000**	Metal basket
	**610-3156**	Valve plate (Silicone)

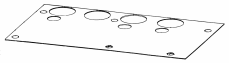
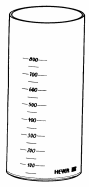
Order information, cont.

	Ord. No.	Description
	**323-0100**	Diaphragm valve
	**323-0101**	Sealing set diaphragm valve, cpl.
	**323-0168**	Membrane for expiration diaphragm valve
	**323-0110**	Coupling nut for diaphragm valve
	**323-0220**	Flow sensor external, cpl.
	**800-5091**	O_2 fuel cell, CR 1, incl. diffuser
	**605-1791**	Valve cover for O_2 cell CR 1
without picture		Connecting cable for O_2 cell CR 1

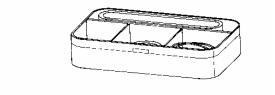
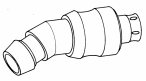
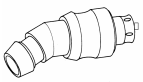
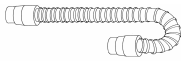
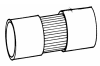
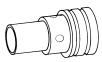
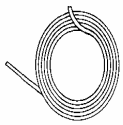
Order information, cont.

	Ord. No.	Description
	**323-0158**	Bellows, silicone
	**323-0045**	Patient dome
	**323-0147**	O-ring for patient dome
	**323-0046**	Absorber canister
	**323-0337**	Threaded insert of absorber holding device
	**323-0104**	Sealing set absorber, cpl.
	**323-0044**	Connecting pipe for absorber
	**323-0333**	Sieve plate for absorber

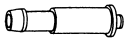
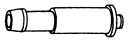
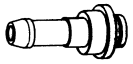
Order information, cont.

	Ord. No.	Description
	**323-0314**	Heating blanket, cpl.
	**323-0142**	Suction glass ´94
	**323-0143**	Cover for suction glass ´94
	**323-0144**	Gasket for suction glass ´94
	**323-0166**	O-ring 82,22 x 2,62 suction glass ´94
	**323-0309**	Tube connector, straight
	**043-3005**	Tube connector, angled
	**660-0252**	Secret-overflow protection device, cpl.

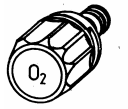
Order information, cont.

	Ord. No.	Description
	**323-0363**	Set of gaskets and adapters
	**022-2960**	Anesthetic gas exhaust plug 45° **HEYER**
	**022-2970**	Anesthetic gas exhaust plug 45° **Dräger**
	**531-2990**	Tube autoclavable 1m
	**605-2900**	Hose connector, diam. = 22 mm / diam. = 22 mm
	**602-2510**	Adapter 30 mm with bypass
	**031-3610**	Pressure tubing blue, running meter
	031-3620	Pressure tubing gray, running meter
	031-3650	Pressure tubing yellow, running meter

Order information, cont.

	Ord. No.	Description
	**046-4146**	Tube clamp
	**980-1161**	DGAI-screwing O_2
	**980-1164**	DGAI-screwing N_2O
	**980-1167**	DGAI-screwing **AIR**
	**980-1162**	Tube connector N_2O
	**980-1162**	Tube connector O_2
	**980-1168**	Tube connector **AIR**
	**980-1174**	Flat gasket O_2
	**980-1174**	Flat gasket N_2O
	**980-1170**	Flat gasket **AIR**

Order information, cont.

	Rod. No.	Description
	**323-0362**	Tube / cable holder (for holding device)
	**800-5484**	Restrictor valve **AIR, cpl**
	**800-5480**	Restrictor valve **O_2, cpl**
	**026-1900**	Fixing screw M8 x 16
	**535-1900**	Catheter cup
without picture	**556-2910**	Holding device for catheter cup

In case of queries or faults please contact
our customer service department:

HEYER MEDICAL AG

Carl-HEYER-Strasse 1-3
56130 Bad Ems
Germany

Tel. + 49-2603 / 791-3

Fax. +49-2603 / 791-209

E-mail: info@heyermedical.de