Narkomat+

Anesthesia System

Operator's Manual

Rev. 3.1 – 05/09

HEYER MEDICAL AG

MODERN SOLUTIONS FOR ANESTHETICS AND INHALATION

Table of Contents

Table of Figures

1 Details of the Manufacturer / Apparatus

Apparatus: **Anesthesia system HEYER NARKOMAT+®**

Manufacturer: **HEYER Medical AG**

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Software version:	Display driver software: 3.0 Ventilator software: 2.5.n

CE 0044

Certificate-No.: 04 207-1743/98

2 Description and Utilization of the Apparatus

2.1 General

Introduction

The HEYER NARKOMAT+ anesthesia system represents a flexible anesthesia workplace for implementing and monitoring inhalation anesthesia in the half-closed system and the nearly closed system for low-flow techniques with minimum gas- and anesthetic agent utilization.

During the development of the system special emphasis was placed on the ergonomic design and consequently, a secure and easy operation. Furthermore the excellent air-tightness of the system ensures the economical daily high and low pressure utilization.

The standard model contains the following system components:

A. Electronic ventilator

The process-controlled ventilator allows constant-volume ventilation for all patient groups with a body weight of 3 kg upwards. Due to the system compliance compensation, even small tidal volumes can be precisely administered. The ventilation type CMV as the standard, the (S)CMV and PCV as optional ventilation modes, as well as various forms of ventilation and considerable variation options of the artificial ventilation cycle, facilitate a secure ventilation even for complicated lung conditions. A comprehensive test and alarm management ensures the required safety for patients and prevents out-of-control operating conditions. The clear design of the user interface and the display allow the secure operation and a quick detection of the selected ventilation parameters.

B. The patient module

The circular patient absorber system is highly integrated and compacted in an aluminum block. The block is tempered to prevent the formation of condensation. The block also contains an emergency air valve, a fresh gas reservoir in form of a hand-held anesthesia bag and an expiratory flow sensor. A motor drive connects the module to the basic apparatus. All sensors are continuously monitored during operation. The sensors are automatically calibrated during the start-up of the apparatus.

C. Integrated fresh-gas dosing system including vaporizer unit

The flow meter tube block contains all mandatory safety equipment as well as a pneumatic control system to maintain a minimum oxygen concentration of 25% in the fresh-gas flow (ratio system).

D. Integrated gas measurement

CO_2
The continuous CO_2 measurement is graphically shown as a capnogramm. The end expiratory and inspiratory CO_2 measurement will be shown as a numerical value. The CO_2 values can be displayed in Vol% or mmHg.

N_2O
The nitrous oxide measurement is similar to the CO_2 measurement and will be shown in Vol% in the form of numerical values.

O_2
The display of the oxygen measurement is based on the same principles as the measurement of CO_2 and N_2O and will be shown in Vol% in the form of numerical values.

Anesthesia gas
The gas module is equipped with an automatic anesthetic agent and anesthetic agent mixture identification. The apparatus measures the agents Halothane, Isoflurane, Enflurane, Desflurane and Sevoflurane. The display of the Anesthesia gas measurement is based on the same principles as the measurement of CO_2, N_2O and O_2 .

MAC
The displayed Minimal Alveolar Concentration is calculated according to the following formula:

$$MAC(AA) = \frac{EtAA[\%]}{xAA} + \frac{EtN_20[\%]}{100}$$

AA = Anesthetic agent
Et = End expiratory concentration
x = Alveolar concentration of the Anesthetic agent for MAC =1 at 100% O_2 and patient age of 40 years.

2.1.1 Product improvements

HEYER MEDICAL AG retains the right to carry out modifications or to update the apparatus and/or operating instructions without prior notification. These Operating Instructions explain all features of the HEYER NARKOMAT+ anesthesia system and are correct at going to print. Instructions and models produced at a later stage may already contain improvements or modifications that were not included in previous models.

2.1.2 Responsibilities of operators

The correct functioning of the HEYER NARKOMAT+ anesthesia system can only be guaranteed if the apparatus is operated and serviced in accordance with the information provided by the manufacturer. The non-compliance with this information voids all guarantee claims against HEYER MEDICAL AG.

NOTE: Before using the apparatus please study the Operating Instructions as well as the section "General precautions", observing all information contained in these Operating Instructions that are highlighted with CAUTION or WARNING. These Operating Instructions only describe the operation of the apparatus. Information about service and repair by qualified trained personnel are contained in the HEYER NARKOMAT+ SERVICE INSTRUCTIONS.

The apparatus may only be operated by qualified and trained skilled personnel. All operators must fully observe these Operating Instructions or relevant additional documentation and information provided by the manufacturer. They must also comply with the general precautions detailed below and must be trained by authorized medical product consultants.

The apparatus may only be operated with an additional gas monitoring if a gas monitoring is not included. The following conditions must be fulfilled (DIN 13 252):

At least the:
- anesthesia-gas concentration and
- the carbon dioxide concentration

must be monitored.

Upper and lower alarm limits must be set for these monitoring parameters. Upon reaching one of these upper or lower alarm limits, an optical and acoustic alarm must be triggered.

The measuring adapter to be installed in the circular system or patient hose system must contain ISO cones (DIN 13 252). These must be applied to the inspiration hose connection or ideally to the Y piece. Measuring close to the tube is, however, recommended as this allows the recording of the inspiratory and expiratory gas values. Monitors using the side-stream procedure should be clearly preferred as a supplement to the additionally required gas monitoring.

Any apparatus not functioning as described in these Operating Instructions must not be used until the fault has been removed. The operators are responsible for any damage or injuries caused by the incorrect operation or repair/servicing of the apparatus by unauthorized personnel.

2.1.3 Liability of the manufacturer

HEYER MEDICAL AG shall only be liable for the safety, reliability and functionality of the apparatus, if:

- the apparatus was operated in accordance with the information issued by the manufacturer;

- extensions, new adjustments, modifications or repairs have been carried out by an expert authorized by the manufacturer;

- the apparatus was only operated in buildings containing grounding facilities according to the IEC regulations.

2.2 General precautions

2.2.1 Warning notes

NOTE: A warning note points out potentially dangerous situations which may cause injuries to the patient or operating personnel.

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.

If possible, always connect the output of the ventilation pressure valve (APL) to the anesthetic gas removal line, usually installed in the operating theatre.

The patient should furthermore be visually monitored by qualified personnel. In certain situations, life-threatening circumstances may occur which may not necessarily trigger an alarm.

Always set the alarm limits so that the alarm is triggered before hazardous situations occur. Incorrectly set alarm limits may result in operating personnel not being aware of drastic changes in the patient's condition.

Always check that the displayed ventilation pressure value lies within an acceptable range before activating the "Set Pmin/Pmax automatically" function, automatically setting new alarm limits.

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

Explosion hazard! The apparatus may not be operated near flammable anesthetic agents or other flammable substances. No flammable anesthetic agents (i.e. ether, cyclopropane) may be used.

As the apparatus may not be used with inflammable anesthetic agents (i.e. ether, cyclopropane), no antistatic ventilation hoses or face masks are required (DIN VDE750, part 214).

Electric shock and fire hazard! Always switch off the apparatus and disconnect from mains before cleaning.

Fire hazard! Fuses (i.e. additional sockets) may only be replaced by fuses of the same type and with the same fuse value.

Electric shock hazard! The apparatus may only be opened by qualified or authorized experts.

The connection of apparatus via the additional socket may, in case of a failure of the protective conductor, lead to a discharge current exceeding the permissible values.

Electromagnetic radiation disturbances exceeding the values of EN 60601-1-2, can affect the function of the machine.

2.2.2 Caution notes

NOTE: A CAUTION note refers to a situation which may cause damage or the incorrect function of the apparatus.

This apparatus may only be operated by trained, skilled medical staff.

Before starting the apparatus, the operating personnel must be familiar with the notes and information contained in these Operating Instructions and must have been trained by a medical product consultant.

If the apparatus does not function as described, the apparatus must be examined and possibly repaired by qualified service personnel, before being used again.

Handle the apparatus with care to prevent damage or functional faults.

Ensure that the gas supply of the apparatus always complies with the technical specification.

Before the operation, the apparatus must be correctly calibrated and/or the respective apparatus tests, as described in the Operating Instructions, must be carried out.

If the apparatus should show faults during the initial calibration or testing, the apparatus may not be operated until the fault has been repaired by a qualified expert.

After servicing, a functional test and a sensor and system test must be carried out before clinical use.

Only bacteriological filters with a low flow resistance must be connected to the patient module and/or the patient connection.

* After the unit has been switched on, a warming period of 4 minutes is necessary to ensure an exact measurement of the anesthesia gas values. The other breathing gas values are within the ISO specifications after 1 min

* Only use the recommended pressure controller when doing the gas verification. A to high or to low calibration gas flow can lead to faulty result.

* Use only the original tube system as measuring tube.

* The gas measurement tube system at the monitor must be connected before putting the apparatus into use or changing the flow rate. Otherwise the apparatus might falsely detect a tube blockage.

3 Functional Description

3.1 Anesthesia ventilator

Ventilators are described according to the principle of controlling the change over from inspiration to expiration. The NARKOMAT+ apparatus offers the following characteristics in the controlled ventilation mode or so-called CMV mode (**C**ontrolled **M**andatory **V**entilation).

time-controlled:
The timely sequence of inspiration and expiration has been specified by the ventilation frequency settings. The ratio of the inspiration to the expiration time of the individual ventilation cycle is determined by the adjustable I/E ratio.

pressure limitation:
The tidal volume during controlled ventilation is supplied during the entire period of the inspiratory flow and can be set as ventilation parameter. The inspiration is, however, terminated before the tidal volume has been administered, once the measured airway pressure reaches the set Peak pressure alarm limit.

constant volume:
The inspiratory flow to the patient required for ventilation with the set parameters, frequency f, tidal volume T. Vol. and ventilation time ratio I/E, is automatically calculated by the ventilator. This inspiratory flow is generated via the drive gas for the patient module. In standard anesthesia ventilators, deviations to the tidal volume actually supplied to the patient could occur due to the respective fresh gas setting and system compliance of the ventilation system. The ventilator of the NARKOMAT+ apparatus supplies in each setting a constant volume. The patient module containing the bellows is decoupled from the fresh gas, and the system compliance of the patient module is automatically taken into consideration by the ventilator when generating the tidal volume.

3.1.1 Fresh gas decoupling

During the fresh gas decoupling in the CMV mode, the fresh gas flow is directed into the manual ventilation bag. The manual ventilation bag serves as a fresh gas reservoir. This principle offers the following advantages for controlled ventilation:

1. The tidal volume is completely independent from the set fresh gas flow. The ventilation is therefore also referred to as constant volume ventilation.

2. The fresh gas flow can be maintained at a very low level, i.e. below 500 ml/min, depending on the patient. The manual ventilation bag serves as a reservoir for the fresh gas administered during the inspiration. The entire fresh gas volume is available during the next inspiration, i.e. not only the fresh gas stored in the reservoir but also the fresh gas supplied during the expiration period.

3.1.2 Constant volume provided by controlled ventilation

During controlled CMV ventilation, the set tidal volume is administered irrespective of the pulmonary circumstances. The ventilator drive represents, in principle, a constant flow generator. The inspiratory flow of the ventilation gas is automatically adapted to the respective settings of the tidal volume VT, the ventilation frequency RATE and the ventilation time ratio I/E.

3.1.3 Compliance compensation

The administered tidal volume is corrected to the set value, set by the user, with the aid of the compliance compensation. The system compliance of each ventilation system, i.e. the compliance of patient hoses and the patient module, always leads to losses in the administered tidal volume. The NARKOMAT^{+}´s automatic compensation of the system compliance can correct this volume loss with the aid of a control loop. For this purpose several ventilation cycles are required with the drive gas flow being slightly increased above the normal values, i.e. the values for achieving the set ventilation volume. The correct tidal volume is, however, administered to the patient, whilst the slightly higher volume is absorbed by the system compliance due to the effective compliance compensation.

3.1.4 Bag-in-bottle system

The so-called bag-In-bottle system is part of the patient section or circuit system. The gas-conducting sections are divided from the ventilator into a primary (ventilator) and a secondary circuit (patient). The gas volume provided by the drive is not directly administered to the patient but instead compresses a bellows inside a pressure dome. As a result, the ventilation gas contained in the bellows is administered to the patient. An increased drive volume, flowing into the pressure dome, also increases the tidal volume. Once the drive-gas flow has finished, also the pressure compensation between the primary and secondary circuit is ended. A distinctive plateau in the ventilation pressure curve is formed, if the system does not switch over to the expiration directly after the end of the inspiratory gas flow. For this purpose, the drive volume contained in the pressure dome is maintained at a steady level for some time. The Bellow is suitable for adults and children. An exchange of the bellows for different patient groups is not necessary.

3.2 Fresh gas dosing

The set-up of the gas quantities administered to the patient is carried out on a measuring tube block. This block contains measuring tubes that are also referred to as rotameters. These measuring tubes consist of a vertical glass tube, containing a suspended body. As the glass tubes expand towards the top, a certain gas flow lifts the suspended body to a respective height. The gas flow is adjusted via valve spindles, located below the individual measuring tube.
The setting of the O_2/AIR or O_2/N_2O is selected with the change-over switch which opens the respective gas line to the measuring tube block.
The fresh gas cannot be set with a mixture of AIR and N_2O as, in this case, a decrease of the oxygen content to below 21% could not be avoided.
The decrease of the oxygen content to below 21% is in theory also possible with O_2 and N_2O gas dosing. Such unfavorable settings are, however, prevented by a pneumatic safety system. This system, which is also referred to as RATIO system ensures the continuous existence of a minimum O_2 content of 25% in the dosed gas mixed with N_2O. In case of an increase of the N_2O flow, the required O_2 flow is also automatically increased. The thus set fresh gas is then fed over a vaporizer, where it is mixed with anesthetic agent.

3.3 Vaporizer mounting device and Vaporizers

The apparatus contains a Selectatec® compatible vaporizer mounting device accommodating two vaporizers. The vaporizer contains two chambers, with the bottom section containing the liquid anesthetic agent. Via a woven metal wick, the top section of the chamber is enriched with saturated anesthetic agent steam. The concentration of the saturated steam at ambient temperatures is considerably higher than that acceptable for clinical purposes. The desired concentration is achieved by a suitable mixing ratio of the gas and anesthetic agent with a gas flow that is passed around this chamber. This is achieved with the aid of the setting wheel. For this purpose, the ratio of the flows of the carrier gas is adjusted by a bypass channel and the vaporizer channel in such a way, that the chosen concentration is achieved at the vaporizer outlet. In the zero position of the vaporizer, this bypass channel remains open whilst the vaporizer chamber is completely closed for the gas flow.
Although the anesthetic agent steam concentration of the vaporizer chamber is saturated, the absolute anesthetic agent content depends, however, on the temperature. Consequently, the bypass channel contains a temperature compensation valve which in case of changes in the steam pressure caused by temperature fluctuations, changes the set dilution ratio in such a way that the anesthetic agent concentration issued is no longer dependant on the temperature.
For further information see:
Instructions of the respective anesthetic agent vaporizer.

3.4 Patient module

3.4.1 Circuit absorber system

The circuit absorber system consists of a ventilation system with CO_2 absorber. This system allows anesthetics to be carried out at extreme low fresh gas settings. The ventilation gas contains various parts of re-breathing gas, i.e. expiratory gas freed from CO_2 parts. This is achieved with a circuit ventilation system, facilitating a re-breathing of the expiratory CO_2-containing gas. A circuit system with high re-breathing contents causes a reduction of the consumption of anesthetic agents. This system also offers an improved breathing gas conditioning. The patient module is designed as a circuit absorber system in the form of a compact aluminum block. The hose connections normally required between the ventilator and the circuit system are thus no longer needed.

3.4.2 CO_2 absorber

The absorber serves to absorb the soda lime and aims to remove the CO_2 from the expiration air. The absorption process is a chemical reaction in which carbon dioxide is bound, most of the reaction water evaporates and the calcium is removed. Consequently the spent soda lime is dry and hard. The soda lime must be stored hermetically sealed, cool and dry in order not to become malabsorbant.

3.4.3 Reservoir and manual ventilation bag

The reservoir consisting of a manual ventilation bag provides an inspiratory interim store for the fresh gas. The reservoir pressure during machine and spontaneous breathing is limited to 1-2 cmH2O. During manual breathing, this valve also allows the manual adjusting of the desired ventilation pressure.

3.4.4 Volume measurement

Volume measurement is carried out by using a flow meter, operating according to the hot-wire anemometer principle, to measure the flow in the expiration branch. The ventilator processors integrate this measured value with the displayed tidal and ventilation minute volume. The tidal volume shown in the display is a measured value. The tidal volume displayed during controlled ventilation is measured by an internal flow sensor and is not dependent on the expiratory volume measurement.

3.4.5 Oxygen measurement*

The oxygen is metered by a measuring cell installed on the inspiration valve. This single-cathode measuring cell, also referred to as fuel cell, offers a longer life compared to other oxygen cells and is less sensitive to existing anesthetic gases.

*not valid with the apparatus option with integrated gas module

3.4.6 Patient module heating

The heating prevents the formation of condensation in the patient module and on the valve caps of the inspiration and expiration valve. The heating positively contributes to a ventilation gas conditioning. The heating mat also functions as a sealing mat and is installed between the top and bottom section of the patient module. An electronic control integrated in the ventilator, keeps the temperature of the patient module constant at an approx. 36°C. An over-temperature protection protects the apparatus against overheating.

3.5 Gas measurement*

The measurement of the single gases in the breathing gas is based on the principle that different gases absorb a different wavelength of infrared light. A pump inside the apparatus continuously sucks a breathing gas probe out of the respiratory circulation into the measurement chamber via a sampling line which is included with the gas module. This gas probe flows through the measurement chamber where the absorption of the different wave lengths of infrared light is measured. Based on these measurements, a microprocessor calculates the concentration of CO_2, N_2O and anesthesia gas.

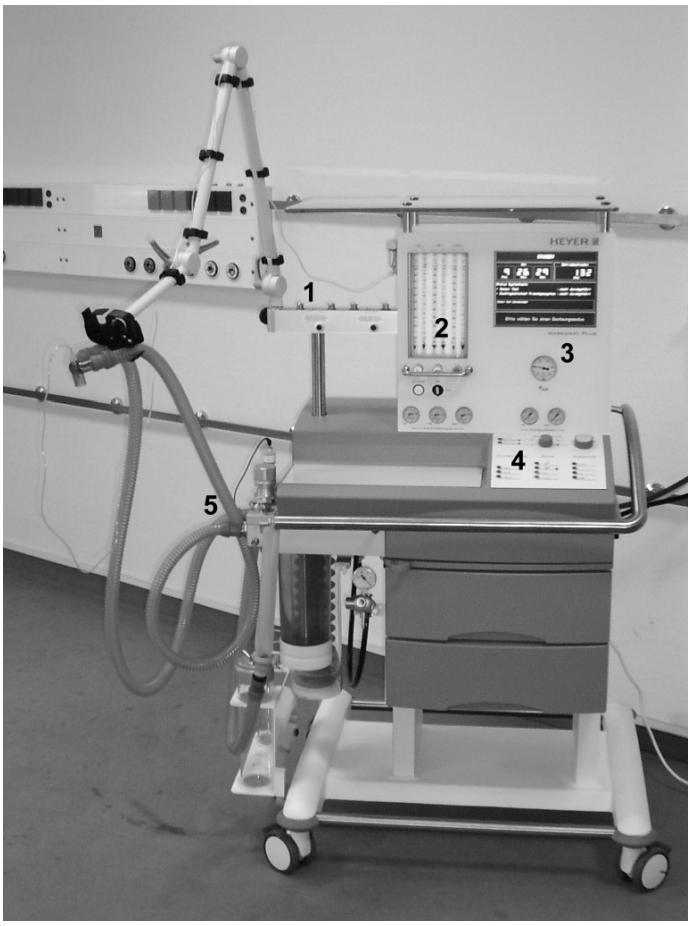
The measurement of oxygen is done with a paramagnetic oxygen sensor. This principle of measurement is based on the paramagnetic characteristics of the oxygen molecule, through which the oxygen concentration can be measured magnetically.

* only valid with the apparatus option with integrated gas module

4 Operating Elements / Connections for Appliances

4.1 Views of apparatus

4.1.1 Front of apparatus



1 Vaporizer mount
Selectatec* compatible vap. mount for connection of 2 vaporizers.

2 Flow meter block
6-fold flow meter block with integrated Ratio-system, O2-Bypass and N20/AIR change over switch.

3 Ventilator unit
Microprocessor controlled ventilator with TFT-display.

4 Control panel
Control panel with keys, selector switch and encoder (rotary switch).

5 Patient module
Absorber circuit system with integrated bag-in-bottle system, active and passive valves, such as APL-valve.

Fig. 1 Front view of the apparatus

4.1.2 Rear of apparatus

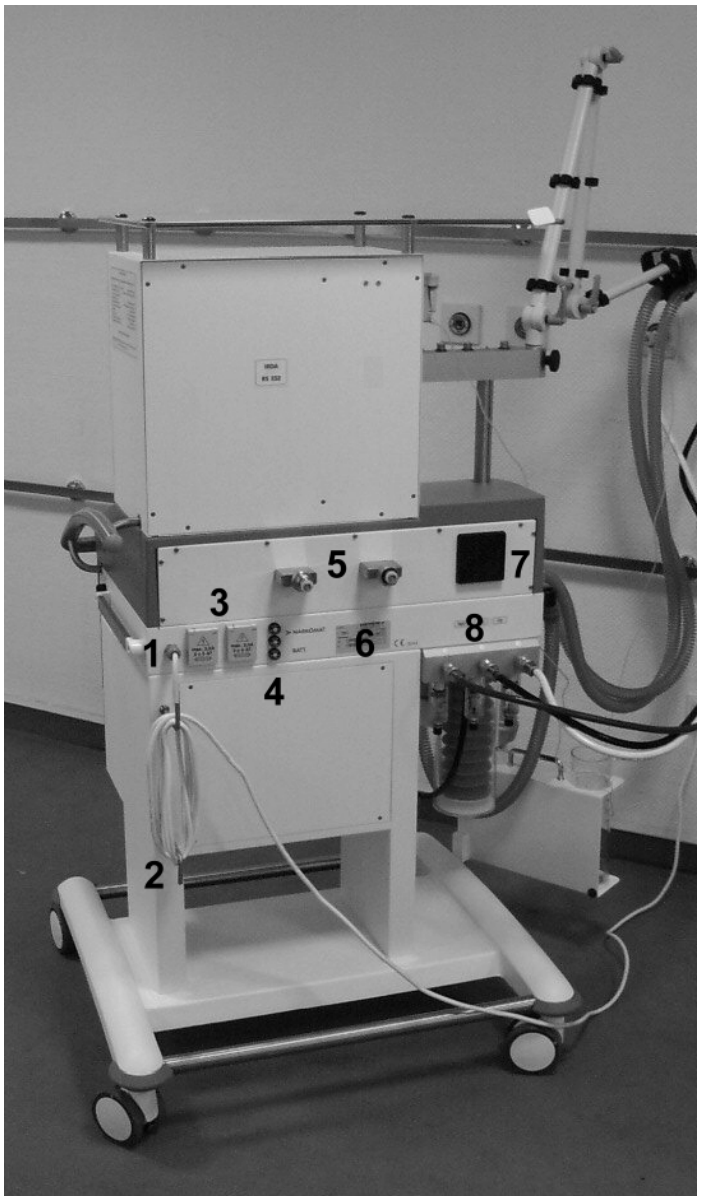


Fig. 2 Rear of the apparatus

1 Mains cable
Voltage supply cable for connecting the apparatus to a socket with grounding contact.

2 Cable hooks

3 Sockets
Additional devices can be connected.

4 Circuit breakers
One 5A circuit breakers for the ventilator unit , one 5A circuit breaker for the battery and one 10A (or two 5A) circuit breaker for the convenient receptacles

5 Cylinder jokes
Pin-index or DGAI cylinder jokes, one for N2O, one for O2.

6 Serial number

7 Fan
A fan provides ventilation of the housing and cooling of the integral components.

8 Pipeline supply connections
Connections for O2, AIR and N2O from central gas supply. Three pipeline pressure gauges inform about supply pressure.

4.1.3 Left side of apparatus

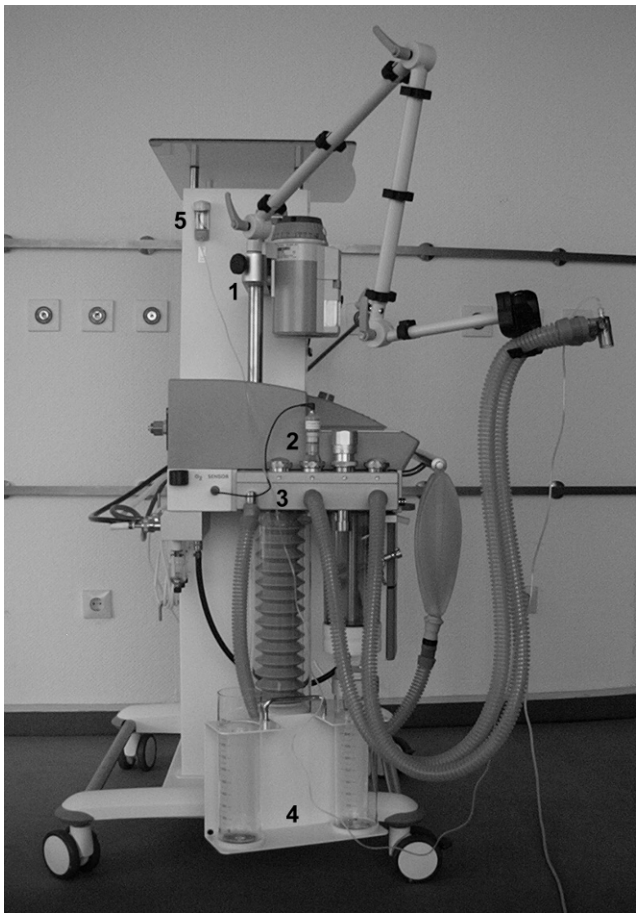


Fig. 3 Left side view on the apparatus

1 Holder for patient arm

2 Oxygen-sensor with cable*

3 Patient module

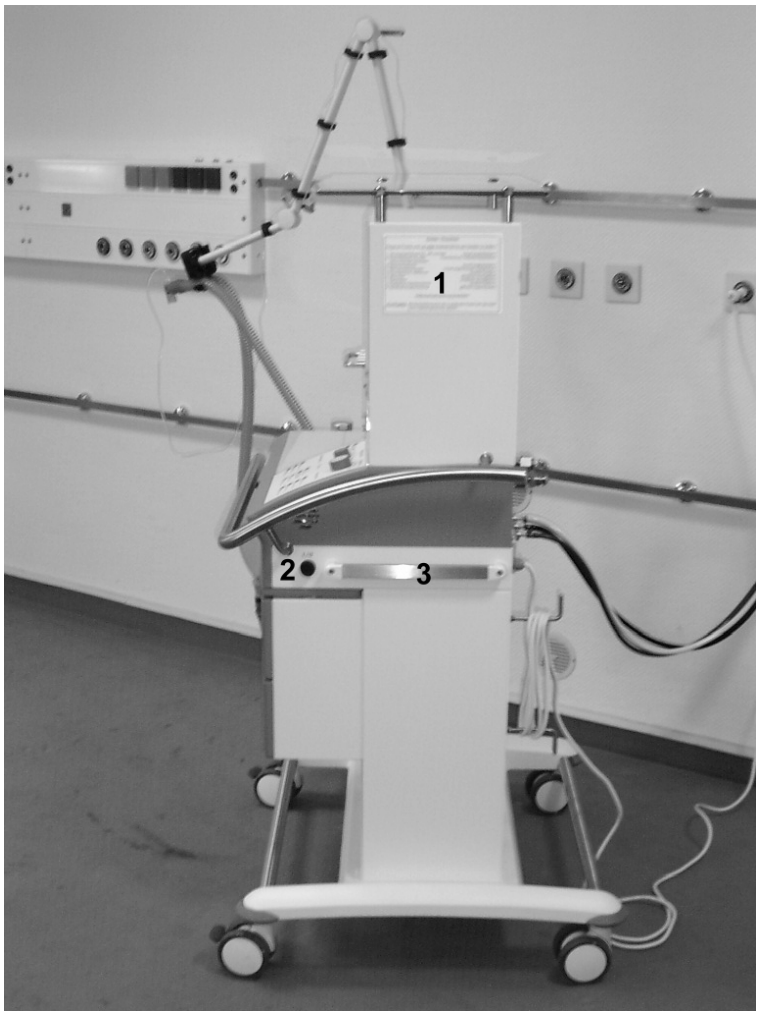
4 Suction stand with glasses (option)

5 Water trap with gas measurement inlet**

* Only valid without the option gas module

**Only valid with the option gas module

4.1.4 Right side of apparatus



1 Machine operation checklist
The checklist informs about several tests which have to be carried out in the start-up procedure.

2 Mains switch
With this switch, the apparatus is switched on/off and the mains connection is activated. During the operation, the switch remains in the ON position.

3 Rail mount 25 x 10

Fig. 4 Right side view on the apparatus

4.2 Ventilator unit

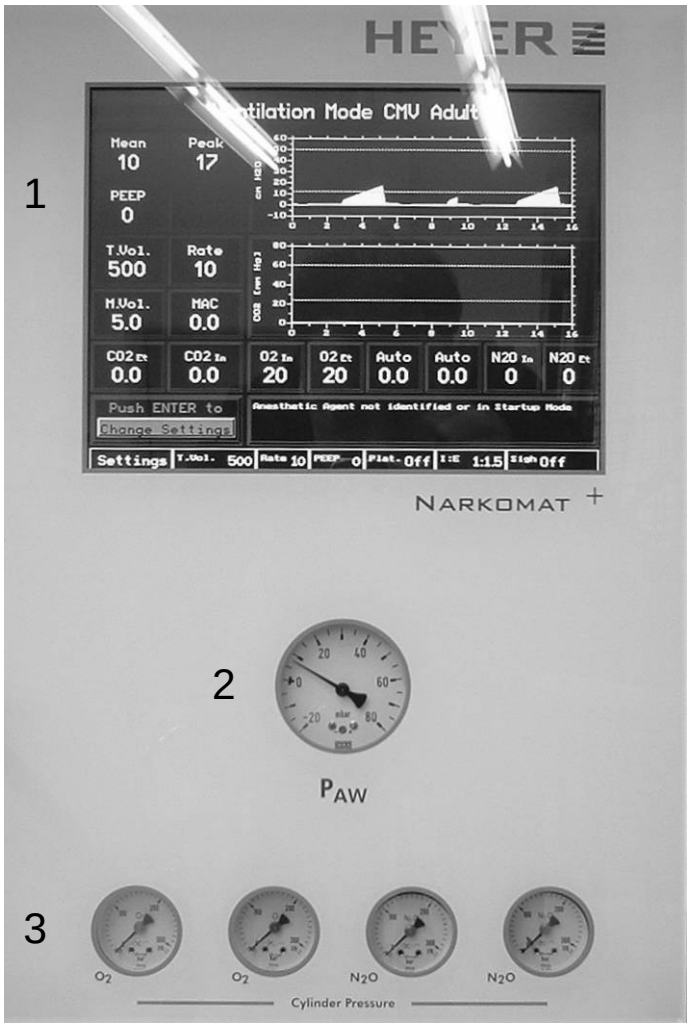


Fig. 5 Ventilator display and airway pressure gauge

1 Ventilator display
The ventilator uses a color TFT display. This display is high in contrast, clearly visible also from the side view and provides all measured values and settings of the ventilator.

2 Airway pressure gauge
Shows the airway pressure on a pressure gauge within a range of -20 to 80 cmH_2O.

3 Cylinder pressure gauges
Shows the cylinder pressure for each cylinder on a pressure gauge within a range of 0 to 315 kPa x 100 (315 bar).

4.2.1 Operating panel, ventilator keyboard

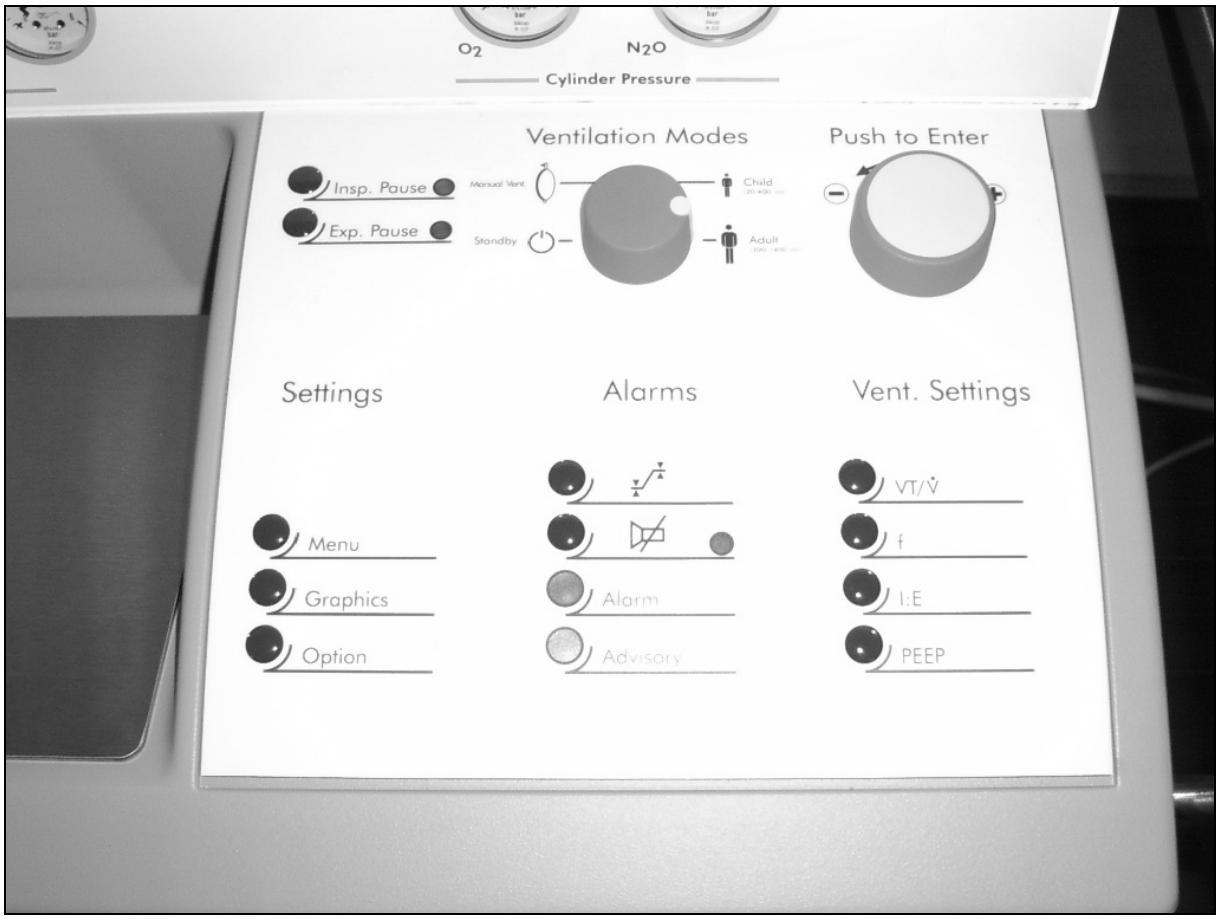


Fig. 6 Operating panel, ventilator keyboard

4.2.1.1 "Ventilation Modes"- selection switch

This switch for the selection of ventilation modes has four positions:

Standby:	Position for starting and implementing sensor and system tests.
Manual/spont.:	In this position the ventilator is switched to the manual or spontaneous ventilation mode.
Child (20-400 ml):	In this position, the ventilator is switched to the mode for the controlled ventilation of children.
Adult (300-1400 ml):	In this position the ventilator is switched to the mode for the controlled ventilation of adults.

4.2.1.2 "Push to Enter" - encoder button to change and confirm settings

With this encoder button the different parameter windows can be selected in the display. By turning the button anti-clockwise or clockwise, the respective windows or selection buttons in the display are selected. By pushing the direct selection button, functions or further windows may be selected or opened. Rotary ventilator set-up buttons shown on the display, are also operated by the direct selection button. The respective parameters are increased in clockwise direction and decreased in anti-clockwise direction.

In case of changes, the changed settings or selections are confirmed and stored once the button is pressed.

4.2.1.3 Operating panel keys for insp. pause and exp. pause

Insp. Pause: Upon pressing this key in the CMV mode, the green LED flashes and an inspiratory pause of up to 5 sec. is inserted at the end of the next inspiration. In order to terminate the pause early, the key may be pressed a second time, after which the inspiratory pause is terminated.

Exp. Pause: Upon pressing this key in the CMV mode, the green LED flashes and an expiratory pause of up to 30 sec. is inserted at the end of the next expiratory. In order to terminate the pause early, the key may be pressed a second time, after which the expiratory pause is terminated.

4.2.1.4 "Settings" - panel keys for basic set-up

Menu: This key opens a ventilator display window menu in all ventilation modes and the standby position. The time and temperature of the patient module are displayed. The alarm level of the acoustic alarms can be set and the alarm limits for three personal settings may be stored or loaded. The test option system display key opens another window in which comprehensive or brief information may be selected for the result of the compliance test.

Graphics: This key opens a ventilator display graphic window in all ventilation modes and the standby position. The time axis of the real-time ventilation pressure and expiratory flow graphics to be displayed can be set to 16, 24 or 32 seconds.

Options This key opens a ventilator display graphic window in all ventilation modes and the standby position. Here the anesthesia gas, the sample flow and the displayed CO_2 unit can be set. *
In the standby mode the patient module can be unlocked and the gas measurement can be verified. *

*Only valid with option gas module

4.2.1.5 "Alarms" - panel keys and displays for alarms

This key opens a display window in the manual/spontaneous, CMV, (S)CMV or PCV ventilation modes for setting all available alarm limits. The respective alarm limits can then be changed to the new settings. By pressing the limits key a second time, an additional alarm window is opened with additional adjustable alarm settings. By pressing the limits key a third time the window is closed and the changed alarm limits are stored.

This key switches off the sound of the acoustic alarms for a maximum of 2 minutes. By pressing the key again, the sound is activated again before the end of the 2 minute period.

4.2.1.6 Vent. Settings" - panel keys for direct selection display windows

For the respective parameters a smaller window is opened for a new setting or the alteration of existing settings. With the aid of the encoder button, the current parameter setting can be changed with a rotary display button. The changed setting is confirmed and stored by pressing the encoder. Or the display window is closed by depressing the key again or automatically after about 5 sec.

VT/$\dot{V}$: In the CMV ventilation mode this key opens a display window for setting the tidal volume VT.

In the PCV ventilation mode this key opens a display window $\dot{V}$ for setting the maximum inspiratory flow.

f: This key opens a Rate display window in the CMV ventilation mode for setting the ventilation frequency Rate.

I:E: This key opens an I:E display window in the CMV ventilation mode for setting the ventilation time ratio I:E from inspiration to expiration time.

PEEP: This key opens a PEEP display window in the CMV ventilation mode allowing a PEEP setting.

4.3 Flow meter tube block including fresh gas dosing

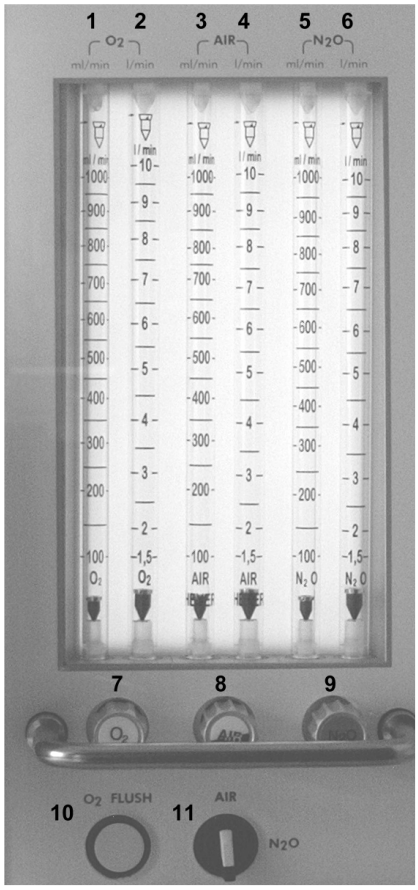


Fig. 7 Flow meter block including fresh gas dosing

1 Flow meter tube O_2 with a low measuring range for settings between 0 to 1000 ml/min
2 Flow meter tube O_2 with a high measuring range for settings between 1,5 and 10 l/min
3 Flow meter tube AIR with a low measuring range for settings between 0 to 1000 ml/min
4 Flow meter tube AIR with a high measuring range for settings between 1,5 and 10 l/min
5 Flow meter tube N_2O with a low measuring range for settings between 0 to 1000 ml/min
6 Flow meter tube N_2O with a high measuring range for settings between 1,5 is 10 l/min
7 Valve spindle for O_2 gas dosing
8 Valve spindle for AIR gas dosing
9 Valve spindle for N_2O gas dosing
10 O_2 bypass
The O_2 bypass supplies a high O_2 flow (approx. 50 l/min) directly to the fresh gas outlet or into the patient module. Upon releasing the bypass key, the key returns to its original position and the O_2 bypass is automatically interrupted.
11 N_2O/AIR change-over switch
This switch allows the pre-selection of N_2O or AIR, which can then be dosed with the respective valve spindles. The previously set volume flow is retained after switching back to the same gas type.

4.4 Vaporizer mounting device

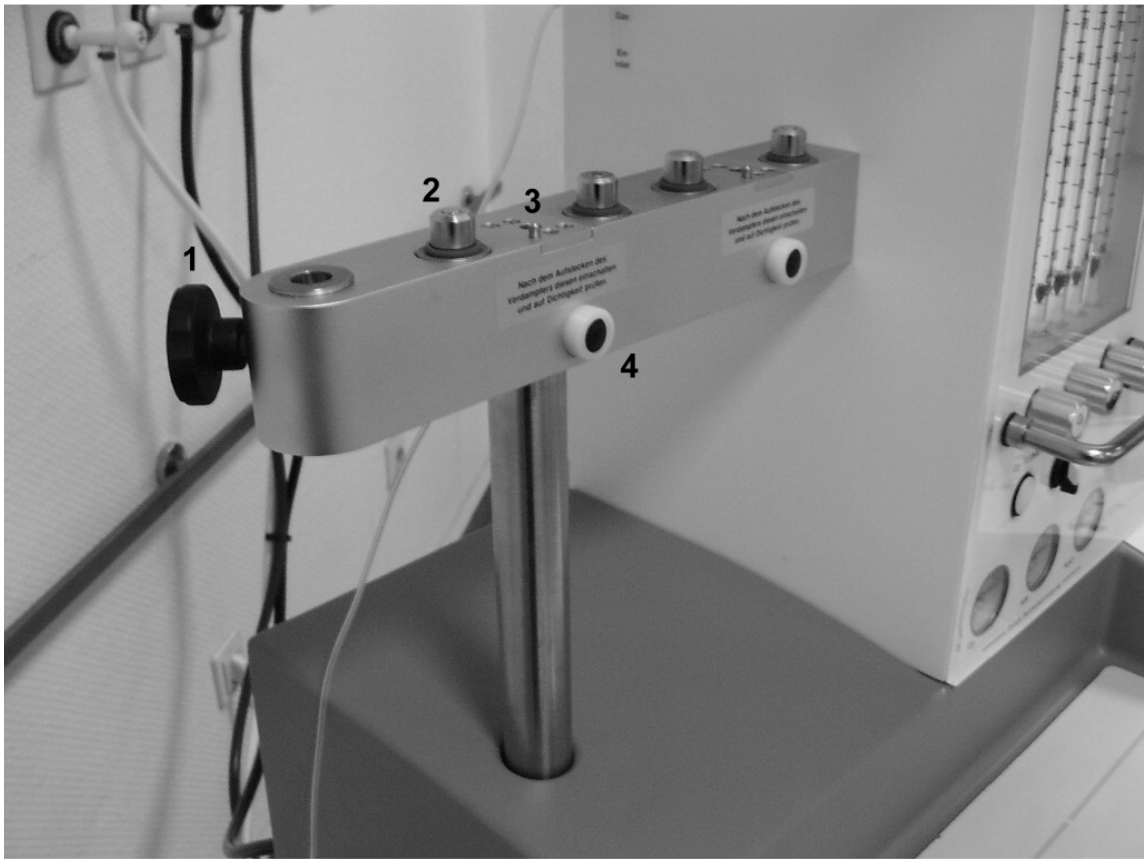


Fig. 8 Vaporizer mounting device

1 Fixing knob for patient arm

2 Valve cartridge of vaporizer mount

3 Locking device

4 Stopping face

4.5 Patient module (circuit system)

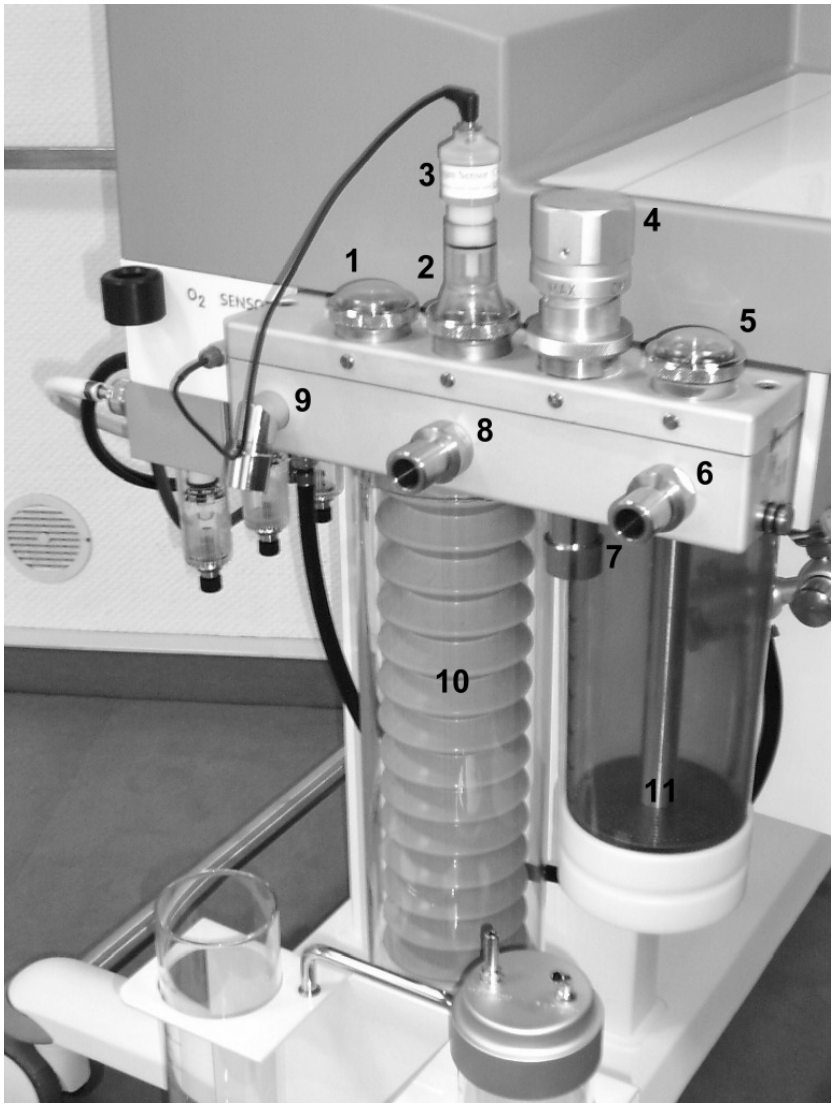


Fig. 9 Patient module (circuit system)

1 Emergency air valve
2 Inspiration valve
3 Oxygen sensor*
(fuel cell)
4 Ventilation pressure valve (APL valve): Including rotary regulator for setting the pressure control during manual ventilation or for setting it as a 2 cmH2O release valve during CMV or spontaneous ventilation.
5 Expiration valve
6 Hose connection branch
7 Outlet of ventilation pressure valve (APL-valve):
The anesthetics gas scavenging system is connected to this point.
8 Hose connection for inspiration branch
9 Hose connection for reservoir/manual ventilation bag
10 Bellows including bellows dome
11 CO_2 absorber canister

*only the apparatus option without the gas module

4.6 Sample gas recirculation

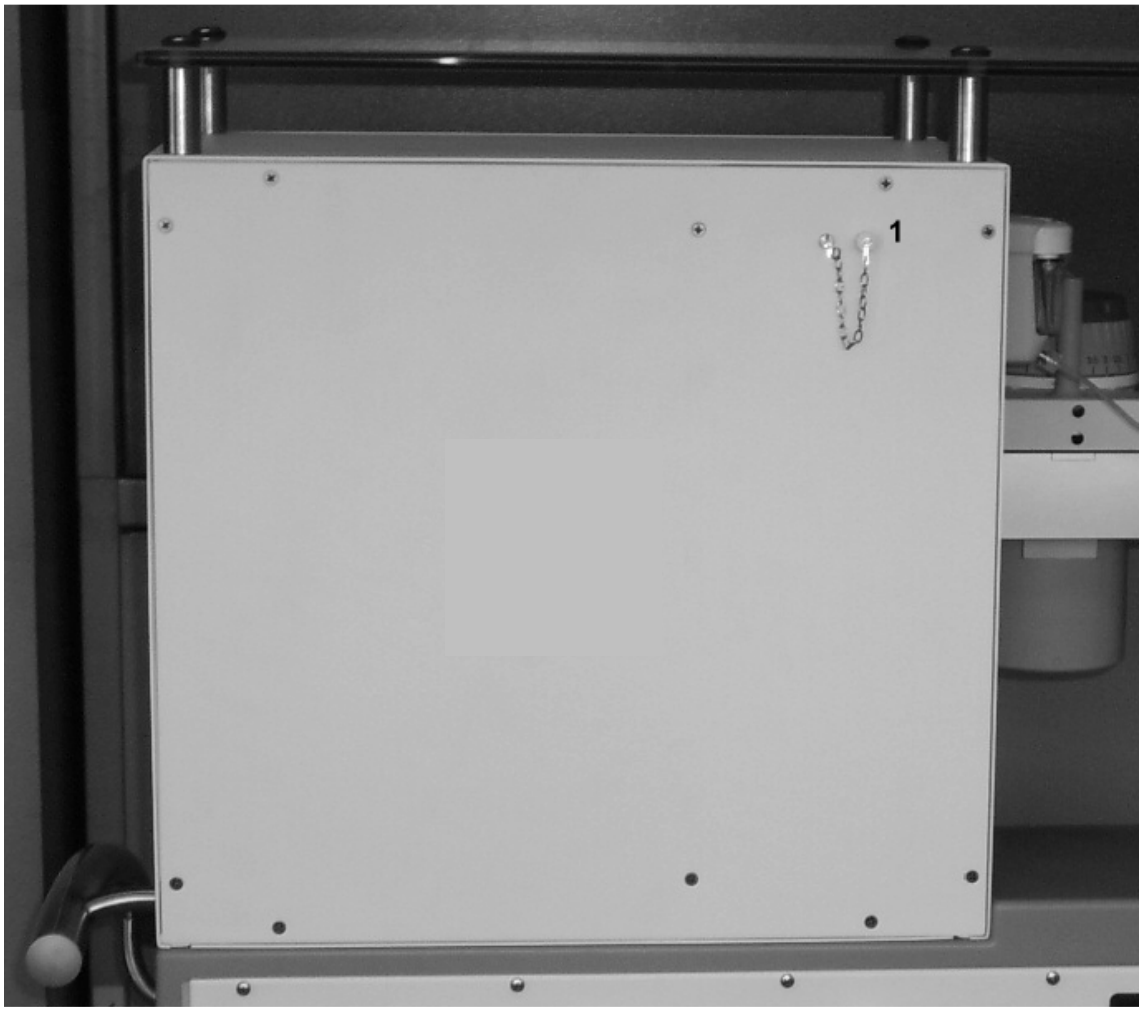


Fig. 10 Sample gas recirculation

1 Sample gas recirculation connector*

The gas return line from external monitors operating according to the side stream procedure are connected to the "Sample gas recirculation" adapter at the rear side. The sample gas is putted back to the reservoir bag by this adapter.

* only the apparatus option without the gas module

4.7 Vacuum source for bronchial suction (optional)

Fig. 11 Vacuum source

1 Tube clamp for suction tube/finger tip

2 Quick coupling AIR for vacuum source

3 Vacuum source (injector) with vacuum gauge and control knob

4 Connection for tube to suction glass "vacuum" connector

4.8 Symbols on the Unit

Attention, check the accompanying documents

I/O

On/Off (connection to the power supply)

5 Alarm Messages and Safety Devices

The NARKOMAT+ anesthesia system displays alarm messages on the ventilator display during operation. The alarm message is displayed until the fault condition that triggered the alarm is resolved. High priority alarms are displayed against a light background in the alarm window. Low priority alarms are displayed against a dark background. The switching of the alarm muting key does not influence the alarm shown on the display.

In the following, all alarm situations that may arise during the different operating conditions are explained.

There are three priority levels of the alarms:

No.	Alarm LEDs	Acoustic
1	Continues red	Continues tone
2	Red blinking	Intermitting tone
3	Yellow blinking	

5.1 Alarm messages direct after the System start

Direct after the switching on and booting of the system, alarm messages are displayed in the bottom section of the screen. The alarm has to be acknowledged by pushing the encoder button before the booting procedure continues.

Direct after the switching on and booting of the system, alarm messages are displayed in the bottom section of the screen. The operating conditions can be checked and, if necessary, errors can be corrected.

Fig. 12 Example of an alarm message during the booting procedure

5.2 Alarm Messages in Standby

In standby, the alarm messages are display in the middle section of the screen.

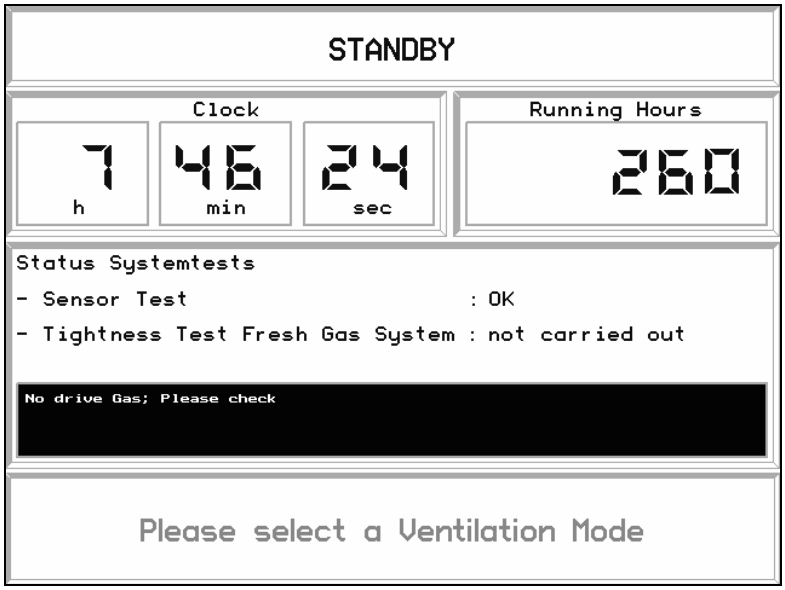


Fig. 13 Example of an alarm message during the booting procedure

In standby, the alarm messages are display in the middle section of the screen. The operating conditions can be checked and, if necessary, errors can be corrected.

5.3 Compliance test alarm messages

During or after the compliance test, alarm messages are displayed in the middle or top section of the screen

During or after the compliance test, alarm messages are displayed in the middle or top section of the screen
The operating conditions can be checked and, if necessary, errors can be corrected.

Fig. 14 Example of a sensor test alarm message

If the system was locked because of a sensor failure, only use the apparatus in case of an emergency for manual ventilation and contact a service technician if the compliance test fails repeatedly.

5.3.1 Compliance test alarm messages

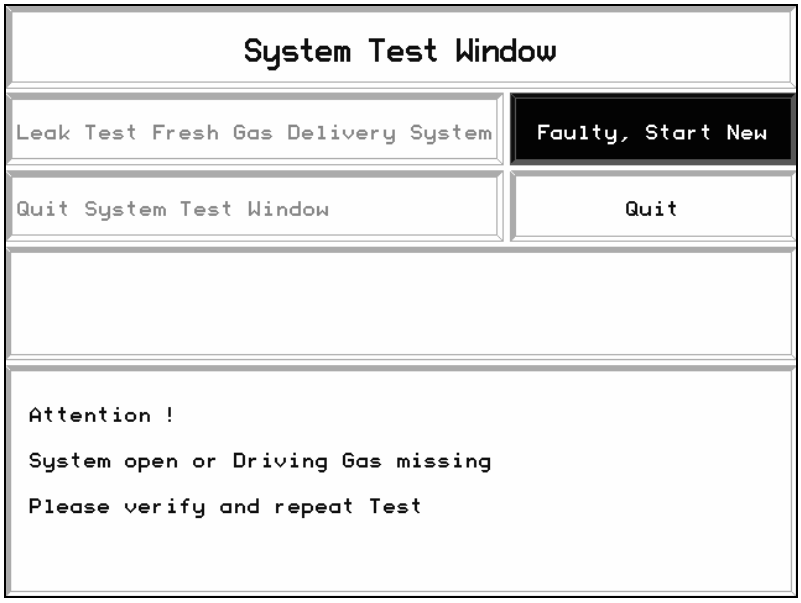
Alarm message	Significance/ cause	Corrective action
System Resistance too high	Resistance of patient hoses or bacteria filter is too high.	Replace bacteria filter and breathing circuit. Use the Compliance test in Standby / OPTIONS to retest. If all else fails call Service.
Compliance test Passed. Leak rate is higher than 600 ml/min. Tighten valve rings Check breathing circuit Press OK to continue	The leakage of the circle system and the patient hoses is higher than 600 ml/min at 40 cm H2O.	Ventilator may be used safely with adequate fresh gas flows. If necessary use the Compliance test in Standby / OPTIONS to retest after tightening the breathing circuit and valve rings.

Compliance test alarm messages (continued)

Alarm message	Significance/ cause	Corrective action
Compliance out of range	The compliance of the connected patient hoses lies outside the range of 3.0 to 9.9 ml/cm H2O.	Replace bacteria filter and breathing circuit. Use the Compliance test in Standby / OPTIONS to retest. If all else fails call Service.
System Error Cal Required – Call Service	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.
Check Diaphragm Valves	The system has detected a pressure increase. The diaphragm valves may be leaking drive gas into the circle system.	Remove the Breathing circuit from the Docking Station and check the Decoupling and Expiratory valves for intact membranes. Replace as required or call Service.
Pressure Reading out of tolerance Perform Compliance Test when convenient	The system has detected a fault on one or both pressure sensors.	Perform the Compliance test in Standby / OPTIONS. If all else fails call Service.
Flow/Volume Readings not available Replace Flow Sensor - Call Service	During the test, the hotwire sensor did not pass its test. Sensor may be faulty.	Retry function. Perform the Compliance test in Standby / OPTIONS Reboot machine. If all else fails call Service.
Flow/Volume Readings not available Replace Flow Sensor - Call Service	During the test, the hotwire sensor did not pass its test. Sensor may be faulty.	Retry function. Reboot machine. If all else fails call Service.
Valve Error: Use Manual Ventilation Call Service	The proportional valve for generating the ventilation volume does not function correctly.	Perform the Compliance test in Standby / OPTIONS. If all else fails call Service.
Vent Error: Use Manual Ventilation Call Service	The automatic test routine has detected a processor control fault.	Call Service.
Calibrate Breathing System Perform Compliance Test when convenient	One or more solenoid valves actuating the bellows valve have failed.	Remove the Breathing circuit from the Docking Station. Check the Bellows valve actuation. Perform the Compliance test in Standby / OPTIONS. If all else fails call Service.
Patient module unlocked	The Patient module is not adapted correctly in the docking station.	Check if the Patient module is adapted correctly. If else fails, call service

5.4 System test alarm messages

During or after the sensor test, alarm messages are displayed in the lower section of the ventilator display:



If the system cannot create a sufficient pressure increase in the breathing circuit, the following fault message is for instance displayed in the lower section of the system test window.

Fig. 15 Example of a system test alarm message

System test alarm messages (continued)

Alarm message	Significance/ cause	Corrective action
System Resistance too high	Resistance of patient hoses or bacteria filter is too high.	Replace bacteria filter and breathing circuit. Use the Compliance test in Standby / OPTIONS to retest. If all else fails call Service.
Leakage greater than 200 ml/min	The fresh gas system leakage test has detected a leakage of over 200 ml/min.	Ventilator may be used safely with adequate fresh gas flows. Retest after checking the breathing circuit, tighten valve rings, o-rings, seals on vaporizer mounts, bellows and absorber domes
Compliance out of range	The compliance of the connected patient hoses lies outside the range of 3.0 to 9.9 ml/cm H2O.	Replace bacteria filter and breathing circuit. Use the Compliance test in Standby / OPTIONS to retest. If all else fails call Service.
System Error Cal Required – Call Service	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.
Calibrate Breathing System Perform Compliance Test when convenient	One or more solenoid valves actuating the bellows valve have failed.	Remove the Breathing circuit from the Docking Station. Check the Bellows valve actuation. Perform the Compliance test in Standby / OPTIONS. If all else fails call Service.
CPU Error: Use Manual Ventilation Call Service	The watchdog control system has detected a failure.	Call Service.
O2 Cell is out of range Replace O2 Sensor Press OK to Start	O2 cell is either in a concentration of O2 that is lower than 21%, is disconnected from the cable or is faulty.	Expose cell to 21% oxygen, with its cable plugged in, or replace the cell.
O2 concentration too high. Expose Sensor to room air. Press OK to start.	O2 cell is either in a concentration of oxygen that is higher than 21% or cell is faulty.	Expose cell to 21% oxygen or replace the cell.

5.5 Alarm messages during normal operation

During normal operation, alarm messages are displayed in the lower section of the ventilation mode window:

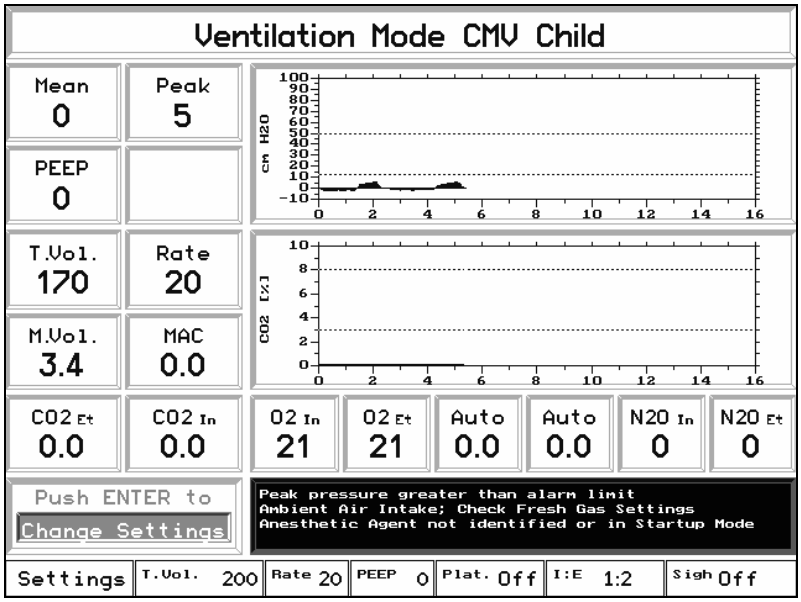


Fig. 16 Example of an alarm message during normal operation

After each activation of the CMV mode, the following alarm message is, for instance, displayed because the selected minimum airway pressure has not been reached and the anesthesia gas concentration is not sufficient for identification.

Alarm messages during normal operation (continued)

Alarm message	Significance/ cause	Corrective action
CPU Error: Use Manual Ventilation Call Service	The watchdog control system has detected a failure.	Call Service.
Vent Error: Use Manual Ventilation Call Service	The automatic test routine has detected a processor control fault.	Call Service.
High system pressure Set APL valve to OPEN	The ventilation pressure does not decrease during expiration.	Remove the Breathing circuit from the Docking Station. Check Expiratory valve actuation.
Valve Error: Use Manual Ventilation Call Service	The proportional valve for generating the ventilation volume does not function correctly.	Perform the Compliance test in Standby / OPTIONS. If all else fails call Service.
Flow Error: Use Manual Ventilation Call Service	The internal flow sensor, measuring the generated ventilation volume, does not functioning correctly.	Perform the Compliance test in Standby / OPTIONS. If all else fails call Service.
Calibrate Breathing System Perform Compliance Test when convenient	One or more solenoid valves actuating the bellows valve have failed.	Remove the Breathing circuit from the Docking Station. Check the Bellows valve actuation. Perform the Compliance test in Standby / OPTIONS. If all else fails call Service.
Pressure Reading out of tolerance Perform Compliance Test when convenient	The system has detected a fault on one or both pressure sensors.	Perform the Compliance test in Standby / OPTIONS. If all else fails call Service.
No Drive Gas; Please Check	The compressed gas (AIR or O2) supply with which the drive gas of the ventilator is generated, has failed.	Check AIR or O2 pressure supply.
Resume Ventilation	Drive gas now available after the ventilator had stopped, because of a loss of drive gas.	Select ventilation mode. Restart the ventilation.
Flow/Volume Readings not available Replace Flow Sensor - Call Service	During the test, the hotwire sensor did not pass its test. Sensor may be faulty.	Retry function. Reboot machine. If all else fails call Service.

Alarm messages during normal operation (continued)

Alarm message	Significance/ cause	Corrective action
A P N E A	No breathing by the patient is detected in manual mode when measuring the expiratory volume.	Check connections and patient breathing. Initial Apnea indication (beeps) is adjustable to 15, 30, or 45 sec. A steady tone indicates Apnea after 2 minutes.
System vented or drive gas missing	The circle system is vented during the pressure or leak test.	Check the O2 cell is present, APL valve is set to max (leak test) and breathing circuit is connected properly.
PEEP greater than Pmin	The measured PEEP exceeds the set Pmin pressure limit.	Check that APL valve setting is appropriate. Check Pmin. Alarm setting.
FiO2 lower than FiO2 min	The measured FiO2 value is less than the set minimum oxygen concentration FiO2 min.	Check that supplied FiO2 is appropriate. Check O2 Alarm setting.
Tidal Volume lower than Vt min	The measured tidal volume V_{TE} value is less than the set V_{TE} min. limit.	Check that Tidal Volume setting is appropriate. Check Vt min Alarm setting.
Peak pressure greater than alarm limit	The peak pressure Ppeak exceeds the set Pmax pressure limit.	Check that Tidal Volume setting is appropriate. Lungs deflate when Pmax is reached. Check Pmin. Alarm setting.
Peak pressure below alarm limit	The peak pressure Ppeak is lower than the set Pmin pressure limit.	Check that Tidal Volume or Plateau Pressure setting is appropriate.
Minute Volume below alarm limit	The ventilation minute volume M vol. is lower than the set M vol. min. limit.	Check that Minute Volume setting is appropriate. Check M.Vol. Alarm setting.
PEEP greater than PEEP-Setting	The PEEP is greater than the PEEP setting.	Check that PEEP setting is appropriate.
FiO2 greater than FiO2 alarm limit	The measured FiO2 exceeds the set FiO2 max. oxygen concentration limit.	Check that supplied FiO2 is appropriate. Check O2 Alarm setting.
Check Vent Dial position	The Vent dial is in an invalid position longer than 3 sec.	Reposition the vent mode vent dial to a valid position. Reselect ventilation mode. Restart ventilator.
Temp Sensor out of tolerance Check Heating System – Call Service	The control of the breathing circuit heating, or the heating mat, is faulty.	Call Service at next opportunity.
Temp Sensor readings not available Call Service	The temperature sensor of the breathing circuit has failed.	Perform the Compliance test in Standby / OPTIONS. If all else fails call Service.

Alarm messages during normal operation (continued)

Alarm message	Significance/ cause	Corrective action
Fan Error Check Fan – Call Service	The fan that ventilates the housing and cools the integral modules has stopped.	Call Service at next opportunity.
AC Power lost, using Battery	The mains voltage supply has failed, the machine is being powered by the battery.	Check AC line cord is plugged into AC outlet. Call Service if required.
AC Power lost, using Battery 30 min. remaining	Less than 30 minutes of battery power available.	Plug in AC Line cord.
AC Power lost, using Battery 25 min. remaining	Less than 25 minutes of battery power available	Plug in AC Line cord.
AC Power lost, using Battery 20 min. remaining	Less than 20 minutes of battery power available	Plug in AC Line cord.
AC Power lost, using Battery 15 min. remaining	Less than 15 minutes of battery power available	Plug in AC Line cord.
AC Power lost, using Battery 10 min. remaining	Less than 10 minutes of battery power available	Plug in AC Line cord.
AC Power lost, using Battery 5 min. remaining	Less than 5 minutes of battery power available	Mechanical ventilation will discontinue in approximately 5 minutes. Display and numeric values will continue until battery power is exhausted. Patient can be manually ventilated as long as there is compressed gas available.
AC Power lost, using Battery Battery running low Use Manual Ventilation	The power supplied by the battery is too low for automatic mechanical ventilation. The display will fade within minutes.	Check AC line cord is plugged into AC outlet. Call Service if required.
Check Battery – Call Service	The battery is empty or defective	Check the fuses. Call Service if required.
Continuous Pressure	A continuous ventilation pressure without significant change of the pressure value is detected.	Check that APL valve is set to the CMV/SP position.
Ambient Air Intake; Check Fresh Gas setting	The emergency air valve in the patient section has opened; check the fresh-gas setting and increase the fresh gas flow, if necessary.	Check if the fresh gas flow is is sufficient. Check for Leaks. Check if patient is breathing Spontaneously. call Service at next opportunity.

Alarm messages during normal operation (continued)

Alarm message	Significance/ cause	Corrective action
Set APL Valve to CMV/SP position	Message to remind operators to set the ventilation pressure valve (APL) to the CMV/SP position after activating the CMV mode. This message also appears if there is a peep that is higher then the chosen peep.	Set the airway pressure limiting valve (APL) to the CMV/SP position after activating either mechanical ventilation mode.
Rate lower than f min	The measured ventilation frequency Rate value lies below the set f min. limit.	Only in the manual mode. Increase the ventilation frequency
Rate greater than f max	The measured ventilation frequency Rate value exceeds the set f max. limit.	Only in the manual mode Decrease the ventilation frequency
Check Settings	The set parameters for CMV mode ventilation are for an inspiratory flow that cannot be achieved by the machine. The max. limit is a minute volume of < 20 l/min, or an inspiratory flow < 75 l/min.	Check Tidal Volume setting is appropriate.
Compliance Test bypassed	The Startup Compliance test has been bypassed	Perform the Compliance test in Standby / OPTIONS as soon as time allows to ensure the safe function of the system

5.5.1 Alarm messages during normal operation with the integrated Gas Module *

Alarm message	Significance/ cause	Corrective action
Insp. Agent H I G H	The measured Anesthesia agent concentration is higher than the set maximum value for the end tidal concentration	Check that supplied Insp. Agent is appropriate. Check Insp. Agent Alarm setting.
FiO2 L O W !	The measured FiO2 value is less than the set minimum oxygen concentration FiO2 min.	Check that supplied FiO2 is appropriate. Check O2 Alarm setting.
FiO2 H I G H !	The measured FiO2 exceeds the set FiO2 max. oxygen concentration limit.	Check that supplied FiO2 is appropriate. Check O2 Alarm setting.
CO2 Re-breathing; please check Absorber	The inspiratory CO_2 value is too high	Exchange the soda lime. If all else fails call Service.
Insp. N2O H I G H	The measured N_2O concentration is higher than the set value N_2O max	Check that supplied N2O is appropriate. Check N2O Alarm setting.
ET CO2 H I G H	The measured CO_2 concentration is higher than the set value CO_2 max	Check the soda lime, the conditions of the patient and the alarm settings If all else fails call Service.
ET CO2 L O W	The measured CO_2 concentration is lower than the set value CO_2 min	Check the conditions of the patient and the alarm settings If all else fails call Service.
Insp. Agent L O W	The measured Anesthesia agent concentration is lower than the set minimum value for the inspiratory concentration	Check that supplied Insp. Agent is appropriate. Check Insp. Agent Alarm setting.
Insp. N2O L O W	The measured N_2O concentration is lower than the set value N_2O min	Check that supplied N2O is appropriate. Check N2O Alarm setting.
Gas Monitor Technical Failure	Internal fault in the gas module	Call Service
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
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
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

Alarm messages during normal operation with the integrated Gas Module* (continued)

Alarm message	Significance/ cause	Corrective action
Gas Monitor NOT ready	Power supply or data communication to the gas module is defective	Call Service
Anesthetic Agent Mixture	The presence of a second anesthetic agent has been detected	
Anesthetic Agent not identified or in Startup Mode	The concentration of the anesthetic agent is too low for an auto identification or the sensor is in the startup phase and cannot deliver the measurements within the ISO specifications	Wait up to 4 min for the sensor to warm up. If all else fails call Service.
Anesthetic Agent Measurement in Startup Mode	The sensor is in the startup phase and cannot deliver the measurements within the ISO specifications	Wait up to 4 min for the sensor to warm up. If all else fails call Service.

*Only valid with option gas module

5.5.2 Alarm messages during normal operation with the optional ventilation mode PCV

Alarm message	Significance/ cause	Corrective action
Unable to attain target pressure; Adjust f, flow or I:E Ratio	The inspiration time and/or the flow is too low for the selected plateau pressure to be attained	Check that I:E ratio and breathing frequency setting are appropriate.
PCV Setting not valid	The combination of inspiratory flow, frequency and I:E ratio cannot be realized by the ventilator.	Change the PCV settings
Expiratory time too short	The set expiration time does not allow the below to refill completely	Check that I:E ratio and breathing frequency setting are appropriate.

5.6 Technical failure alarm message

Alarm message	Significance/ cause	Corrective action
Major Technical Failure Switch to Manual Ventilation! Call Service - Technician	The ventilator has a serious technical fault and stops the controlled ventilation in the CMV mode.	Call Service

This alarm is not shown in the usual alarm windows of the various displays. Due to its extremely high priority, this fault is displayed in its own window.

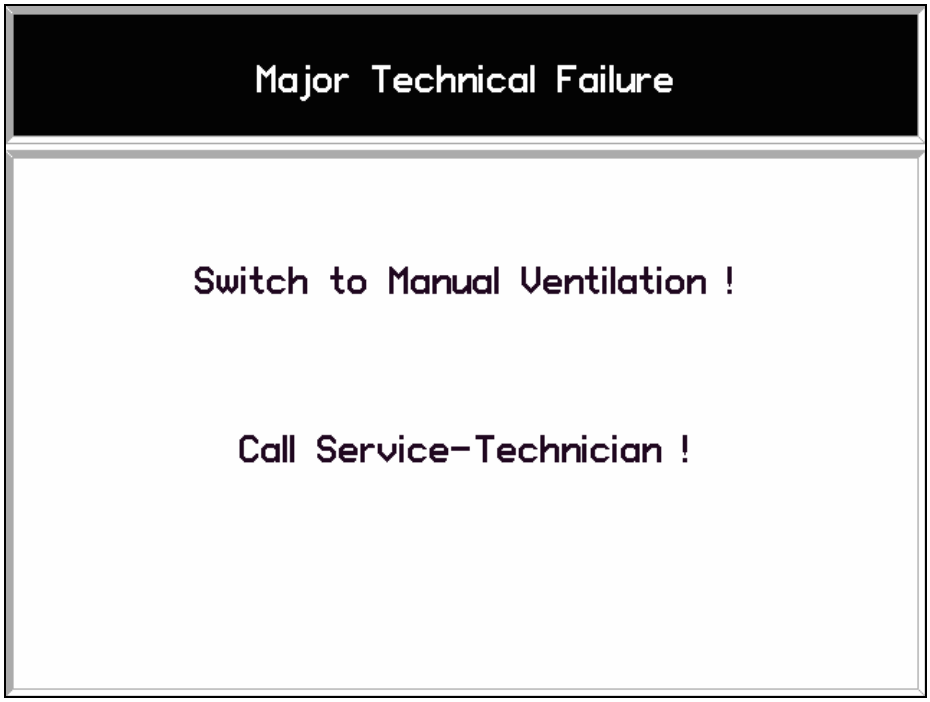


Fig. 17 “Major Technical Failure” alarm message

6 Start-Up and Functional Test

6.1 Preparation of apparatus

1. Install the apparatus in such as way that the touch screen operating panel at the front of the apparatus is within easy reach and the flow measuring tubes can be easily read.

2. Once the apparatus has been installed in the correct location activate the breaks on the front rollers to prevent accidental movement.

3. Connect the gas connection lines to the gas connection at the rear of the unit. Check that the pressure of the gas supply complies with the specifications of the apparatus. Connect the gas supply by plugging in the connectors in the gas supply sockets. Ensure that the connectors are not in the park position.

4. Plug the mains cable into a grounded socket. Switch on the power supply using the mains switch at the right side of the apparatus.

5. Wait until the ventilator display requests the compliance test. If the breathing circuit should not be connected to the apparatus remove the transportation cover, if necessary, and slide the breathing circuit into position. After sliding in the breathing circuit nearly up to the stop, you will need to turn the lever below the docking station clockwise to adapt the breathing circuit.

6. Next equip the breathing circuit with the bag-in-bottle system, consisting of a bellows and the bellows dome. Install the CO_2 absorber canister. Connect the set of hoses for the anesthesia gas scavenging to the outlet of the ventilation pressure valve (APL-valve). Connect the hose set of anesthesia gas scavenging to the gas scavenger installed in the operation theatre.

7. Connect the manual ventilation bag and the respective hose to the breathing circuit. Connect the set of patient hoses to the insp. and exp. connections.

6.2 Pre-Operation Tests

The tests and examinations described below must be carried out before each system start. They are also specified on the check list kept at the apparatus.

1. Install and lock the vaporizers to be used on the device.

2. Start the compliance test of the device. Follow the instructions on the ventilator display.

3. Carry out the leak test. The O2 calibration should by carried at least every 30 running hours Respective instructions are shown on the ventilator display.

4. Ensure that a suitable independent device for manual ventilation (i.e. ambulatory bag) is available at or near the apparatus.

5. If required start the additional monitoring for CO_2 and anesthesia gases (Not necessary with the optional integrated gas module) and if available ECG and check function according to the respective operating instructions. The gas return line from monitors operating according to the side stream procedure should be connected to the connection at the rear side labeled as "Sample gas recirculation".

6. Ensure via a manual test that the APL valve does not allow a pressure greater than 100 cmH_2O

6.3 Sample Tube Connection (optional integrated Gas Module)

WARNING
The gas measurement tube system at the monitor must be connected before putting the apparatus into use or changing the flow rate. Otherwise the apparatus might falsely detect a tube blockage.

WARNING
Use only the original tube system as measuring tube. If a different tube system is used, faulty measurements can occur due to condense water and anesthesia gases. Condensed water can also damage the internal sensors.

WARNING
Ensure the sample tube is going direct upward from the y-piece to avoid condense water going into the system.

6.4 System Start

After switching on the apparatus the message “Please wait...” appears for approx. 20 seconds while the software is loading. During the booting process the apparatus shows two displays for the system start and the automatic apparatus test. The system then asks the operator to carry out the sensor test

Fig. 18 First display message during system start

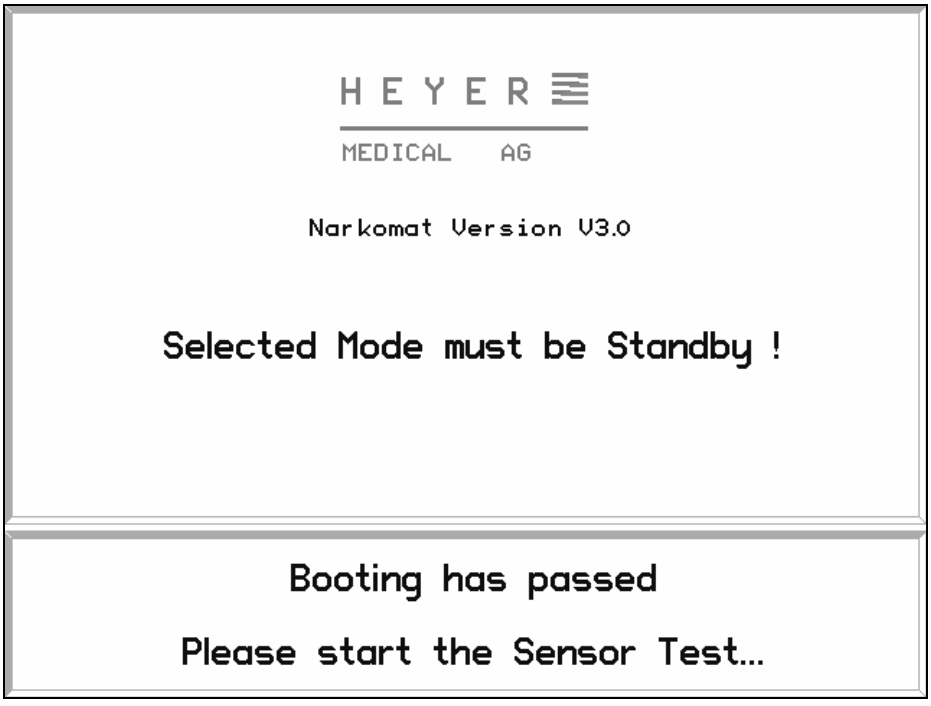


Fig. 19 Second display message during system start

6.5 Battery Control

After the apparatus has been switched on, the charging status of the battery will be checked. Depending on the charging status of the battery, the apparatus may start charging the battery which can take up to 7 hours.

6.6 Sensor Test

After the automatic system start has been completed, the following display for implementing the sensor test appears.

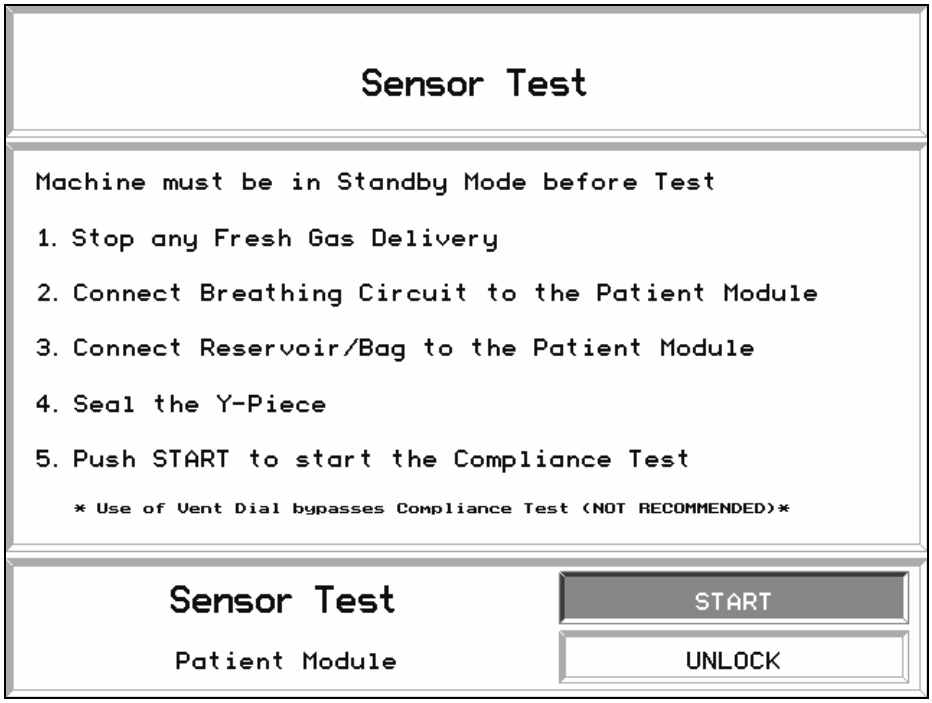


Fig. 20 Display before sensor test

In the case of an emergency, the sensor test can be bypassed via turning the selector switch. Otherwise follow the instructions of the ventilator display and activate by pressing the “START” button.

The system now checks and calibrates all sensors, i.e. the expiratory flow sensor and the pressure sensors. Also the internal sensors of the ventilator drive and the active components such as pneumatics control valves are checked during the compliance test.

The breathing circuit, patient connection hoses, the Y-piece etc. are also tested for leaks. Furthermore the system compliance to which in particular also the patient hoses contribute is detected during the compliance test.

Compliance test (continued)

During the compliance test a display message confirms that the test is running.

After the successful sensor test the text message "Sensor Test ok" with information about leakage rate and system compliance appears.

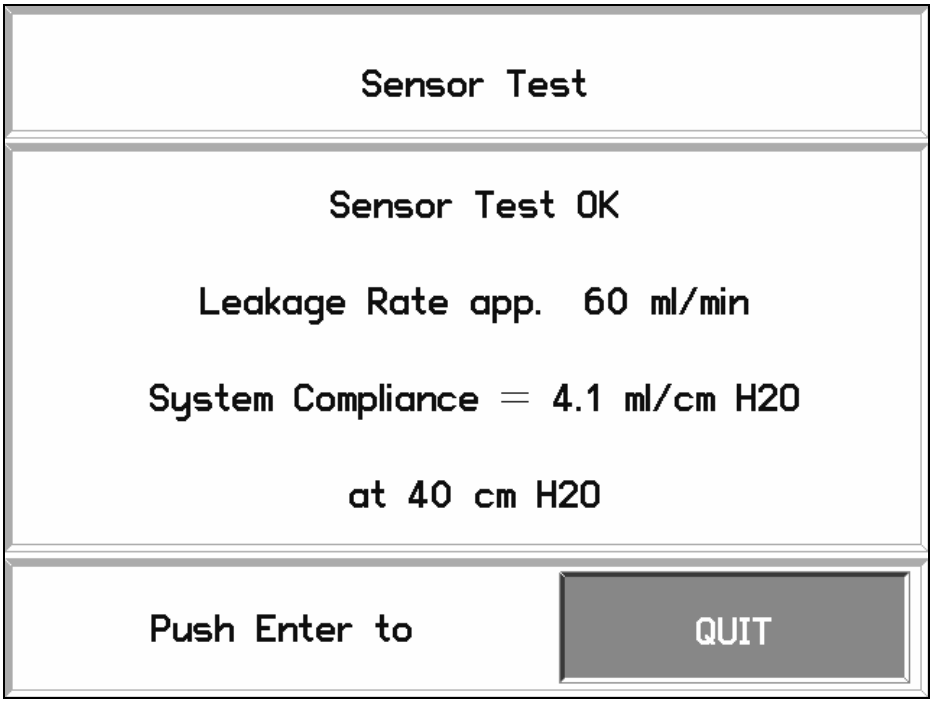


Fig. 21 Display after the sensor test

After the successful completion of the sensor test, a similar test, the compliance test can be carried out in the standby mode. Apart from detecting the system compliance this compliance test also checks for leaks in the patient module, patient connecting hoses, Y-piece, etc. The compliance test should be carried out, if the patient tubes were exchanged against others, with a relevant difference in the tube compliance.

6.6.1 Compliance Test

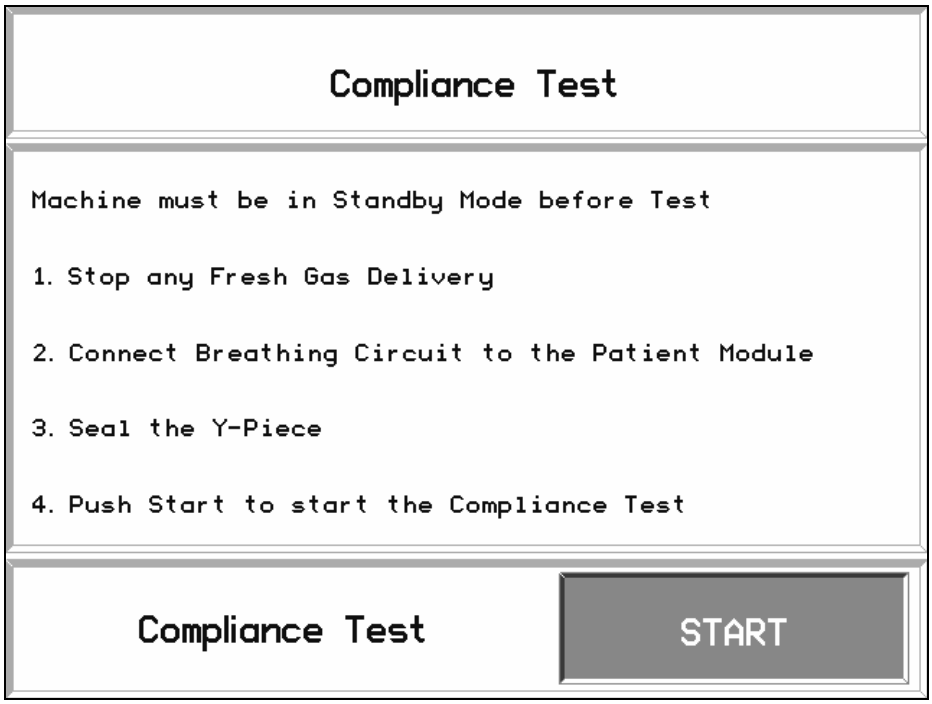


Fig. 22 Display prior to the compliance test

Follow the instructions of the ventilator display and activate by pressing the “START” button.

Compliance test (continued)

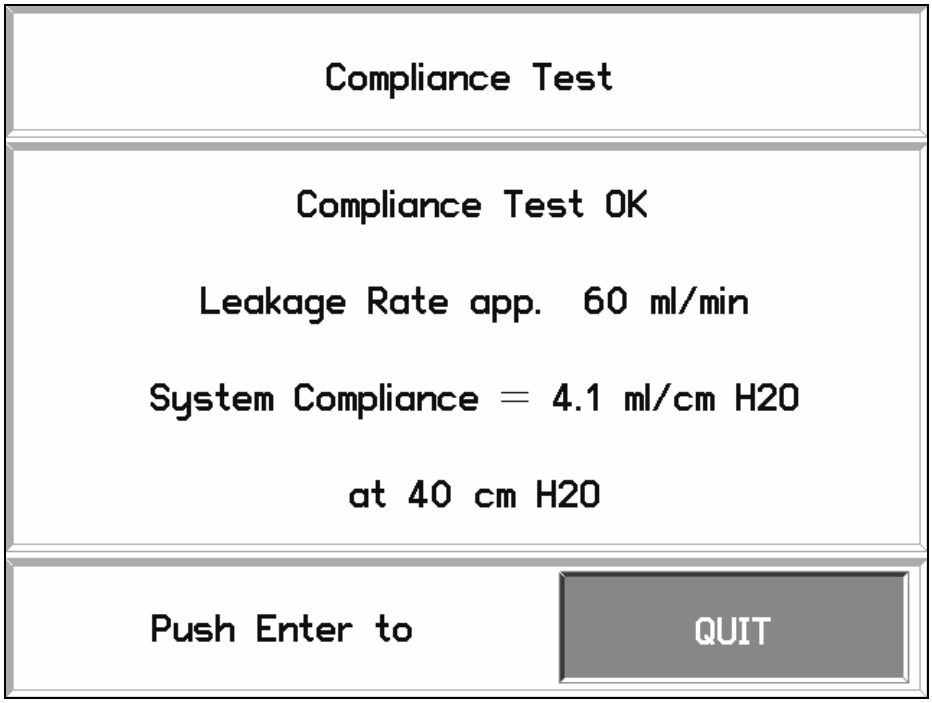


Fig. 23 Display after the compliance test as extended information

As extended information to the test result of a compliance test, the leakage of the patient module at 40 cmH_2O and the detected system compliance is displayed.

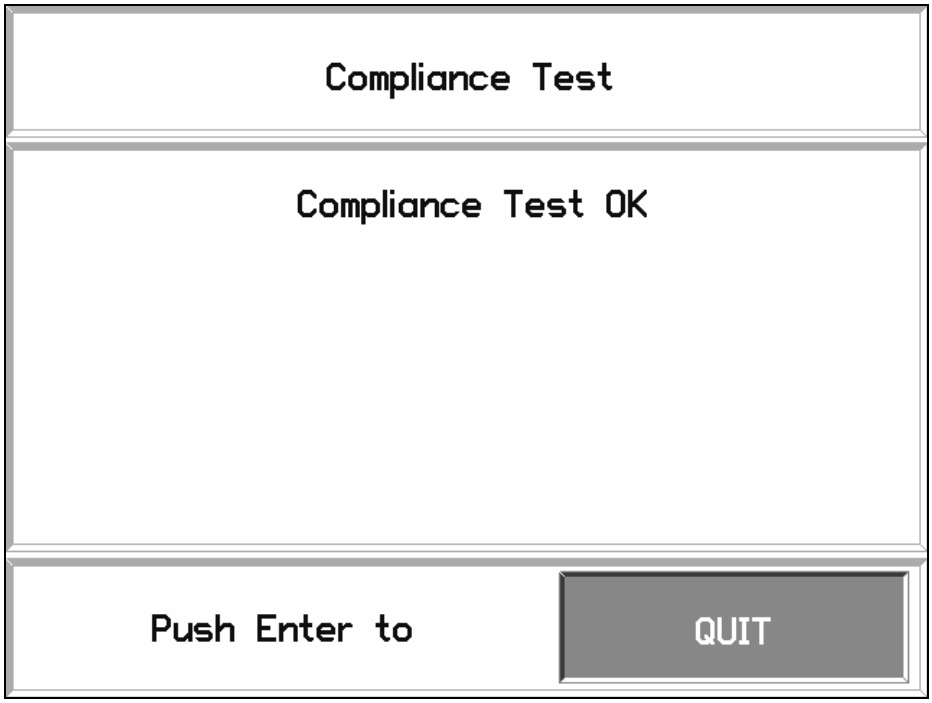


Fig. 24 Display after the compliance test as pass/fail information

Compliance test (continued)

The menu window allows the operator to select whether the result should be displayed as a brief pass/fail message or if extended information should be displayed.

By activating the “menu” key, the menu window is opened. Under the sub-menu “System test options” and “Sensor test options” “Pass/Fail Info” or “Extended Info” can be selected.

6.7 System Test

Once the successful sensor test is confirmed with the “Quit” display key, the system test selection screen is displayed.

Fig. 25 System test selection display

Only in emergencies, where the system is required immediately, should the system test be skipped. The system test involves a calibration of the oxygen sensor and a fresh-gas system leak test and should be carried out during a correct system start.

* Only valid with option gas module

System test (continued)*

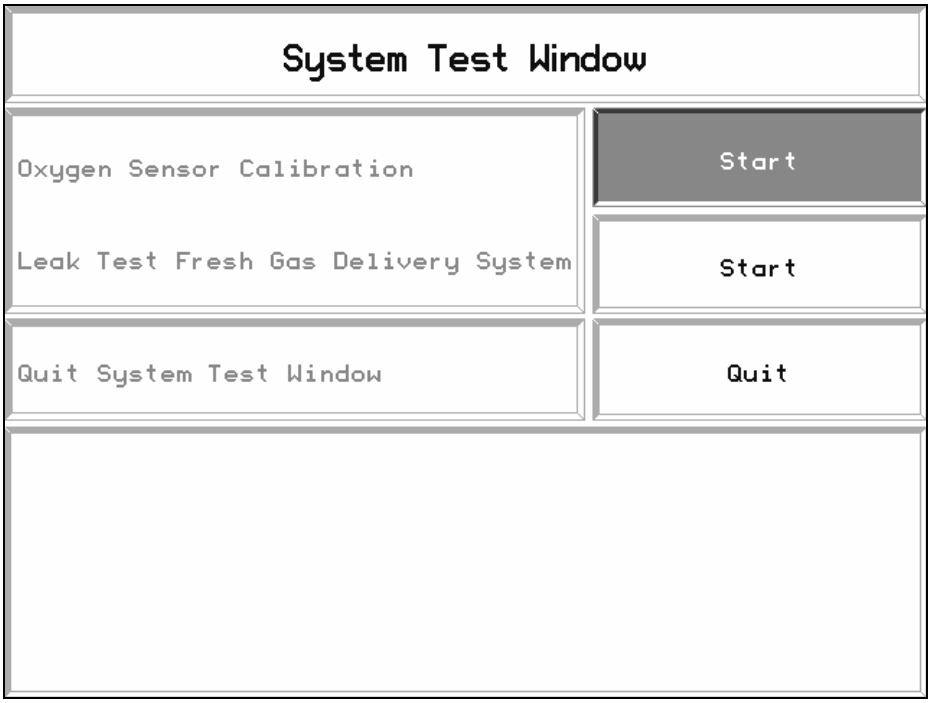


Fig. 26 Display of system test selection sub-menu

Both tests should be carried out during the start of the system; select the respective system test sub-menu by turning the encoder button. Confirm the selection by pressing the encoder on the “Run” display key.

* The oxygen calibration is not valid with the apparatus option with integrated gas module

6.7.1 O2 sensor calibration*

When starting the O_2 sensor calibration the following display appears.

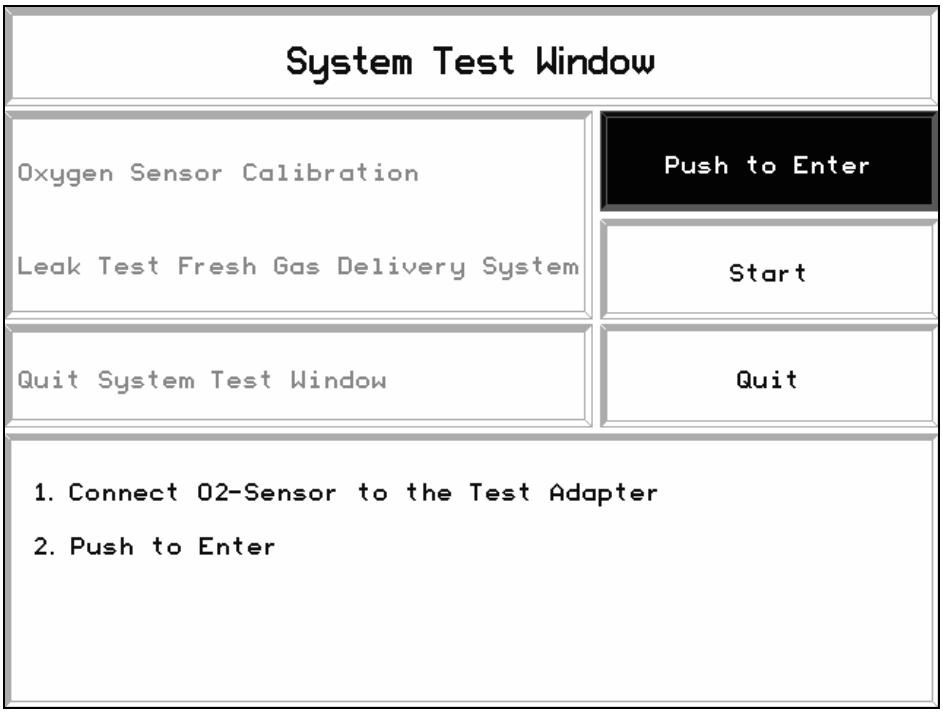


Fig. 27 First display message of O_2 sensor calibration

Pull the O_2 sensor out of the inspiration valve cap. For calibration, place the sensor into the calibration adapter in ambient air left near the port of the O_2 sensor cable.

* The oxygen calibration is not valid with the apparatus option with integrated gas module

O_2 sensor calibration (continued)*

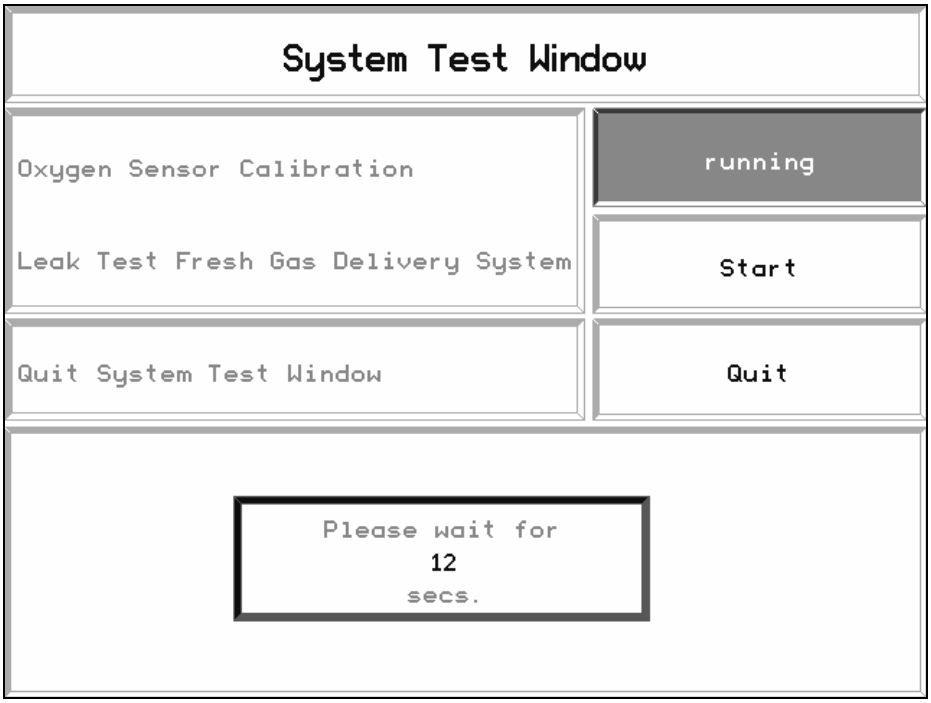


Fig. 28 Second display message of O_2 sensor calibration

In order to allow sufficient time for aerating the O_2 sensor in ambient air, a 15 second countdown is displayed in a calibration start window.

* The oxygen calibration is not valid with the apparatus option with integrated gas module

O_2 sensor calibration (continued)*

During the calibration of the O_2 sensors a window providing information about the progress of the calibration process appears.

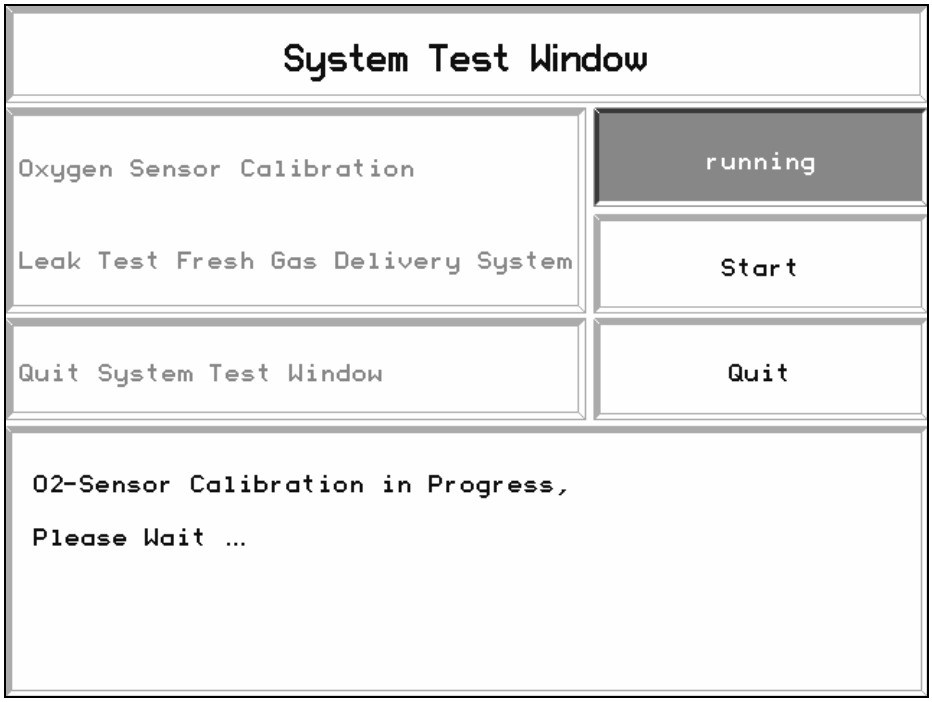


Fig. 29 Third display message of O_2 sensor calibration

* The oxygen calibration is not valid with the apparatus option with integrated gas module

O_2 sensor calibration (continued)*

The result of the O_2 sensor calibration is then displayed as follows:

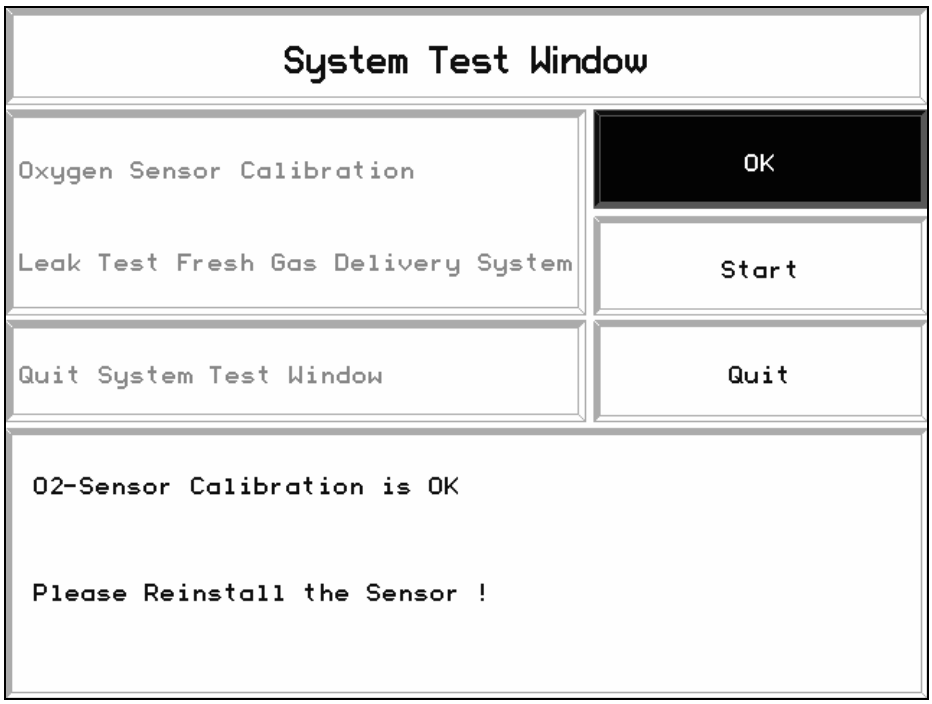


Fig. 30 Fourth display message of O_2 sensor calibration

Remove the O_2 sensor from the calibration adapter and reinsert it in the inspiration valve cap. This completes the calibration of the O_2 sensor.

* The oxygen calibration is not valid with the apparatus option with integrated gas module

6.7.2 Leak Test Fresh Gas Delivery System

To carry out a leak test for the entire fresh gas system, select menu item “Leak Test Fresh Gas Delivery System” on the display by turning and pressing the encoder button.

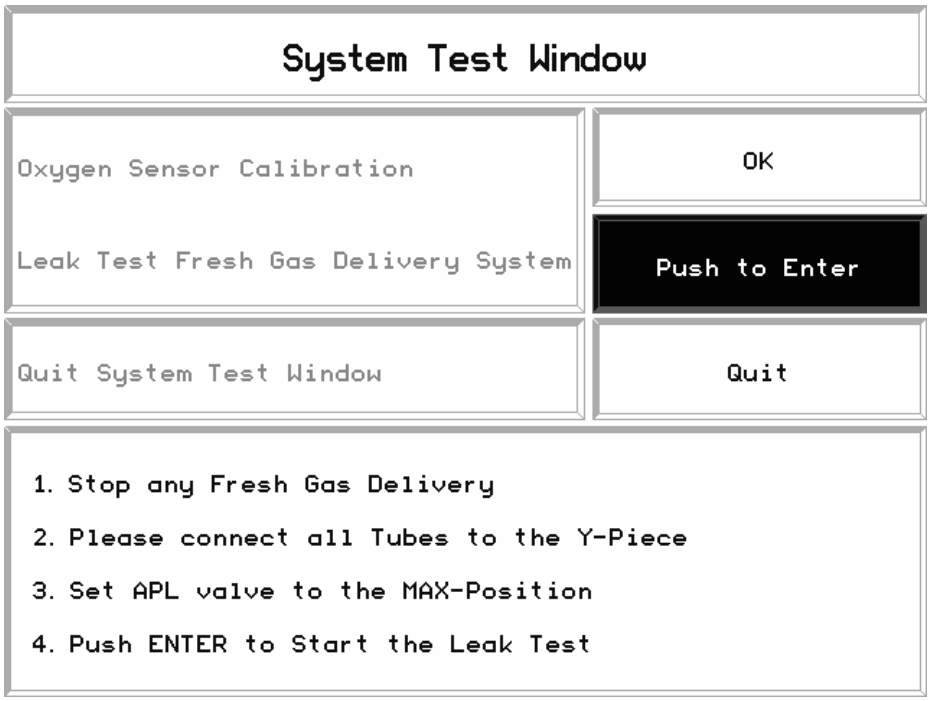


Fig. 31 Display prior to the fresh gas system leak test

Follow the instructions on the ventilator display. Connect the patient hoses and the hose of the reservoir/manual ventilation bag to the Y piece. Set the ventilation pressure valve (APL) to max. and start the leak test by activating the display key “Push to enter” by pushing the encoder button.

Apart from the patient module, patient connection hoses, the Y piece, etc., the leak test of the fresh gas system checks also the flow meter tube block, the vaporizer mount and the vaporizers if activated , absorber canister, manual ventilation hose and ventilation pressure valve (APL) for any leaks.

Leak Test Fresh Gas Delivery System (continued)

During the fresh gas system leak test, a message confirming that the test is carried out, is displayed. After a successful fresh gas system leak test, the following window is displayed.

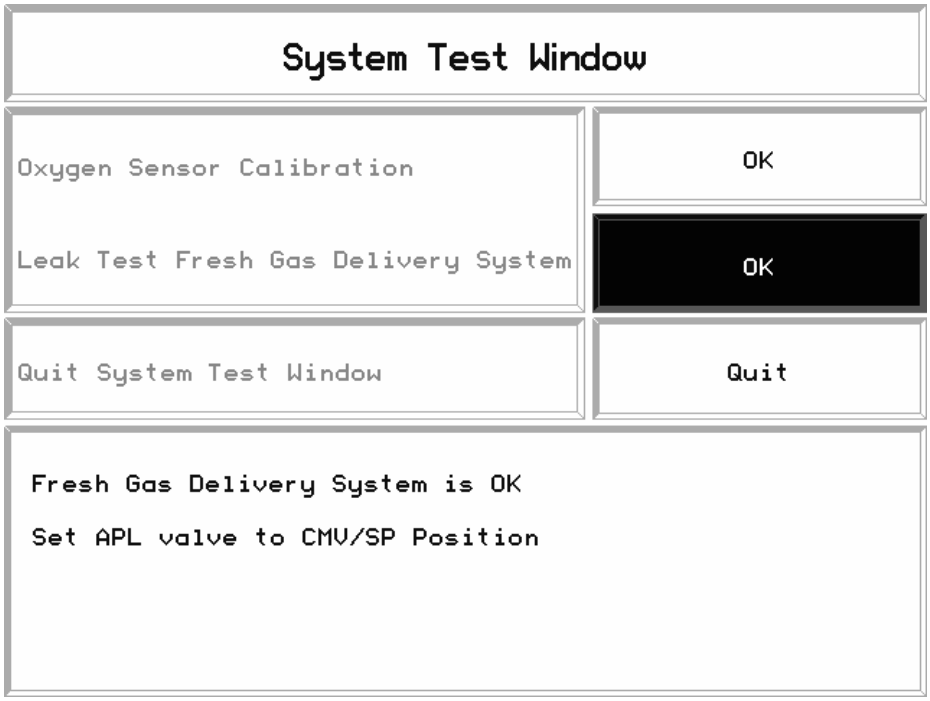


Fig. 32 Display after the Leak Test Fresh Gas Delivery System

Return the hoses of the patient module to their normal condition and reconnect the reservoir/manual ventilation bag to its hose. Return the ventilation pressure valve to the CMV/SP position. The fresh gas system leak test has now been completed.

Leave the system test window by selecting the display key “Quit” by pressing the encoder button.

The ventilator is now operational after the completion of the sensor and system test and observation of the checklist test points. The Standby window of the normal operating mode is displayed.

In the following section 7 “Operation in the individual functions” this window is described under section 7.1 “Standby mode”.

6.8 Gas module verification*

The verification mode can be called up by pressing the button “options” on the display. For Verification, the selection switch must be in the “standby” position.
Following display will appear:

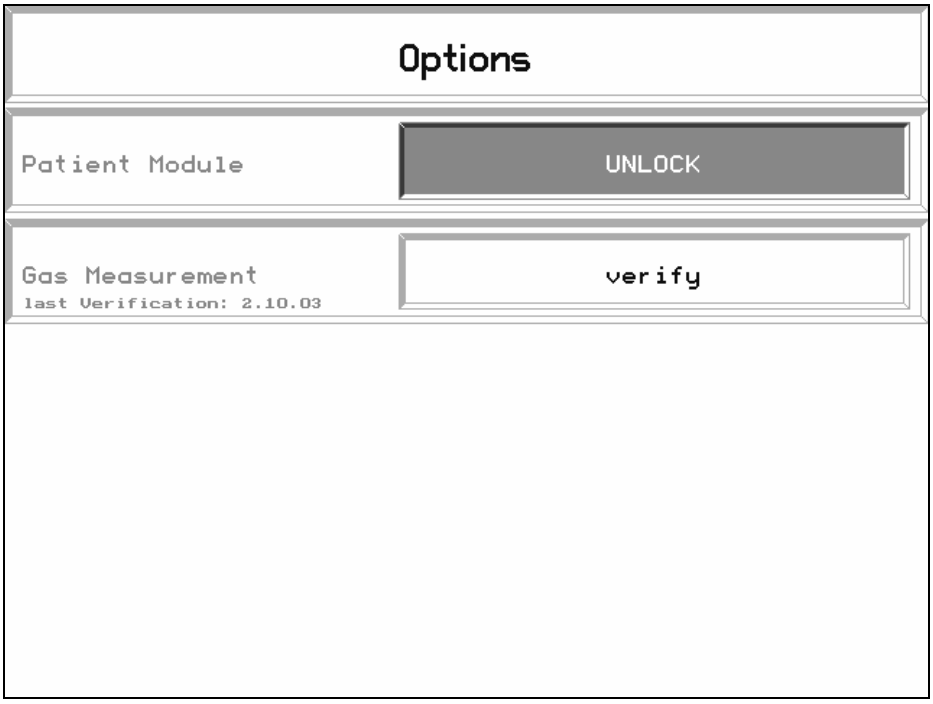


Fig. 33 Display of the gas module verification

A calibration of the gas module is not necessary because it is maintenance free. Should a value of the gas measurement be outside of the tolerance, call an authorized service technician.

*only for apparatus option with integrated gas module

Gas module verification (continued)*

The verification procedure is described step by step on the screen.

WARNING:
Use only the recommended verification gas and pressure regulator. If using a different pressure regulator, reinsure that the sample gas flow rate is about 300 ml/min. A to high or to low flow rate can lead to faulty readings.

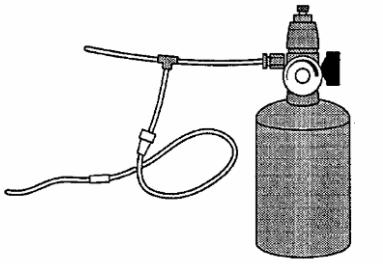


Fig. 34 Connection of the tube system to the verification gas bottle

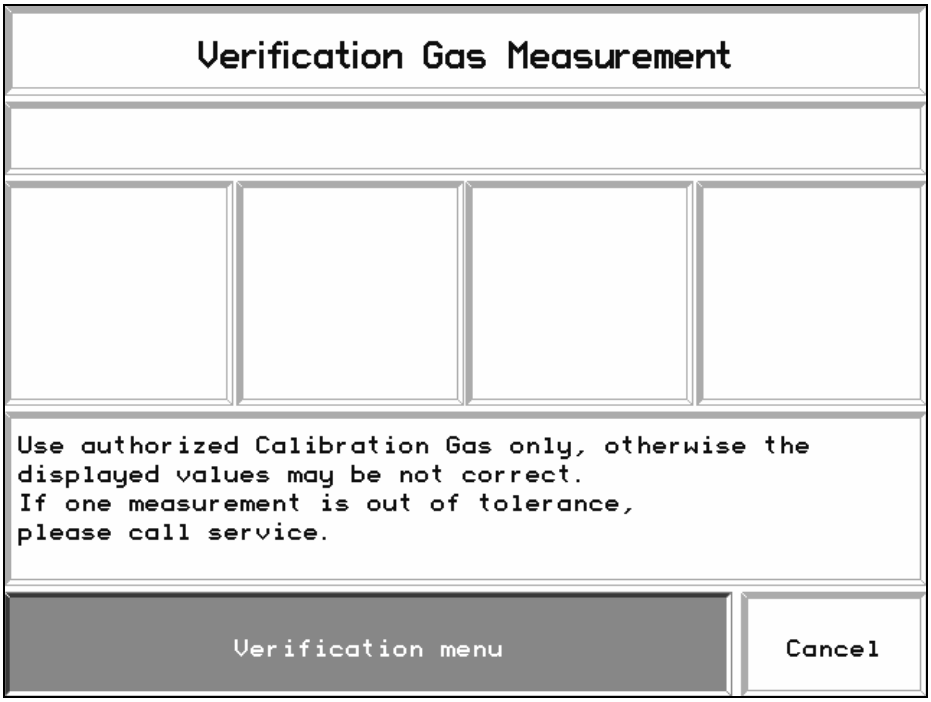


Fig. 35 Display No. 1 for gas measurement verification

*only for apparatus option with integrated gas module

Gas module verification (continued)*

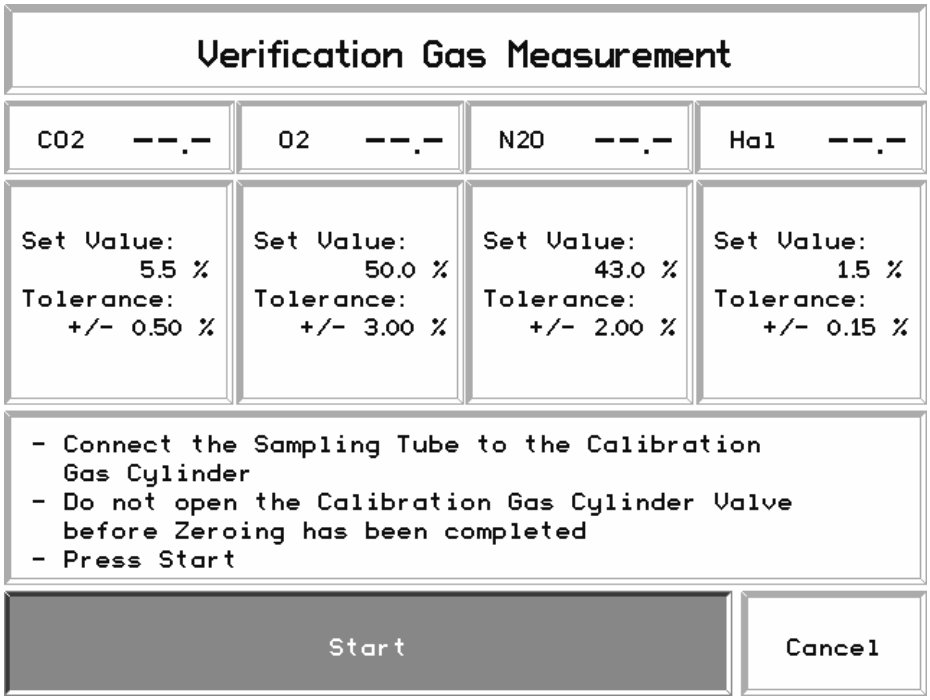


Fig. 36 Display No. 2 for gas measurement verification

1. Connect the gas measurement tube to the verification gas bottle
2. Open the Valve of the verification gas bottle
3. Confirm “start” through turning and pressing the encoder button.

*only for apparatus option with integrated gas module

Gas module verification (continued)*

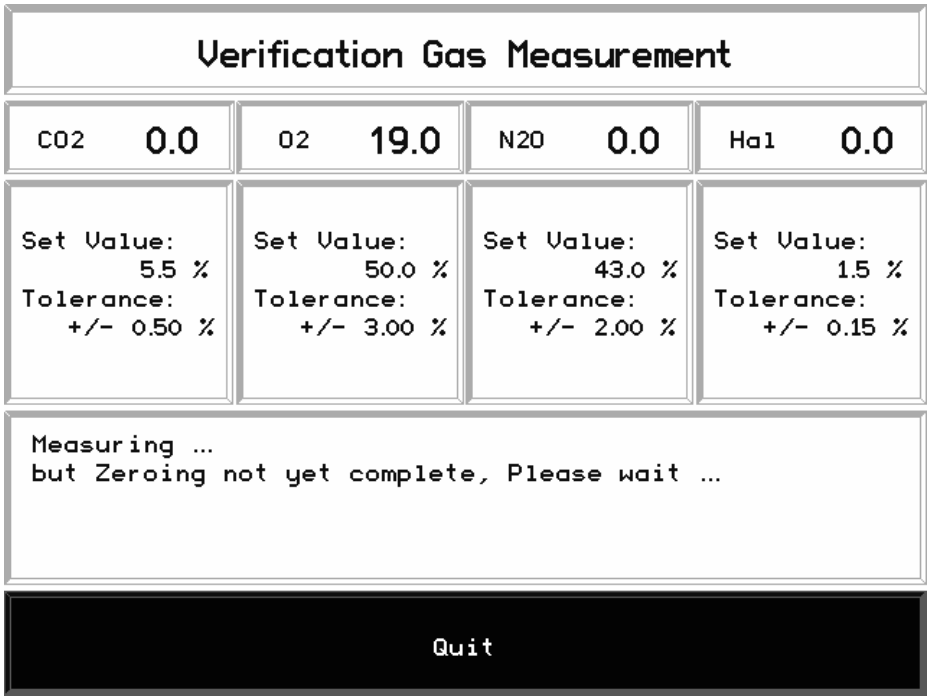


Fig. 37 Display No. 3 for gas measurement verification

To ensure the correct display of the values, a zeroing of the gas module is performed first. The maximum time for a zeroing is 1 min. Do not press the „Quit“ button during this time.

*only for apparatus option with integrated gas module

Gas module verification (continued)*

After the zeroing is completed, open the gas cylinder valve.

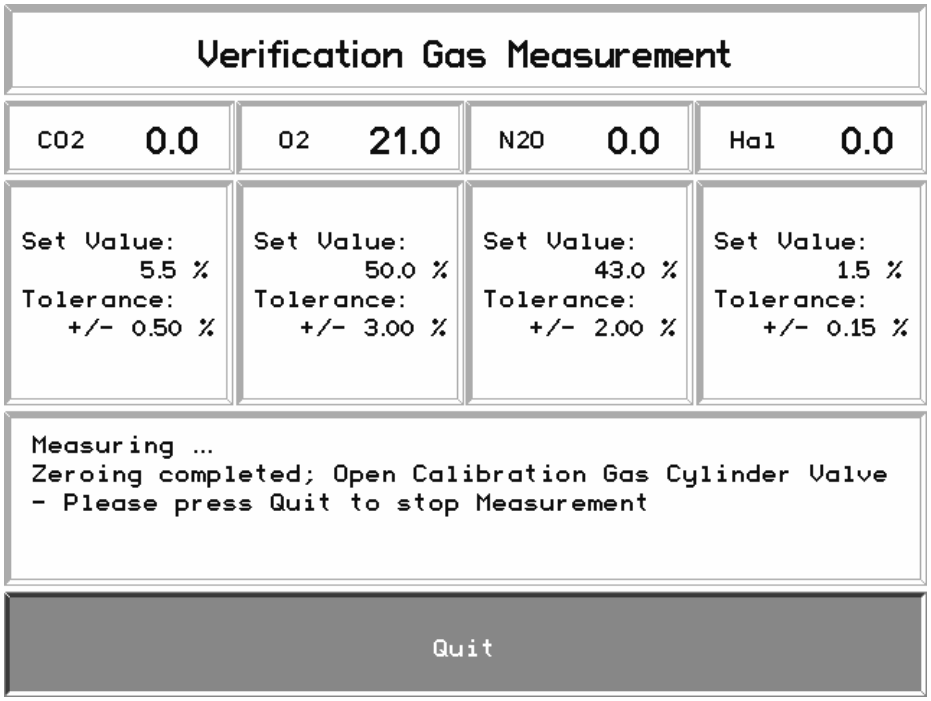


Fig. 38 Display No. 4 for gas measurement verification

*only for apparatus option with integrated gas module

Gas module verification (continued)*

If continues values are being displayed, activate the button quit and close the valve of the verification gas bottle.

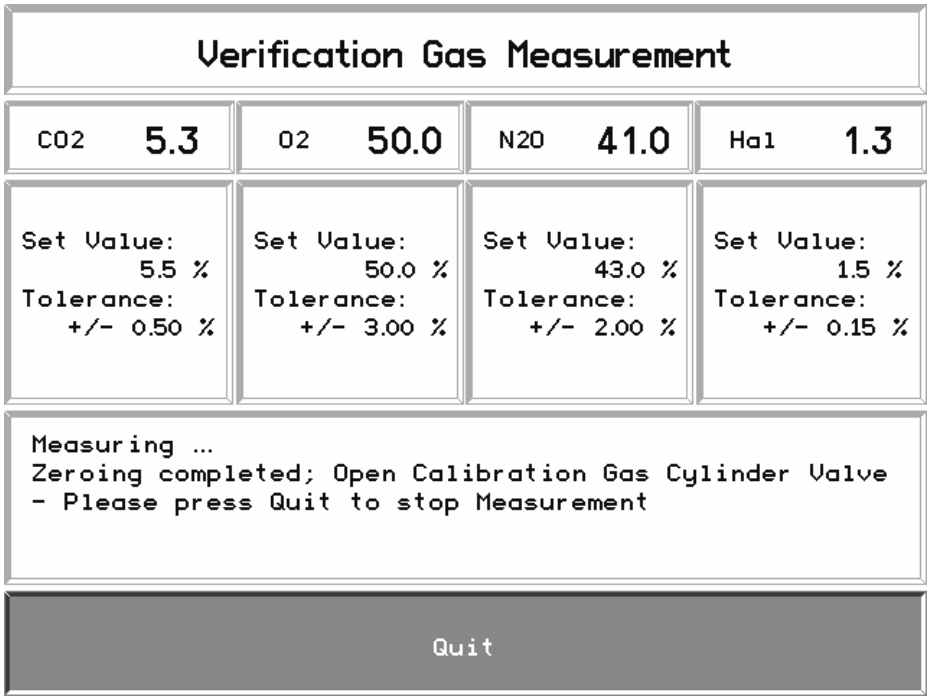


Fig. 39 Display No. 5 for gas measurement verification

*only for apparatus option with integrated gas module

Gas module verification (continued)*

Compare the display results with the values printed on the verification bottle.

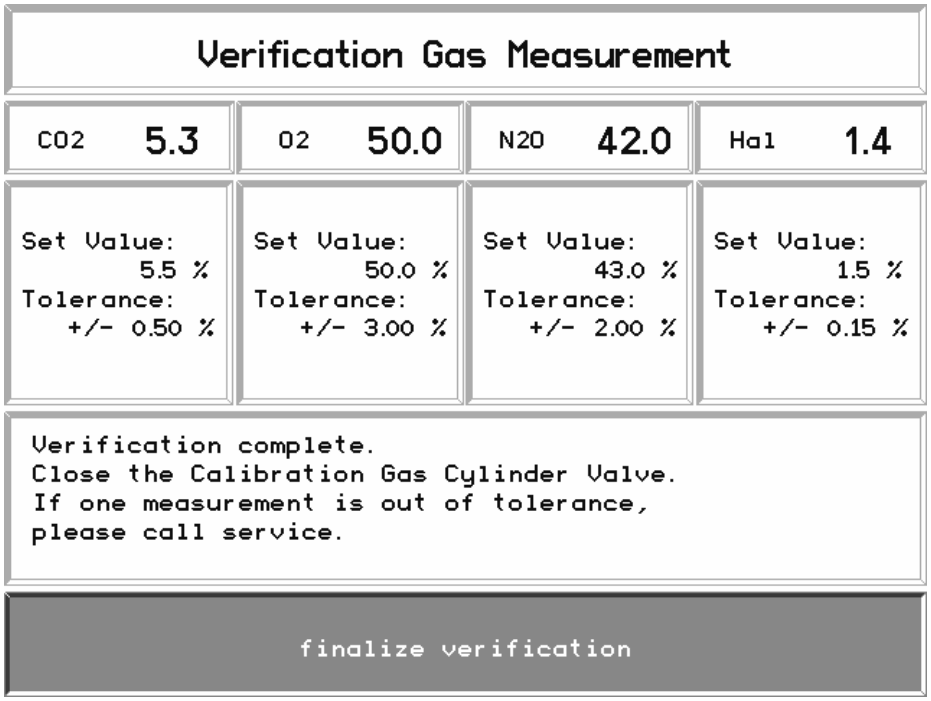


Fig. 40 Display No. 6 for gas measurement verification

Activate the button “finalize verification“ to return to the options menu.

*only for apparatus option with integrated gas module

7 Operation in the Individual Functions

The preparation and operation of the system up to the standby mode is described in section 6 “Start-up and functional test” and its sub-sections. The following sections describe how to operate the system for the various ventilation modes in the standby mode and the operating modes.

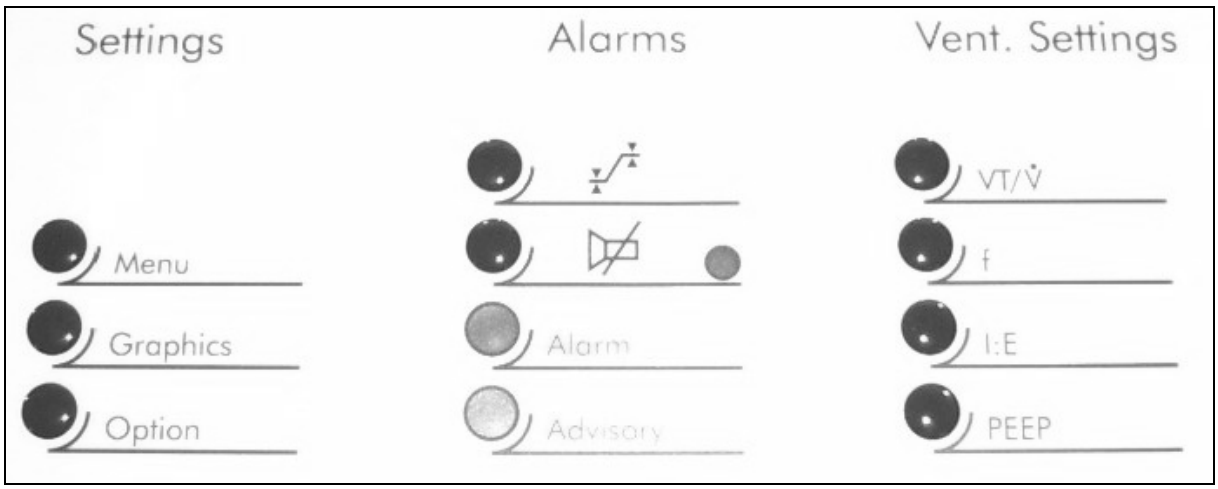


Fig. 41 Control panel

7.1 Standby mode

This is the normal operating mode prior to switching on a ventilation mode or in between ventilation operations. The system returns to this mode after the sensor test and the fresh gas system leak test have been carried out. The display shows the following window:

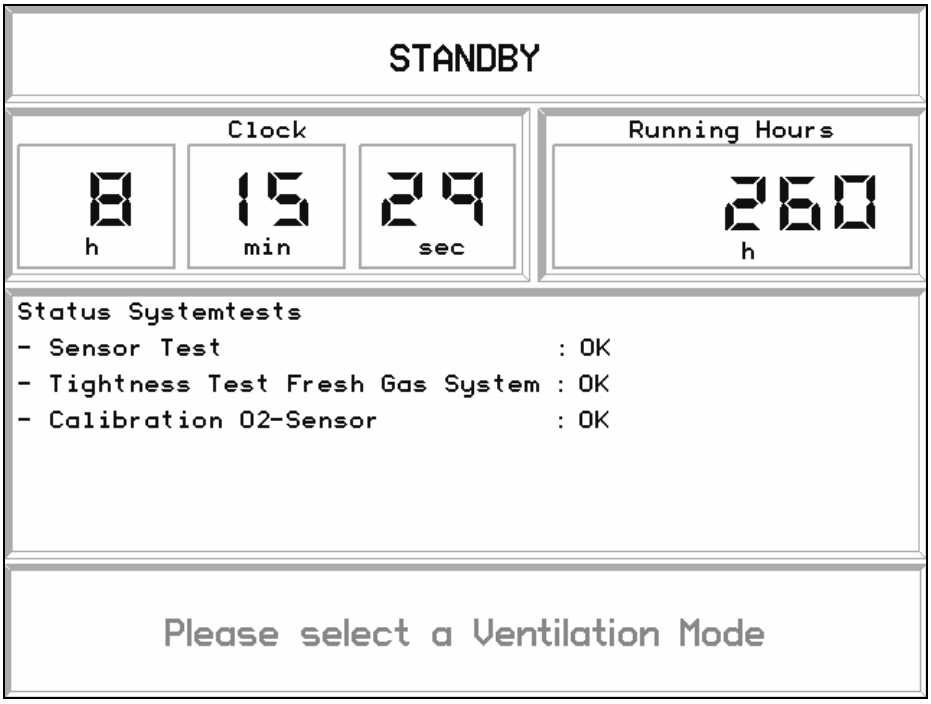


Fig. 42 Standby mode display

The ventilator display shows the current time, the total number of system operating hours and the status of the system tests.

7.1.1 Standby mode menu window

The standby mode menu window is opened by pressing the "Menu" key on the control panel. The screen displays the following:

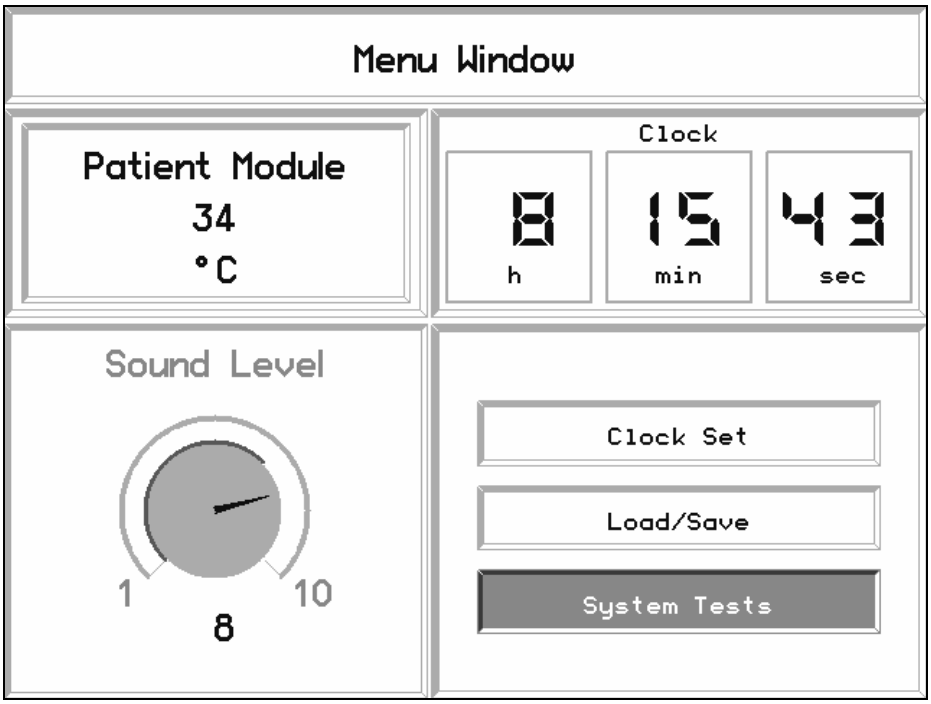


Fig. 43 Standby mode menu window

The menu window shows the measured temperature of the heated patient module.

The system time is shown in hours, minutes and seconds.

Using the “Sound level” display regulator the volume of the acoustic alarms can be preset from 1 to 10. This setting will remain stored until the next system start. In the Manual/spontaneous mode the alarm acoustic is automatically set to “0”. When leaving the Manual/spontaneous mode, the alarm acoustic is automatically set to the previous set value.

The display keys "Clock Set", "Load/save" and "System Test Options" open further sub-menus determining further basic settings.

Standby mode menu window (continued)

By activating the display key "Clock Set", the window "Set time" is opened.

Fig. 44 "Set time" within the menu window

The options of this window can be selected by turning the encoder button and can be activated for setting different values by pressing the encoder button.

Turning the encoder anti-clockwise reduces, turning it clockwise increases the value.

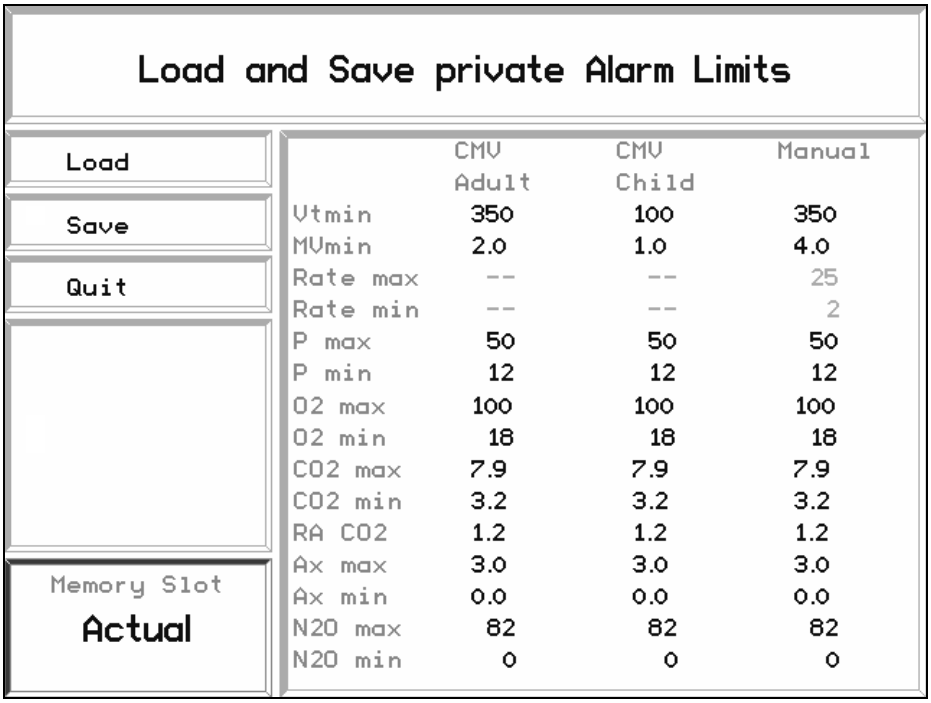
To quit the respective option, press the encoder button again.

The new date or time settings are confirmed with “OK” and will then be stored in the system.

To quit the "Set date and time" window, the display key "Cancel" is pressed.

Standby mode menu window (continued)

By activating the "Load/save" display key, the window "Load and Save private Alarm Limits" is opened.
Here you can save the save the alarm limits which were set in the ventilation mode, or recall alarm limits which were previously saved.



	CMV Adult	CMV Child	Manual
Vtmin	350	100	350
MVmin	2.0	1.0	4.0
Rate max	--	--	25
Rate min	--	--	2
P max	50	50	50
P min	12	12	12
O2 max	100	100	100
O2 min	18	18	18
CO2 max	7.9	7.9	7.9
CO2 min	3.2	3.2	3.2
RA CO2	1.2	1.2	1.2
Ax max	3.0	3.0	3.0
Ax min	0.0	0.0	0.0
N2O max	82	82	82
N2O min	0	0	0

Fig. 45 "Load/save personal alarm limits" within the menu window

Using following scheme, you can load or save your personal alarm limits:

1. Choose one of the four available memory slots through turning and pressing the encoder button in the panel “Memory Slot”. The saved alarm limits will be shown in the menu.

2. If you wish to save the currently set alarm limits, confirm it through turning and pressing the encoder button in the panel “Memory Slot”. Please notice that you will overwrite settings which have saved in this slot previously

3. If you want to use previously saved alarm settings, confirm this slots through turning and pressing the encoder button in the panel “Load”.

4. You can leave the menu "Load and Save private Alarm Limits” slots through turning and pressing the encoder button in the panel “Quit”.

Note: Due to safety reasons, the system will activate the **default settings** after every new start

Standby mode menu window (continued)

By confirming the “System test options" key, a window bearing the same name is opened.

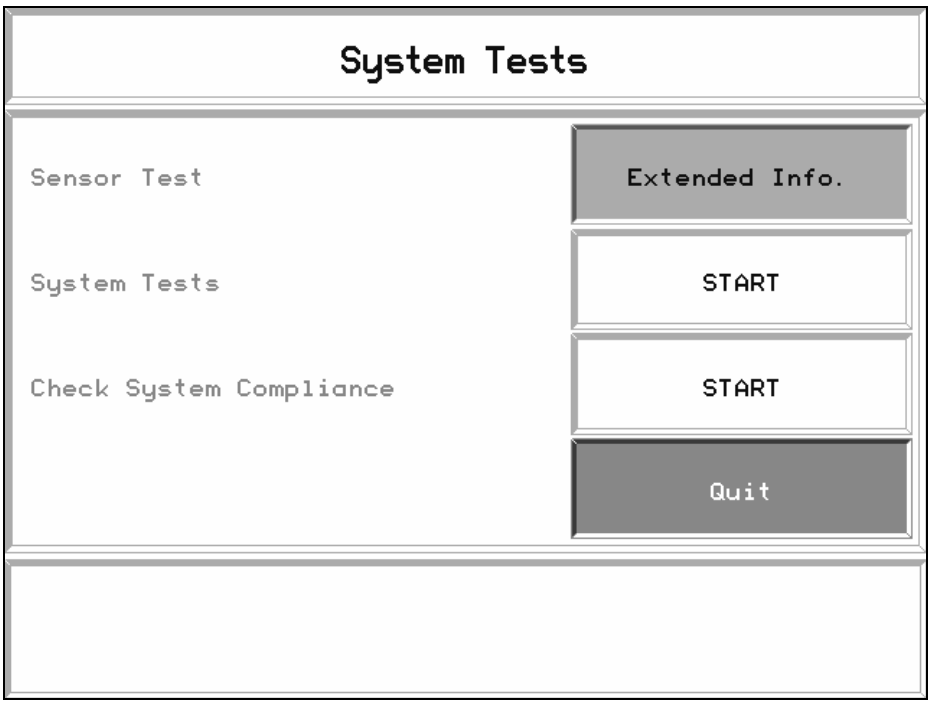


Fig. 46 "System test options“ within the menu window

Through selecting and confirming with the encoder button:

1. you can switch the “sensor test” between the options “Extended Info” and “short Info”.
2. the window “System Tests” can be called up.
3. the “System Compliance” can be checked. This test, which determines the system compliance, should be done when e.g. the ventilation tubes are changed between two patients and their compliance have a significant difference.

This window can be closed and the settings saved through the button “Quit”.

7.1.2 Standby mode graphics window

The standby mode graphic window is opened by pressing the "Graphics" key on the operating panel. The following window is displayed.

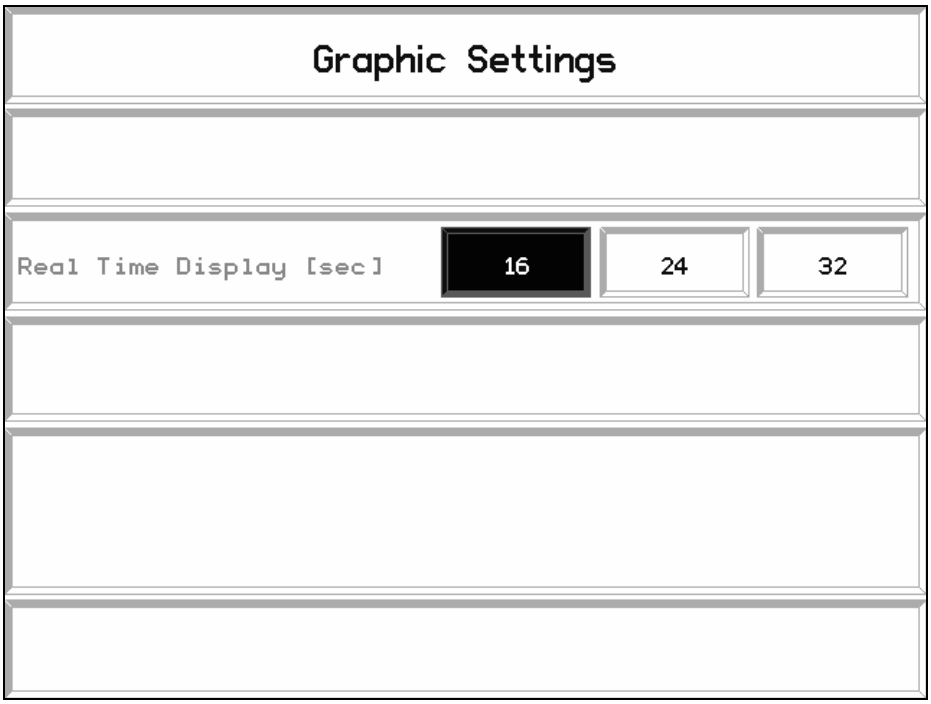


Fig. 47 Standby mode graphic settings window

The graphic window allows the setting of the time axis for the display of the ventilation pressure and expiratory flow or CO2 capnogram real-time curves.

16, 24 or 32 seconds can be set as values. 16 seconds is the default setting.

The desired time axis representation for the real time curves can be chosen by selecting the respective screen key.

By pressing the "Graphics" key for the second time, the window is closed again and the selected setting is stored.

7.1.3 Standby mode options window

The "Options" window in the standby mode is opened by pressing the “Options” key on the operating panel. The following window is displayed:

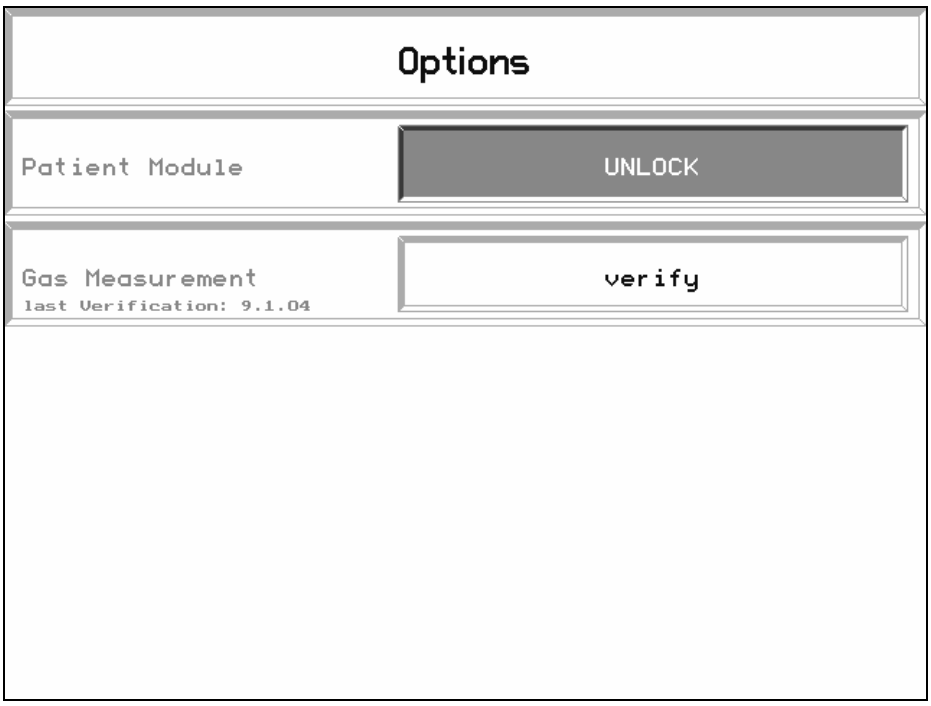


Fig. 48 Stand-by mode options display

The patient module can be unlocked by pressing the "unlock" screen key and is then unlocked from the apparatus by the integral motor drive.
If the patient module has been removed, the display key shows "unlocked".
The patient module is also reconnected by the motor drive. The motor starts automatically, once the patient section is sufficiently pushed into the apparatus. Upon pressing the "Options" key again, the window is closed.

In the field “Gas Measurement“ the date of the last verification is displayed. Activating the button “verify“ opens the menu fort the Gas verification.

7.1.4 Standby mode screen saver function

If the unit is switched to standby mode for longer than 10 minutes without any operation of a key or selection switch, the display is switched dark. The text line "Press ENTER for Standby screen" is displayed on different positions of the display. To deactivate this screen saver function just press or turn the encoder button.

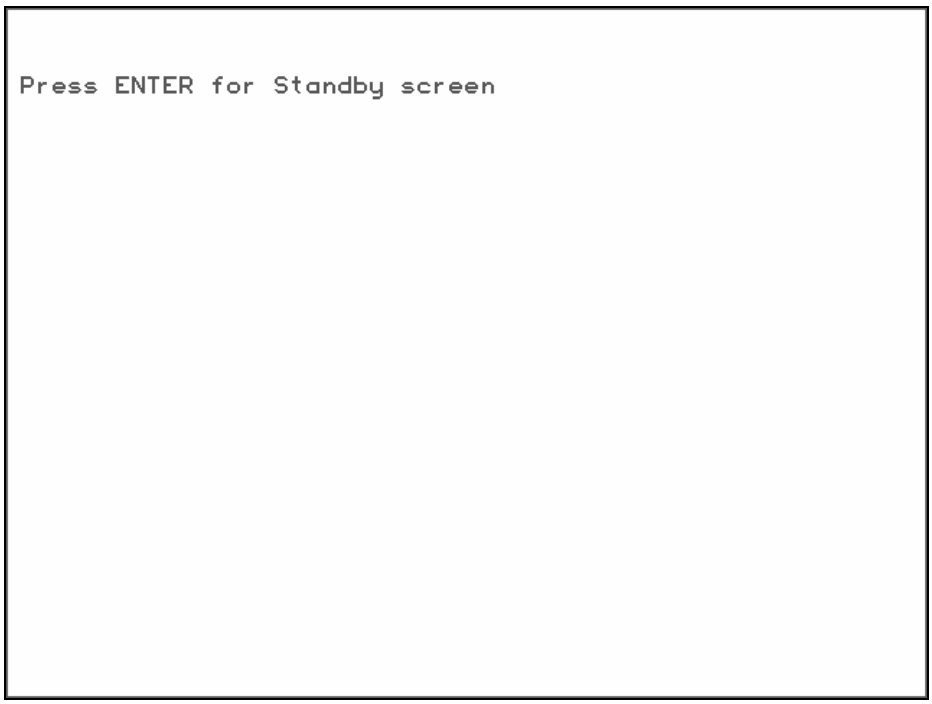


Fig. 49 Screen saver

7.2 Control Panel Keys in the Ventilation Modes CMV / (S)CMV / PCV * Adult / Child

Described is only the ventilation mode CMV-Adult. Differences in the ventilation CMV-Child will be explained specifically.

(The screen titles change according to the ventilation modes CMV / (S)CMV / PCV * Adult / Child)

7.2.1 Menu-Window in the Ventilation Modes CMV / (S)CMV / PCV * Adult / Child

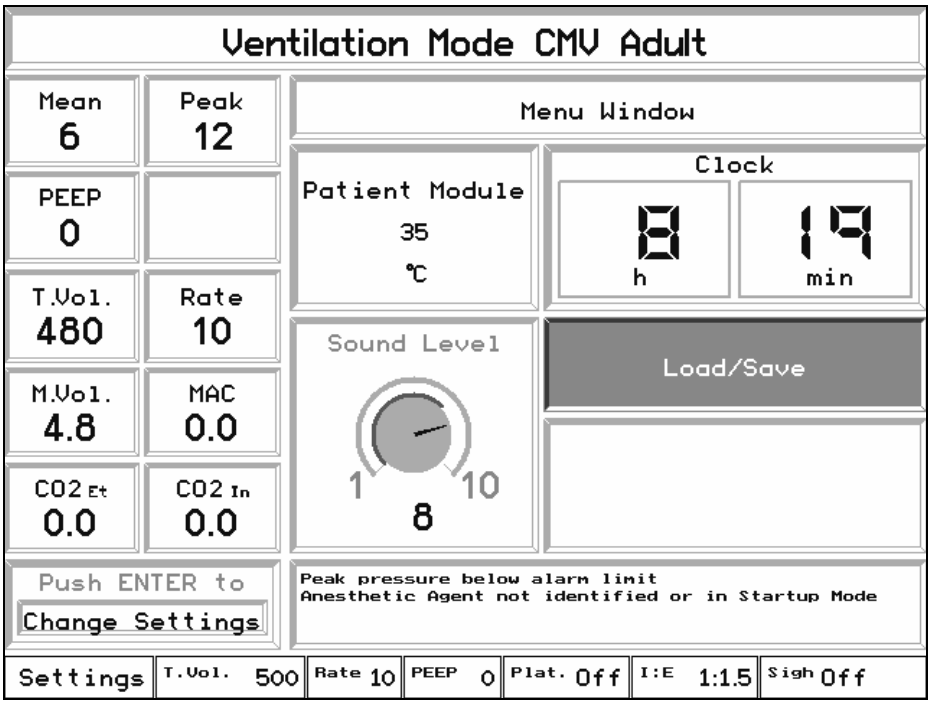


Fig. 50 Menu-Window in the ventilation mode CMV-Adult

The menu window shows the measured temperature of the heated patient module.

The system time is shown in hours, minutes and seconds.

Using the “Sound level” display regulator the volume of the acoustic alarms can be preset from 1 to 10. This setting will remain stored until the next system start.

The display keys "Clock Set", "Load/save" and "System Test Options" open further sub-menus determining further basic settings.

* The ventilation modes (S)CMV / PCV are optional.

7.2.2 Graphic Window in the Ventilation Modes CMV / (S)CMV / PCV * Adult / Child

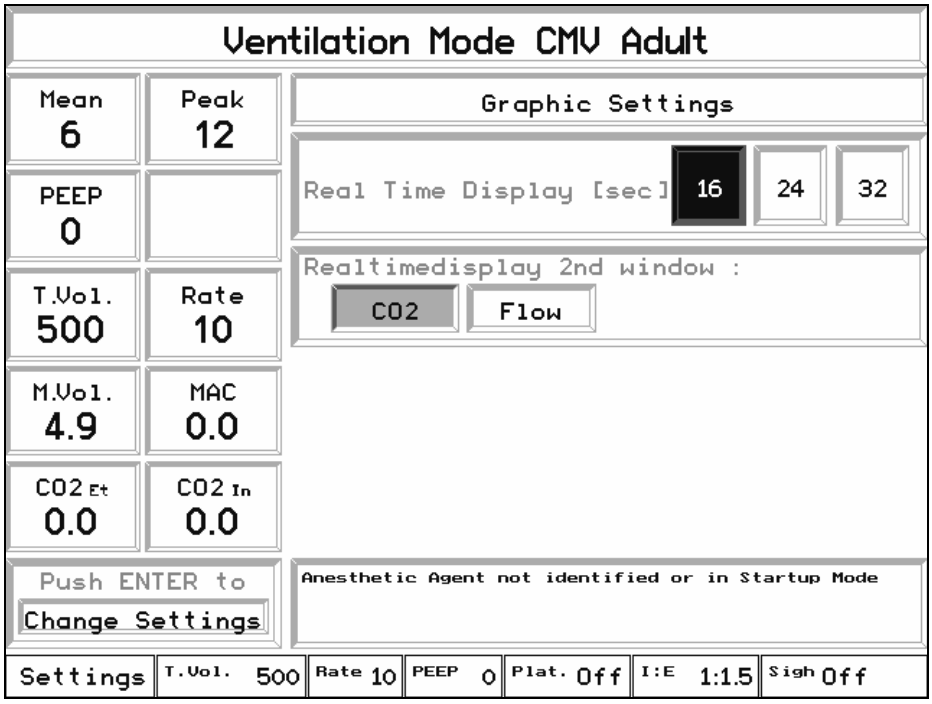


Fig. 51 Graphic-Window in the ventilation mode CMV-Adult

The graphic window allows the setting of the time axis for the display of the ventilation pressure and expiratory flow or CO2 capnogram real-time curves.

16, 24 or 32 seconds can be set as values. 16 seconds is the default setting.

Expiratory flow or CO2 capnogram real-time curves can be chosen for the lower graphic

By pressing the "Graphics" key for the second time, the window is closed again and the selected setting is stored.

* The ventilation modes (S)CMV / PCV are optional.

7.2.3 Options Window in the Ventilation Modes CMV / (S)CMV / PCV * Adult / Child

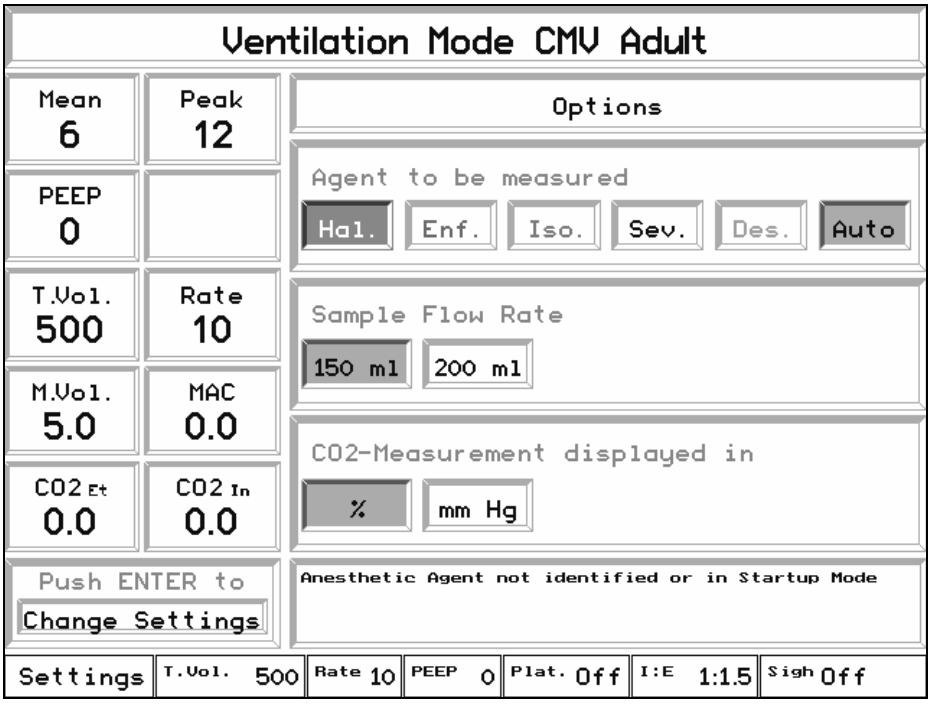


Fig. 52 Options-Window in the ventilation mode CMV-Adult

Through selecting and confirming the encoder button the used anesthesia gas can be defined and a sample flow can be set.

The display of the CO_2 unit can be changed to mmHg or %.

* The ventilation modes (S)CMV / PCV are optional.

7.2.4 Automatic Anesthetic Agent and Agent Mixture Identification *

The gas module incorporates automatic anesthetic agent and agent mixture identification. The data of the agent measurement is displayed as follows:

Anesthetic Agent Identification	Status of the measurement	Name of the Agent	Concentration	Color	Error Message
Automatic	Startup Mode **or insufficient accuracy ***	Auto	**--.-**	White	Anesthetic Agent not identified or in Startup Mode
Automatic	concentration of the anesthetic agent is too low for an auto identification ****	Auto	Concentration value	White	Anesthetic Agent not identified or in Startup Mode
Automatic	Agent identified	Hal./Enfl./Isofl./ Sev./Des.	Concentration value	Color coded	
Automatic	The concentration of an 2nd agent has become so high that the concentration of the 1st agent cannot be measured accurately		Concentration value of the 1st anesthetic agent		Anesthetic Agent Mixture
Specific agent elected	Startup Mode **or insufficient accuracy ***	Hal./Enfl./Isofl./ Sev./Des.	**--.-**	Color coded	Anesthetic Agent Measurement in Startup Mode
Specific agent elected	Specific agent elected	Hal./Enfl./Isofl./ Sev./Des.	Concentration value	Color coded	

** In Startup mode

*** The accuracy of all gas measurements corresponds to the requests of the ISO 11196 (Accuracy of the indicated reading for Anesthetic agents) and ISO 9918 (Capnometers for use with humans, requirements) the latest 4 min after switching on the unit.

Accuracy (ISO):
CO_2 : +/- 0,5 %
O_2 : +/- 3%
Agent : +/-0,15%
N_2O : +/- 2%

**** The minimum concentration for the identification of anesthetic agents is approx. 0,3 Vol%.

* only for apparatus option with integrated gas module

Automatic Anesthetic Agent and Agent Mixture Identification (continued)

Anesthetic Agent and MAC values are color coded as follows:

Gas	Abbreviation	Color Coding
Halothane	Hal.	Red
Enflurane	Enfl.	Orange
Isoflurane	Isofl.	Purple
Sevoflurane	Sev.	Yellow
Desflurane	Des.	Blue
No gas identified	Auto	White

After the unit has been switched on, the gas module is in the startup mode for approx. 4 min. During this period following rules apply:

Cold Start:

Time	Relative Time	Accuracy			Event
(Min)	(Min)	Agent 1/2	N2O	CO2	
00:00	00:12	-	-	-	Communication not possible
00:12	00:12	Not ready	Not ready	Not ready	
00:20	00:20	Start phase	Start phase	Start phase	
00:40	00:20	Start phase	Unknown	Reduced accuracy	
02:50	02:20	Start phase Zero in Progress	Start phase Zero in Progress	Start phase Zero in Progress	
03:00	00:10	Start phase	Reduced accuracy	Reduced accuracy	
04:00	01:00	Start phase	Reduced accuracy	Reduced accuracy	Zeroing required
04:00	00:00				Zeroing in progress
04:30	**00:30**	**ISO accuracy**	**ISO accuracy**	**ISO accuracy**	Zeroing completed
124:00	120:00	ISO accuracy	ISO accuracy	ISO accuracy	Zeroing required

7.2.5 Panel Key VT/$\dot{V}$ in the Ventilation Modes CMV / (S)CMV Adult / Child

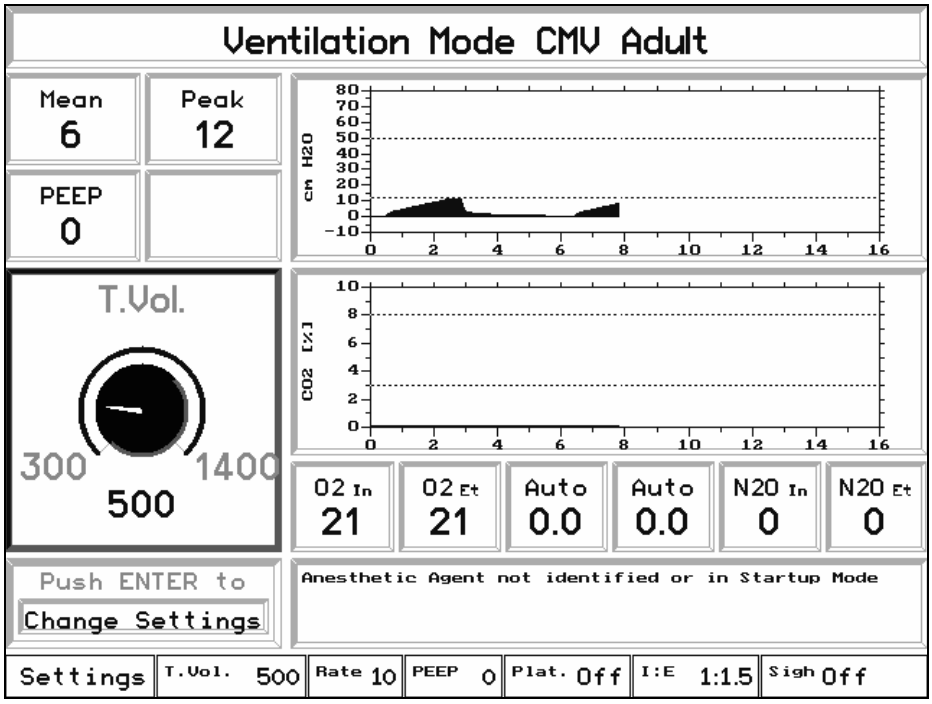


Fig. 53 Vt adjustment in the ventilation mode CMV Adult

The Menu window shows the screen adjustment Vt for the setting of the tidal volume in ml during the controlled ventilation.

This adjustment is stored until the unit is switched off.

The window closes after pressing the encoder button or automatically after 10 s.

7.2.6 Panel Key VT/$\dot{V}$ in the Ventilation Mode PCV Adult / Child

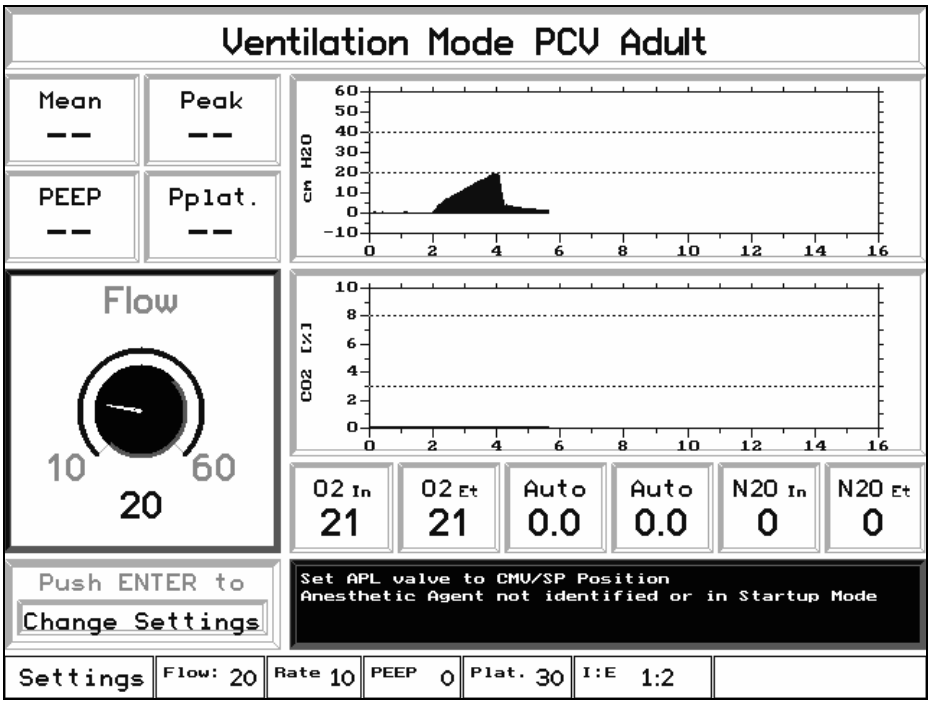


Fig. 54 $\dot{V}$ adjustment in the ventilation mode PCV Adult

The Menu window shows the screen adjustment $\dot{V}$ for the setting of the maximum inspiratory flow in l/min during the controlled ventilation.

This adjustment is stored until the unit is switched off.

The window closes after pressing the encoder button or automatically after 10 s.

7.2.7 Panel Key f in the Ventilation Modes CMV / (S)CMV / PCV Adult / Child

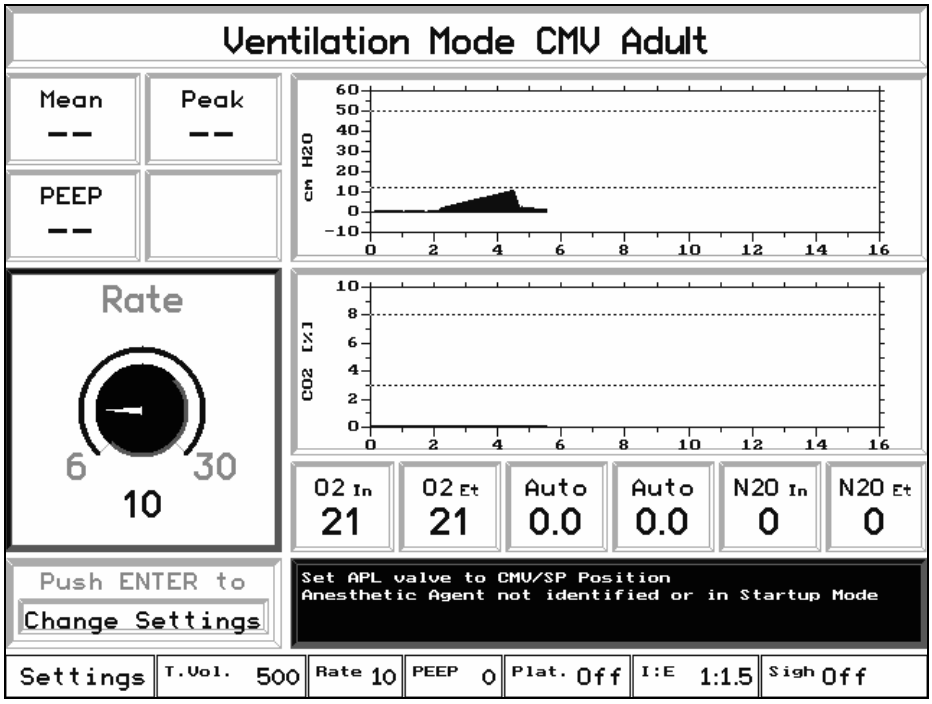


Fig. 55 Rate adjustment in the ventilation mode CMV Adult

The Menu window shows the screen adjustment f for the setting of the ventilation rate in 1/min.

This adjustment is stored until the unit is switched off.

The window closes after pressing the encoder button or automatically after 10 s.

7.2.8 Panel Key I:E in the Ventilation Modes CMV / (S)CMV / PCV Adult / Child

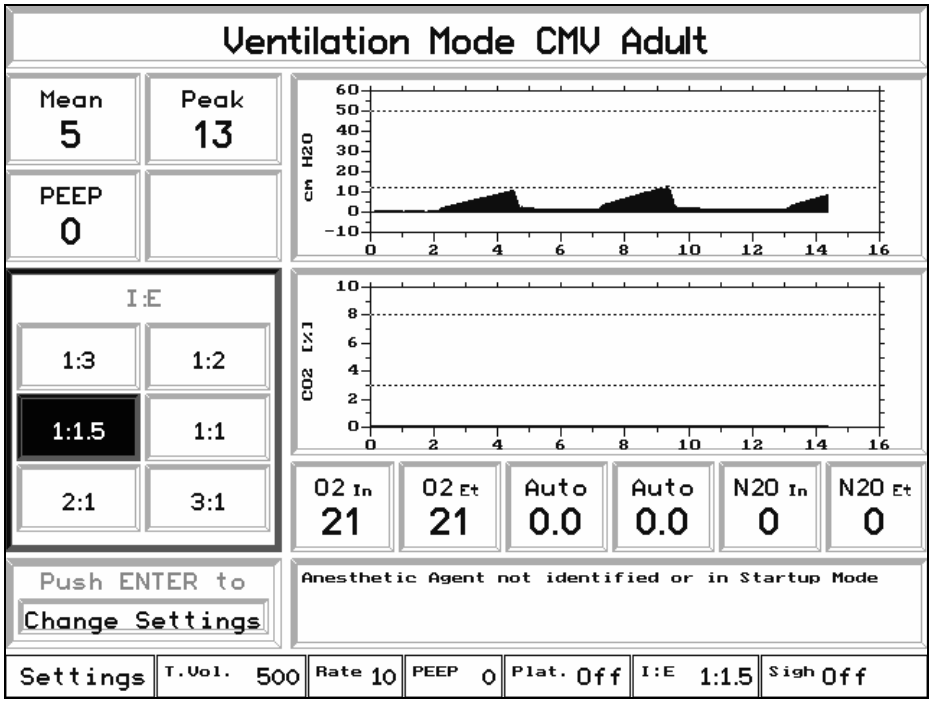


Fig. 56 I:E adjustment in the ventilation mode CMV Adult

The Menu window shows the screen adjustment I:E for the setting of the inspiration-exspiration time ratio

This adjustment is stored until the unit is switched off.

The window closes after pressing the encoder button or automatically after 10 s.

7.2.9 Panel Key PEEP in the Ventilation Modes CMV / (S)CMV / PCV Adult / Child

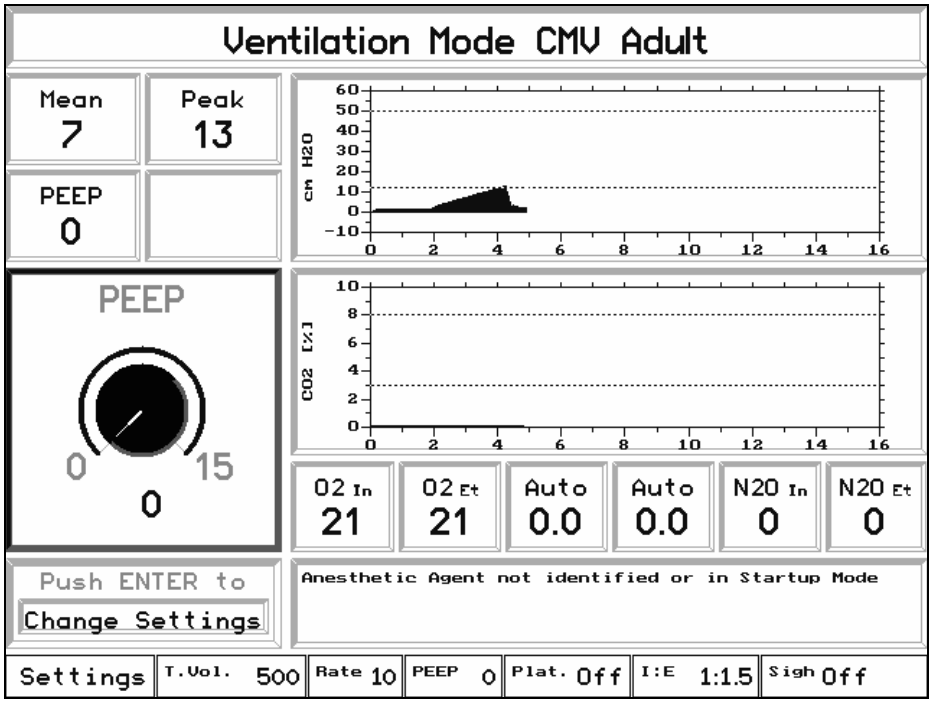


Fig. 57 PEEP adjustment in the ventilation mode CMV Adult

The Menu window shows the screen adjustment PEEP for the setting of the PEEP in cmH2O.

This adjustment is stored until the unit is switched off.

The window closes after pressing the encoder button or automatically after 10 s.

7.3 “Manual/spontaneous” ventilation mode

For a manual ventilation or the application of the system for spontaneous ventilation, set the selection switch of the operating panel to "Manual/spontaneous".

7.3.1 “Manual/spontaneous” ventilation mode

In the ventilation mode “Manual/spontaneous” the display informs you about the measured values for pressure, flow or volume, ventilation frequency and gas concentration. The displayed alarms will appear below the real time curves.

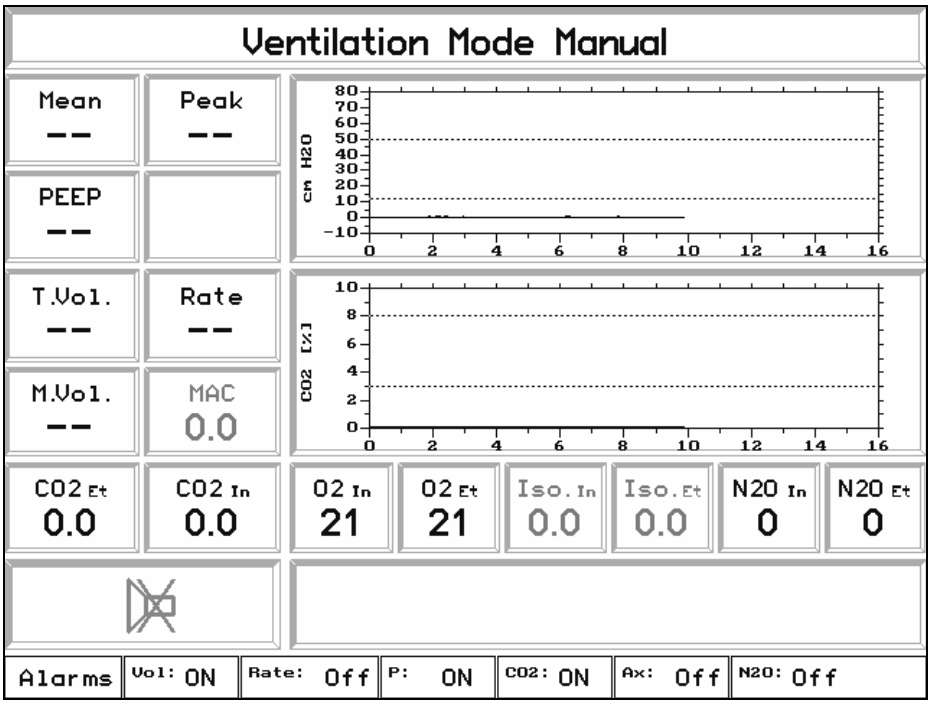


Fig. 58 "Manual/spontaneous settings" display 1

In the panels for the measurement values the following will be displayed:

Mean	Average pressure in cmH2O	Peak	Airway peak pressure in cmH2O
PEEP	Positive end expiratory pressure in cmH2O		
T. Vol.	Tidal volume in ml	Rate	Ventilation or spontaneous breath rate in 1/min
M. Vol.	Respiratory minute volume in l (1/min)	MAC	minimal alveolar Concentration

“Manual/spontaneous” ventilation mode (Continued)

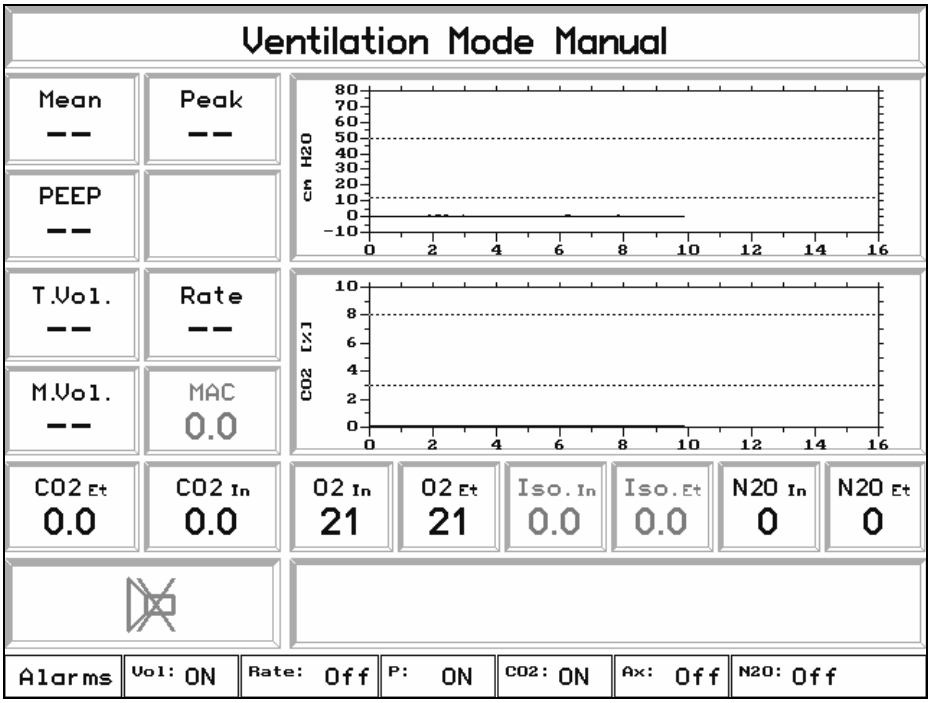


Fig. 59 "Manual/spontaneous settings" display 2

In the panels for the gas measurement values the following will be displayed:

CO2 Et	End tidal CO_2 concentration in mmHg or %	CO2 In	Inspiratory CO_2 concentration in mmHg or %
O2 In	Inspiratory O_2 concentration in %	O2 Et	Expiratory O2 concentration in %
Iso. In	Inspiratory Anesthetic agent concentration in %. Here for example Isoflurane.	Iso. Et	Exspiratory Anesthetic agent concentration in %. Here for example Isoflurane.
N2O In	Inspiratory N_2O concentration in %	N2O Et	Expiratory N_2O concentration in %

“Manual/spontaneous” ventilation mode (Continued)

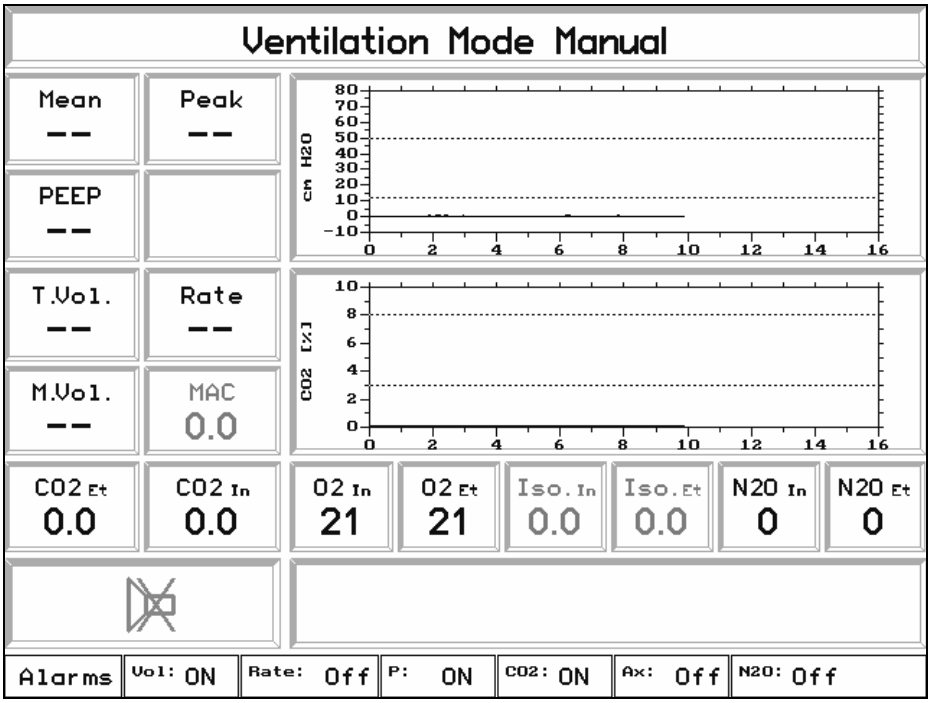


Fig. 60 "Manual/spontaneous settings" display 3

In the panels for the alarm configuration the following will be displayed:

The displayed symbol shows that the patient alarms are suppressed acoustically

Vol: ON — The Volume alarms T.Vol min and M.Vol are switch on

Rate: Off — The frequency alarms f min and f max are switched off

P: ON — The airway pressure alarms Pmin and Pmax are switched on

CO2: ON — The CO2 alarms CO2 high, CO2 low and RA CO2 are switched on

Ax: Off — The anesthetic gas alarms e.g. ISO high and ISO low are switched off

N2O: Off — The N2O alarms N2O high, N2O low are switched off

Fig. 61 Ventilation pressure valve (APL) in CMV/SP setting

Set the ventilation pressure valve (APL) to the CMV/SP setting for spontaneous ventilation.

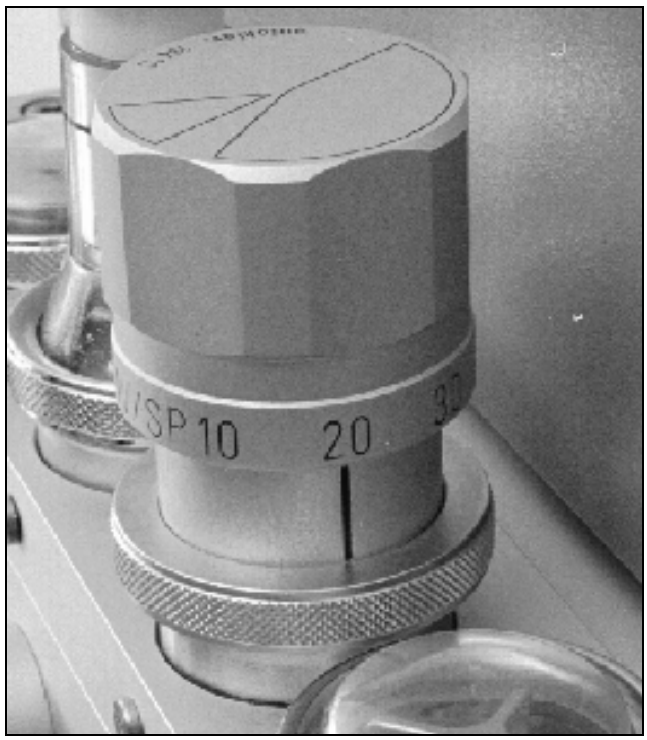


Fig. 62 Ventilation pressure valve (APL) in 20 cmH2O setting

For a manual ventilation, the ventilation pressure valve (APL) must be set to a respective pressure limiting value, for example 20 cmH2O. The patient will be ventilated with the manual ventilation bag.

7.3.1.1 Alarm limit setting in “manual/spontaneous” mode

The alarm limits in the “Manual/spontaneous” ventilation mode are set by pressing the “Limits” key on the operating panel.

Above the graphics representation the "Alarm limits page 1 of 2" window is opened, showing the respective alarm parameters in pairs.

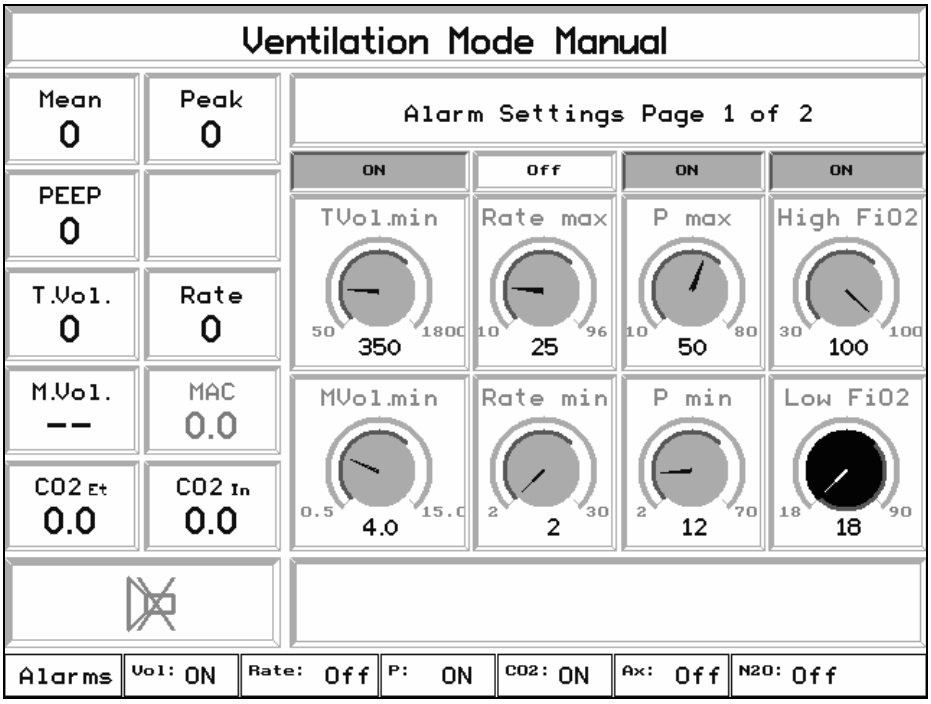


Fig. 63 Alarm limits 1 in the Manual/spontaneous ventilation mode

With the buttons “On” and “Off” the alarms, with the exception of In O_2 (O_2 max, O_2 min), can be activated and deactivated.

Explanation of individual alarms:

T.Vol. min	Limit for minimum tidal volume in ml.	MVol. min	Limit for minimum minute volume in l.
Rate max	Limit for maximum breath or ventilation rate in 1/min	Rate min	Limit for minimum breath or ventilation rate in 1/min
P max	Maximum pressure limit (high pressure limit) in cmH2O	P min	Minimum pressure limit (low pressure limit) in cmH2O
High FiO_2	Limit for maximum oxygen concentration in %	Low FiO_2	Limit for minimum oxygen concentration in %

Alarm limit setting in “manual/spontaneous” mode (continued)

Through pressing the button “limits” a second time, the alarm limits for the gas module can be set.

Above the graphics representation the "Alarm limits page 2 of 2" window is opened, showing the respective alarm parameters in pairs.

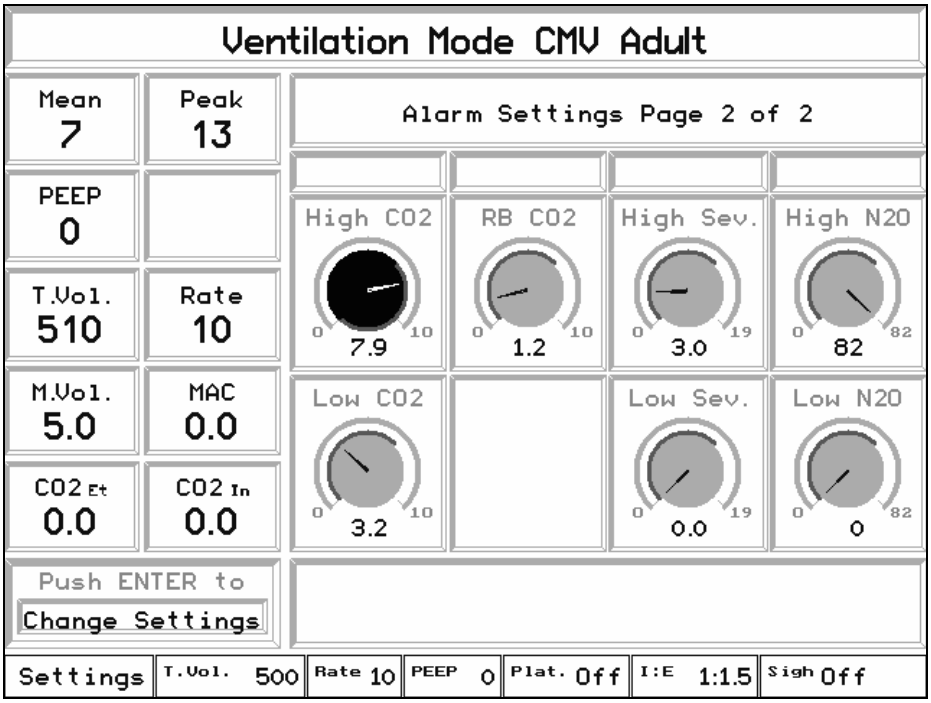


Fig. 64 Display “Alarm limits 2 in the Manual/spontaneous ventilation mode”

Explanation of individual alarms:

High CO_2	Limit for the maximum end CO_2 concentration	Low Iso.	Limit for the minimum inspiratory anesthesia gas concentration
Low CO_2	Limit for the minimum end CO_2 concentration	High N_2O	Limit for the maximum inspiratory N_2O concentration
RB CO_2	CO_2 re-breathing alarm. The maximum inspiratory CO_2 concentration	Low N_2O	Limit for the maximum inspiratory N_2O concentration
High Iso.	Limit for the maximum inspiratory anesthesia gas concentration		

Alarm limit setting in “manual/spontaneous” mode (continued)

The alarm limits are selected and changed with the aid of the encoder or are switched “On” or “Off” in pairs.

To change an individual alarm parameter, it is selected with the encoder.

The rotary display button is activated by pressing the encoder. The frame around the rotary button is highlighted.

The alarm limit value is decreased by turning the encoder anti-clockwise and increased by a clockwise rotation.

The alarm limit settings of the parameters offer different value graduations.

The changed setting is stored by pressing once again on the encoder and the frame around the rotary button returns to normal.

The alarm limit window is closed by pressing once again on the “Limits” key, or closes automatically after 10 seconds.

Table of adjustable alarm limits in manual/spontaneous mode				
Parameter	default for ON/OFF	default setting	value graduation	adjustable values
TVol. min.	On	350 [ml]	50 [ml]	50 – 1800 [ml]
MVol. min		4 [l]	0.5 [l]	0.5 – 15 [l]
Rate max.	Off	25 [1/min]	5 [1/min]	10 – 96 [1/min]
Rate min.		2 [1/min]	2 [1/min]	2 – 30 [1/min]
P max	On	50 [cmH2O]	5 [cmH2O]	10 – 80 [cmH2O]
P min		12 [cmH2O]	2 [cmH2O]	2 – 70 [cmH2O]
High FiO_2	On (always)	100 [%]	5 [%]	30 – 100 [%]
Low FiO_2		18 [%]	2 [%]	18 – 90 [%]
High CO_2	On	7,9 [%]	0,2 [%]	0-10 [%]
Low CO_2		3,2 [%]	0,2 [%]	0-10 [%]
RB CO_2	---	1,2 [%]	0,2 [%]	0-10 [%]
High Iso.	Off	3,0 [%]*	0,2 [%]	0-19 [%]
Low Iso.		0,0 [%]	0,2 [%]	0-19 [%]
High N_2O	Off	82 [%]	2 [%]	0-82 [%]
Low N_2O		0 [%]	2 [%]	0-82 [%]

Fig. 65 Alarm limits in manual/spontaneous mode

For manual ventilation mode the alarm parameters should be switched on and adjusted to values, referred to the requirements for a save monitoring of the patient.

For a spontaneous ventilation mode the airway pressure alarms P max and P min have not to be switched on.

The default setting for the alarm volume is set to “0” in the manual/spontaneous mode, which is displayed through a crossed loudspeaker. The acoustic alarms for the configurable alarms will be suppressed. Technical alarms and the O_2 min alarm are not affected by this feature. The acoustic alarm suppression can be switched off by changing the alarm volume in the menu window.

* The default setting for the Desflurane high alarm is 8 %

“Manual/spontaneous” ventilation mode (continued)

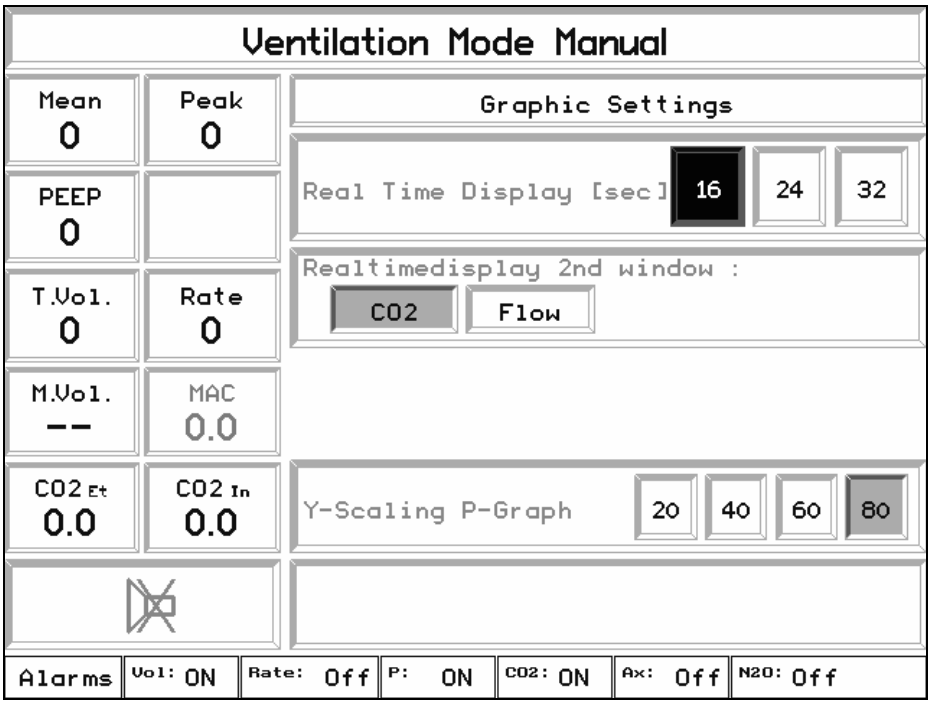


Fig. 66 Graphics window in manual/spontaneous ventilation mode

The graphics menu in the manual/spontaneous ventilation mode allows the setting of the time axis for the display of the ventilation curves.

16, 24 or 32 seconds can be set as values. 16 seconds is the default setting.

The desired time axis representation for the real time curves can be chosen by selecting the respective screen key.

In the real time display 2nd window you can choose which value shall be displayed. CO_2 capnogram* or expiratory flow curve

The Y scaling of the pressure graph can be set to 20, 40, 60 or 80 cmH2O.

By pressing the "Graphics" key for the second time, the window is closed again and the selected setting is stored.

*only for apparatus option with integrated gas module

7.4 Controlled Ventilation Mode

The NARKOMAT+ anesthesia system offers two modes for controlled ventilation, the CMV child and the CMV adult settings on the selection switch of the operating panel. The differences between the two modes are the various ventilation parameters and alarm limits for these patient groups.

Select the ventilation mode, depending on the ventilation requirements of the patient. Different bellows are not required for the ventilation of adults and children. The used tube and filter systems should be fitted to the patient.

Described is only the ventilation mode CMV-Adult. Differences in the ventilation CMV-Child will be explained specifically.

7.4.1 CMV adult ventilation mode

(The screen titles change according to the ventilation modes Adult / Child)

Set the operating panel selection switch to “CMV adult” for the controlled ventilation of adults.

In the appearing display the requested ventilation mode “CMV-adult” can be selected through turning and pressing the encoder button.

The ventilation modes (S)CMV and PCV are options. The appearance of this window depends on the apparatus configuration.

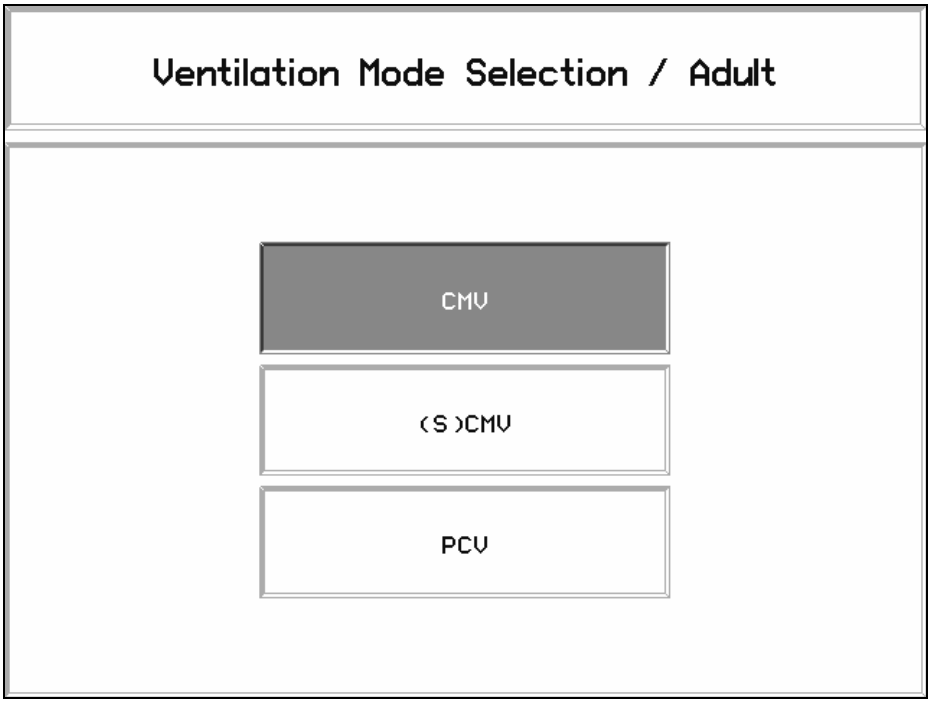


Fig. 67 Display “ventilation mode adult”

CMV adult ventilation mode (continued)

The parameters for the machine ventilation of adults can be determined and controlled on the display. The figure shows the standard setting for this patient group.

To implement a controlled ventilation, these parameters must be confirmed with the encoder button by pressing the "Push ENTER to Activate" display key.

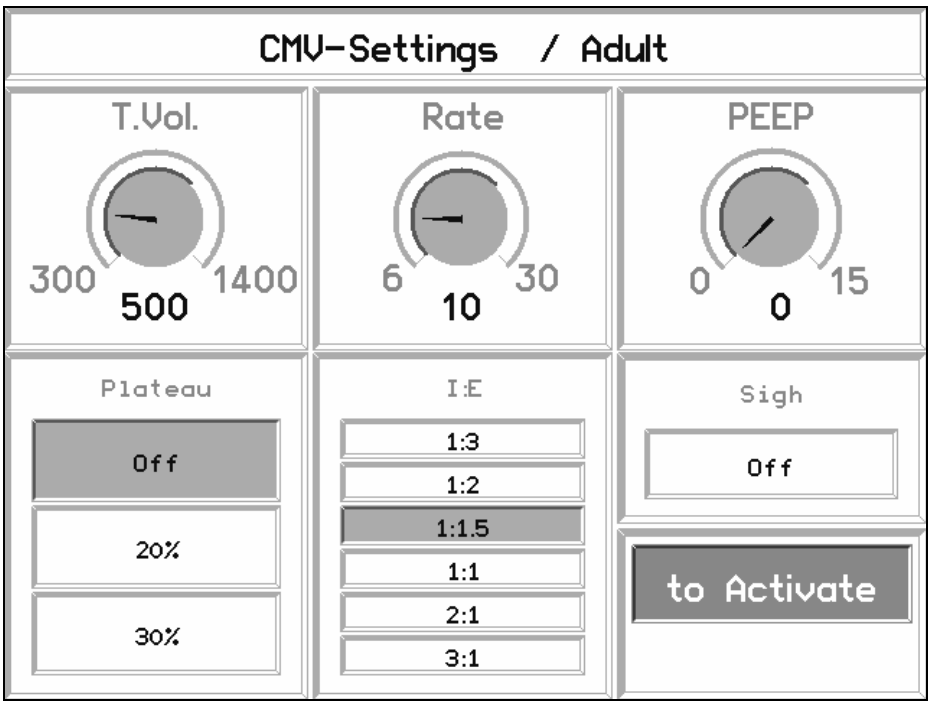


Fig. 68 "CMV-Settings / Adult" display

The parameter setting fields determine the following:

T. Vol.	Tidal volume of the controlled ventilation in ml	Plateau	A plateau for the inspiratory pressure curve expressed in % to the overall inspiration period.
Rate	Ventilation rate in 1/min	I:E	Ventilation time ratio of inspiration and expiration
PEEP	Setting of a PEEP in cmH2O	Sigh	Setting for a sigh ventilation. Every 100 breathing cycles an inspiration with 1.5 times the volume and 1.5 times the duration is carried out, the display key shows "ON".

CMV adult ventilation mode (continued)

Parameter settings ventilation mode CMV Adult / Child

Parameter	Ventilation Mode					
	CMV	(S)CMV	PCV	CMV	(S)CMV	PCV
	Child			Adult		
Tidal Volume [ml]	20-400 (200)			300-1400 (500)		
Flow [l/min]			10-60 (20)			10-60 (10)
Frequency [1/s]	10-60 (20)			6-30 (10)		
I:E	1: 3 1: 2 1: 1,5 1: 1 2: 1 3: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 3: 1 4: 1 (1: 2)	1: 3 1: 2 1: 1,5 1: 1 2: 1 3: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 3: 1 4: 1 (1: 2)
PEEP [cmH2O]	0-15 (0)		0-10 (0)	0-15 (0)		0-10 (0)
Plateau [cmH2O]	20%, 30%, OFF (OFF)		10-60 (20)	20%, 30%, OFF (OFF)		10-60 (20)
Sigh	EIN, AUS (OFF)			EIN, AUS (OFF)		
Trigger [cmH2O]		-2, -4, -6 (-2)			2, -4, -6 (-2)	

() The values inside the brackets are the default values

CMV adult ventilation mode (continued)

During the CMV adult ventilation mode, the display shows the measured pressure, flow and volume, ventilation rate as well as the gas concentration values.

Alarms are displayed below the real-time graphic diagrams.

The set parameters are displayed in the bottom line of the display.

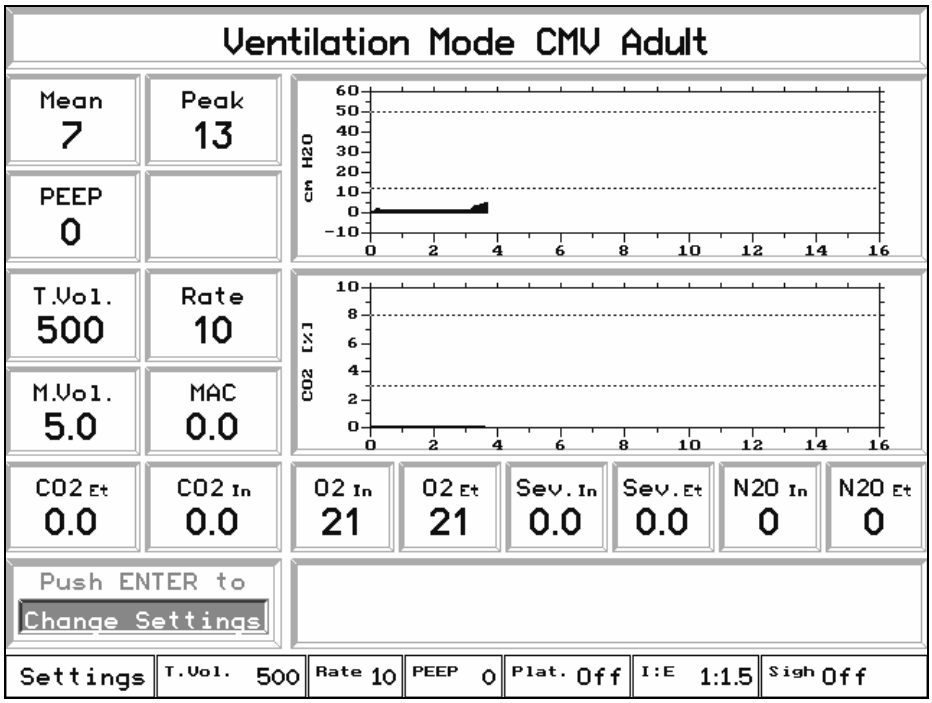


Fig. 69"Start in CMV adult" ventilation mode display

In the measured value fields, the following is displayed:

Mean	Average pressure in cmH2O	Peak	Peak airway pressure value in cmH2O
PEEP	Positive end expiratory pressure in cmH2O		
T. Vol.	Tidal volume in ml	Rate	Ventilation rate in 1/min
M. Vol.	Minute volume in l	MAC	Minimum alveolar concentration

CMV adult ventilation mode (continued)

After the parameter settings have been confirmed, an alarm such as, for instance, the warning message for setting the ventilation pressure valve (APL) is displayed. This message alarm automatically disappears after approx. 15. sec.

In the graphical representation of the ventilation pressure, the set Pmax and Pmin limits appear as thin lines.

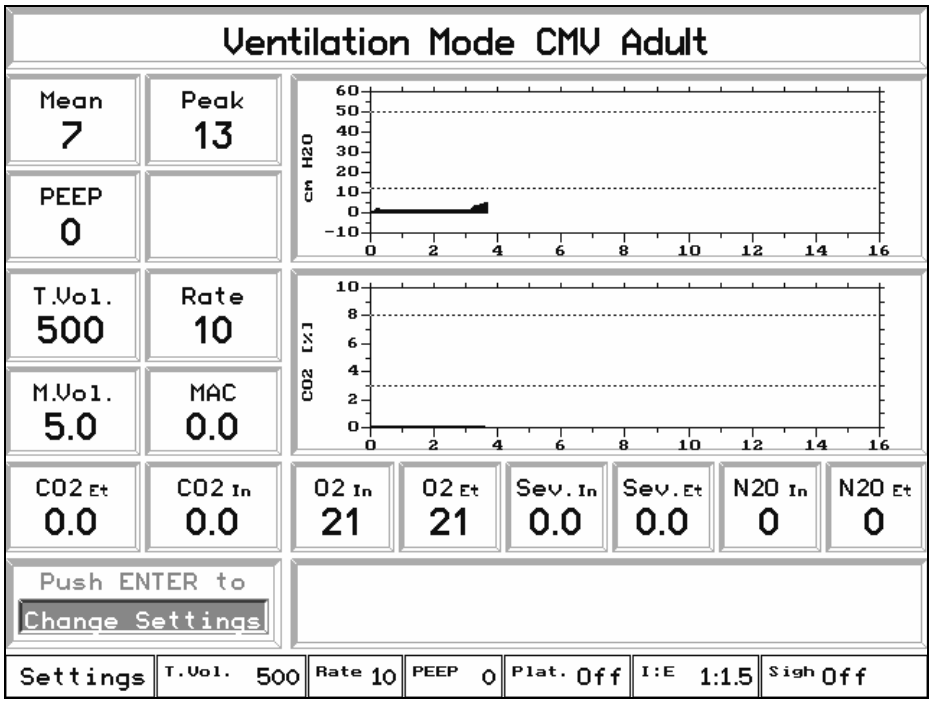


Fig. 70" CMV adult" ventilation mode display

In the measured value fields, the following is displayed:

CO2 Et	End Tidal CO_2 concentration of breathing gas in % or mmHg	CO2 In	Inspiratory CO_2 concentration of breathing gas in % or mmHg
O2 In	Inspiratory oxygen concentration of breathing gas in %	O2 Et	Expiratory oxygen concentration of breathing gas in %
Iso. In	Inspiratory Agent concentration of breathing gas in %	Iso. Et	Expiratory Agent concentration of breathing gas in %
N2O Et	Exspiratory Nitrous oxide concentration of breathing gas in %	N2O In	Inspiratory Nitrous oxide concentration of breathing gas in %

7.4.1.1 Parameter Settings in CMV Adult Mode

To change the current ventilation parameters, press the key “Change settings” in the “Push enter to” display field. A CMV-Settings/Adult window replaces the graphical presentation.

The parameters are set as at the start of the ventilation mode with the aid of the operating panel encoder button. Additionally you have the possibility to change the ventilation mode in this window.

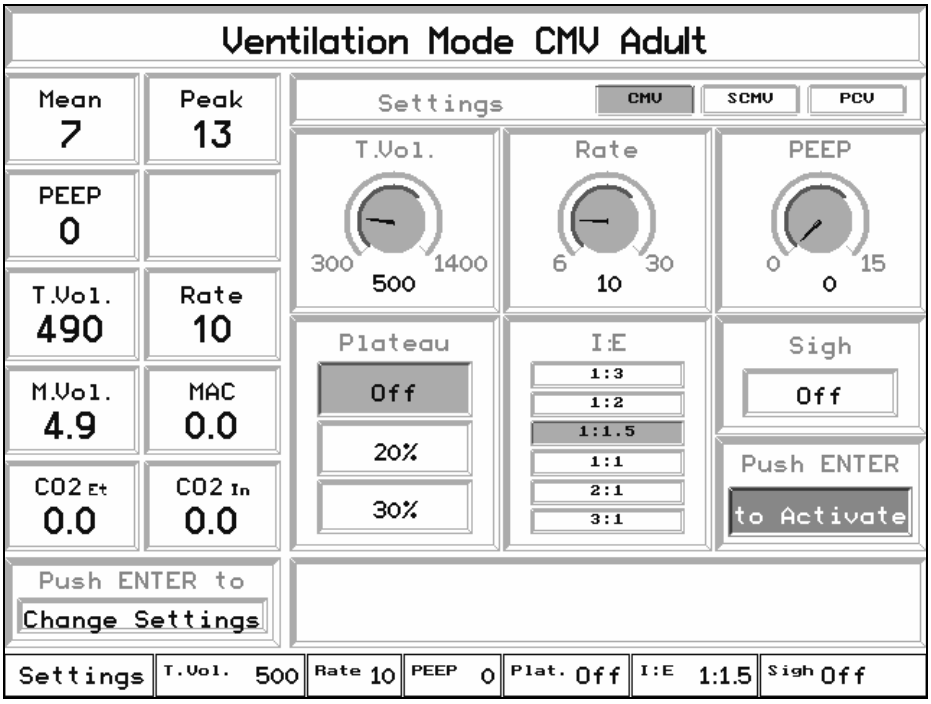


Fig. 71 "Parameter setting during the CMV adult" ventilation mode display

7.4.1.2 Alarm limits setting in CMV adult mode

The alarm limits in the “CMV Adult” ventilation mode are set by pressing the “Limits” key on the operating panel.

Above the graphics representation the "Alarm limits page 1 of 2" window is opened, showing the respective alarm parameters in pairs.

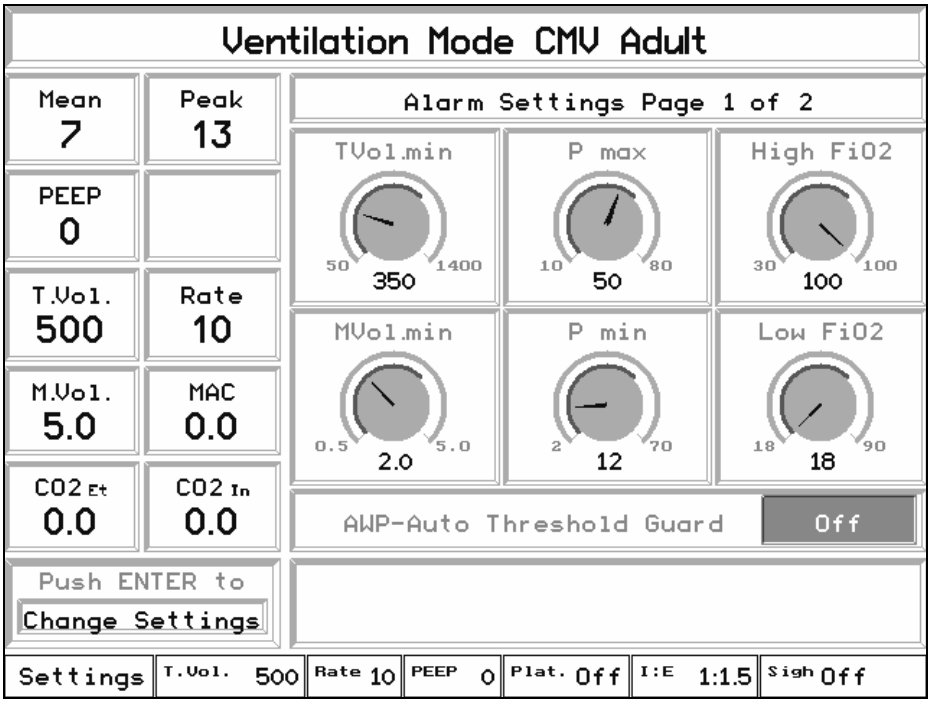


Fig. 72 Display “Alarm limits 1 in the CMV Adult ventilation mode

Explanation of individual alarms:

T.Vol. min	Limit for min. tidal volume in ml	MVol. min	Limit for min. minute volume in l
P max	Maximum pressure limit (high pressure limit) in cmH2O	P min	Minimum pressure limit (lowest pressure limit)) in cmH2O
High FiO_2	Limit for max. FiO_2 value in %	Low FiO_2	Limit for min. FiO_2 value in %

Automatic Pmin/Pmax setting — Special function to adapt the Pmin and Pmax limits automatically to the current airway peak pressure.

Alarm limits setting in CMV adult mode (continued)

Through pressing the button “limits” a second time, the alarm limits for the gas module can be set.

Above the graphics representation the "Alarm limits page 2 of 2" window is opened, showing the respective alarm parameters in pairs.

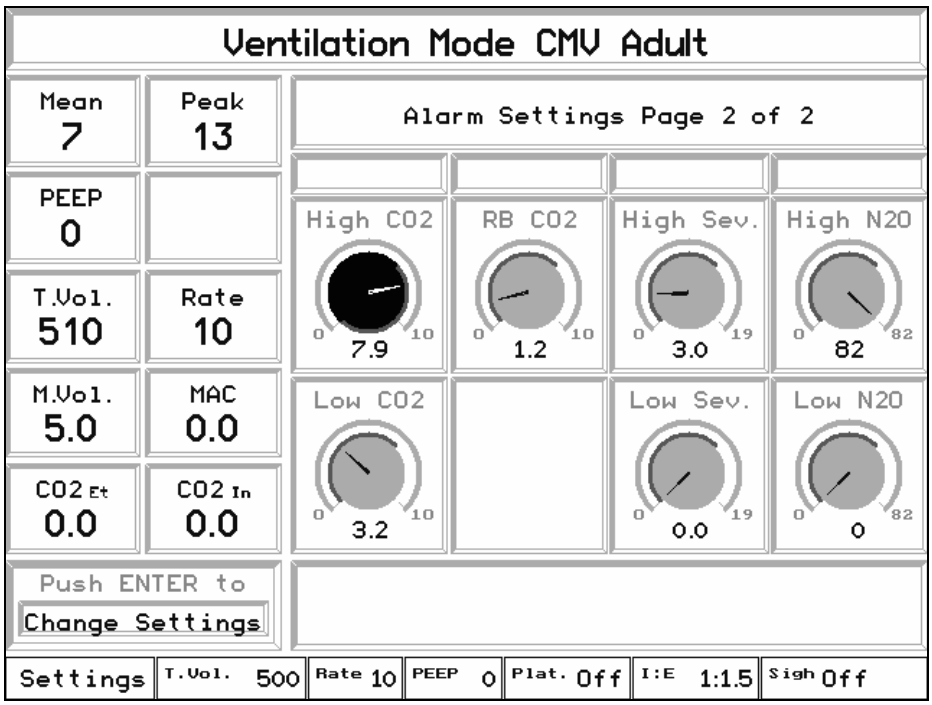


Fig. 73 Display “Alarm limits 2 in the CMV Adult ventilation mode”

Explanation of individual alarms:

High CO_2	Limit for the maximum end CO_2 concentration	High Sev.	Limit for the maximum inspiratory anesthesia gas concentration
Low CO_2	Limit for the minimum end CO_2 concentration	Low Sev.	Limit for the minimum inspiratory anesthesia gas concentration
RB CO_2	Maximum difference between the inspiratory and expiratory value of CO_2	High N_2O	Limit for the maximum inspiratory N_2O concentration
		Low N_2O	Limit for the maximum inspiratory N_2O concentration

Alarm limits setting in CMV adult mode (continued)

The alarm limits are selected and changed with the aid of the encoder. The alarm limit window is closed by activating the “Limits” key for the second time.

To change the individual alarm parameter, it is selected with the encoder.

The rotary display button is activated by pressing the encoder. The frame around the rotary button is highlighted.

The alarm limit value is decreased by turning the encoder anti-clockwise and increased by a clockwise rotation.

The alarm limit settings of the parameters offer different value graduations.

The changed setting is stored by pressing once again on the encoder, and the frame around the rotary button returns to normal.

The key "AWP Auto Threshold Guard" offers a special function. By pressing the “Off” key, the display briefly changes to “On” to confirm the activation of the key. The Pmax and Pmin limits are consequently automatically set around the airway peak pressure. A value of +10 cmH2O above Ppeak is automatically set for Pmax. A value of -6 cmH2O below Ppeak is automatically set for Pmin. The setting of a PEEP is not considered.

By pressing the “Limits” key again, the alarm setting window is closed. The window otherwise closes automatically after 10 seconds.

Table of adjustable alarm limits in the CMV adult mode				
Parameter	**default for ON/OFF**	**default setting**	**value graduation**	**adjustable values**
T.Vol. min	On	350 [ml]	50 [ml]	50 – 1400 [ml]
MVol. min	On	2 [l]	0.5 [l]	0.5 – 5 [l]
Rate max.	---			
Rate min.	---			
P max	On	50 [cmH2O]	5 [cmH2O]	10 – 80 [cmH2O]
P min	On	12 [cmH2O]	2 [cmH2O]	2 – 70 [cmH2O]
High FiO_2	On	100 [%]	5 [%]	30 – 100 [%]
Low FiO_2	On	18 [%]	2 [%]	18 – 90 [%]
High CO_2	On	7,9 [%]	0,2 [%]	0-10 [%]
Low CO_2	On	3,2 [%]	0,2 [%]	0-10 [%]
RB CO_2	On	1,2 [%]	0,2 [%]	0-10 [%]
High HAL/ENFL /ISO/ SEV	On	3,0 [%]*	0,2 [%]	1-19 [%]
Low HAL/ENFL /ISO/SEV	On	0,0 [%]	0,2 [%]	0-19 [%]
High N_2O	On	82 [%]	2 [%]	0-82 [%]
Low N_2O	On	0 [%]	2 [%]	0-82 [%]

Fig. 74 Alarm limits in the CMV Adult ventilation mode

* The default setting for the Desflurane high alarm is 8 %

7.4.1.3 Alarm limits setting in CMV child mode

Table of adjustable alarm limits in the CMV child mode				
Parameter	**default for ON/OFF**	**default setting**	**value graduation**	**adjustable values**
T.Vol. min	On	100 [ml]	10 [ml]	20 – 400 [ml]
MVol. min	On	1 [l]	0.5 [l]	0.5 – 1 [l]
Rate max.	---			
Rate min.	---			
P max	On	50 [cmH2O]	5 [cmH2O]	10 – 80 [cmH2O]
P min	On	12 [cmH2O]	2 [cmH2O]	2 – 70 [cmH2O]
High FiO_2	On	100 [%]	5 [%]	30 – 100 [%]
Low FiO_2	On	18 [%]	2 [%]	18 – 90 [%]
High CO_2	On	7,9 [%]	0,1 [%]	0-10 [%]
Low CO_2	On	3,2 [%]	0,1 [%]	0-10 [%]
RB CO_2	On	1,2 [%]	0,1 [%]	0-10 [%]
High HAL/ENFL /ISO/ SEV	On	3,0 [%]*	0,1 [%]	1-19 [%]
Low HAL/ENFL /ISO/SEV	On	0,0 [%]	0,1 [%]	0-19 [%]
High N_2O	On	82 [%]	1 [%]	0-82 [%]
Low N_2O	On	0 [%]	1 [%]	0-82 [%]

Fig. 75 Alarm limits in the CMV Child ventilation mode

* The default setting for the Desflurane high alarm is 8 %

7.5 Ventilation mode (S)CMV

For the controlled ventilation the anesthesia system NARKOMAT+ offers the ventilation modes (S)CMV child and (S)CMV adult.

Differing from the totally controlled ventilation, the patient can start the inspiration phase through own breathing activities during this Synchronized Controlled Mandatory Ventilation. After the “trigger”, a defined tidal volume follows, which can only be stopped through the set limits.
The own respiratory effort is set through the trigger level. If the trigger level is set correctly, the patients own respiratory effort will be very low.
The assisted ventilation therefore is nothing else than a controlled ventilation which is controlled by the patient, which determines the ventilation rate and therefore also the minute volume.

7.5.1 Ventilation mode (S)CMV

(The screen titles change according to the ventilation modes Adult / Child)

For the controlled ventilation the anesthesia system NARKOMAT+ offers the ventilation modes (S)CMV child and (S)CMV adult.

Differing from the totally controlled ventilation, the patient can start the inspiration phase through own breathing activities during this Synchronized Controlled Mandatory Ventilation. After the “trigger”, a defined tidal volume follows, which can only be stopped through the set limits.
The own respiratory effort is set through the trigger level. If the trigger level is set correctly, the patients own respiratory effort will be very low.
The assisted ventilation therefore is nothing else than a controlled ventilation which is controlled by the patient, which determines the ventilation rate and therefore also the minute volume.

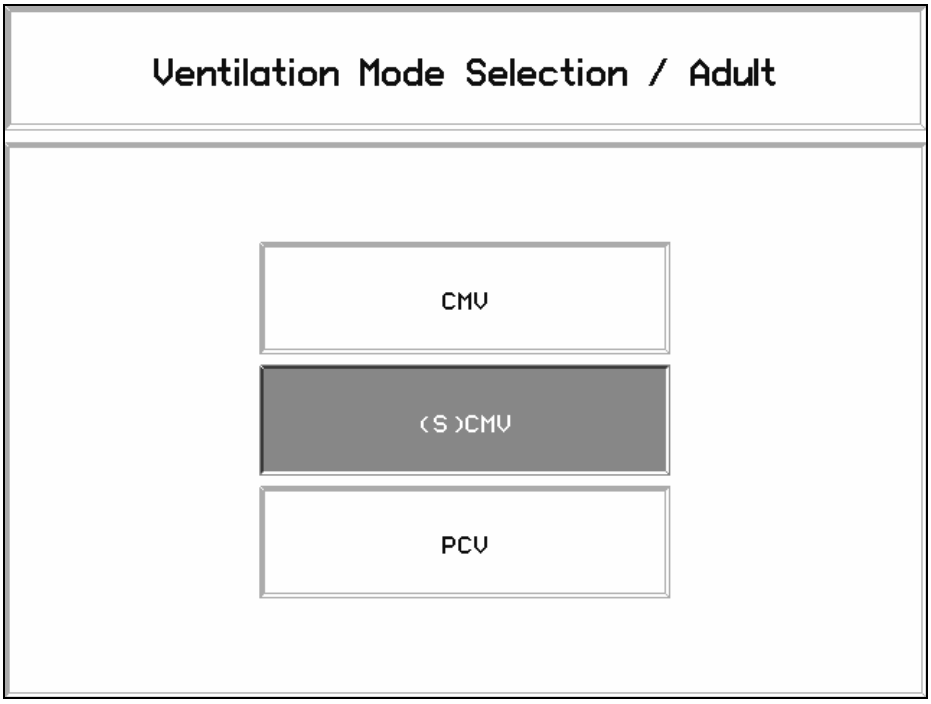


Fig. 76 Display “ventilation mode adult”

Ventilation mode (S)CMV (continued)

The parameters for the machine ventilation of adults can be determined and controlled on the display. The figure shows the standard setting for this patient group.

To implement a controlled ventilation, these parameters must be confirmed with the encoder button by pressing the "Push ENTER to Activate" display key.

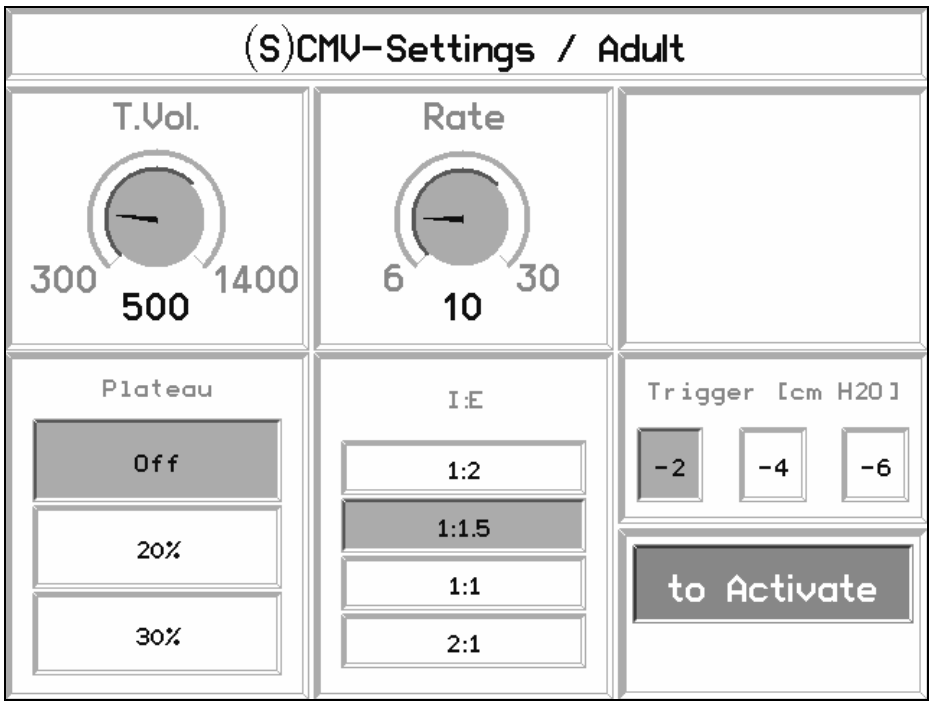


Fig. 77 "(S)CMV-Settings / Adult" display

The parameter setting fields determine the following:

T. Vol.	Tidal volume of the controlled ventilation in ml	I:E	Ventilation time ratio of inspiration and expiration
Rate	Ventilation rate in 1/min	Trigger	Trigger level of the respiratory effort.
Plateau	A plateau for the inspiratory pressure curve expressed in % to the overall inspiration period.		

Ventilation mode (S)CMV adult (continued)

Parameter settings ventilation mode (S)CMV Adult / Child

Parameter	Ventilation Mode					
	CMV	(S)CMV	PCV	CMV	(S)CMV	PCV
	Child			Adult		
Tidal Volume [ml]	20-400 (200)			300-1400 (500)		
Flow [l/min]			10-60 (20)			10-60 (10)
Frequency [1/s]	10-60 (20)			6-30 (10)		
I:E	1: 3 1: 2 1: 1,5 1: 1 2: 1 3: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 3: 1 4: 1 (1: 2)	1: 3 1: 2 1: 1,5 1: 1 2: 1 3: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 3: 1 4: 1 (1: 2)
PEEP [cmH2O]	0-15 (0)		0-10 (0)	0-15 (0)		0-10 (0)
Plateau [cmH2O]	20%, 30%, OFF (OFF)		10-60 (20)	20%, 30%, OFF (OFF)		10-60 (20)
Sigh	EIN, AUS (OFF)			EIN, AUS (OFF)		
Trigger [cmH2O]		-2, -4, -6 (-2)			2, -4, -6 (-2)	

() The values inside the brackets are the default values

Ventilation mode (S)CMV adult (continued)

During the (S)CMV adult ventilation mode, the display shows the measured pressure, flow and volume, ventilation rate as well as the oxygen concentration values.

Alarms are displayed below the real-time graphic diagrams.

The set parameters are displayed in the bottom line of the display.

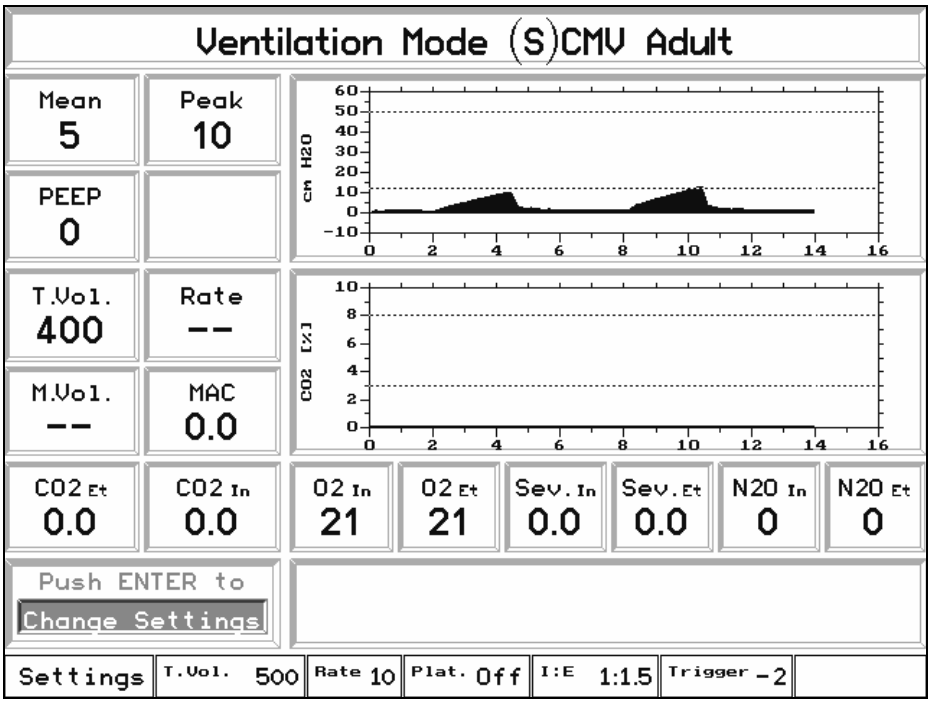


Fig. 78 "(S)CMV adult" ventilation mode display 1

In the measured value fields, the following is displayed:

Mean	Average pressure in cmH2O	Peak	Peak airway pressure value in cmH2O
PEEP	Positive end expiratory pressure in cmH2O		
T. Vol.	Tidal volume in ml	Rate	Ventilation rate in 1/min
M. Vol.	Minute volume in l	MAC	Minimum alveolar concentration

Ventilation mode (S)CMV adult (continued)

After the parameter settings have been confirmed, an alarm such as, for instance, the warning message for setting the ventilation pressure valve (APL) is displayed. This message alarm automatically disappears after approx. 15. sec.

In the graphical representation of the ventilation pressure, the set Pmax and Pmin limits appear as thin lines.

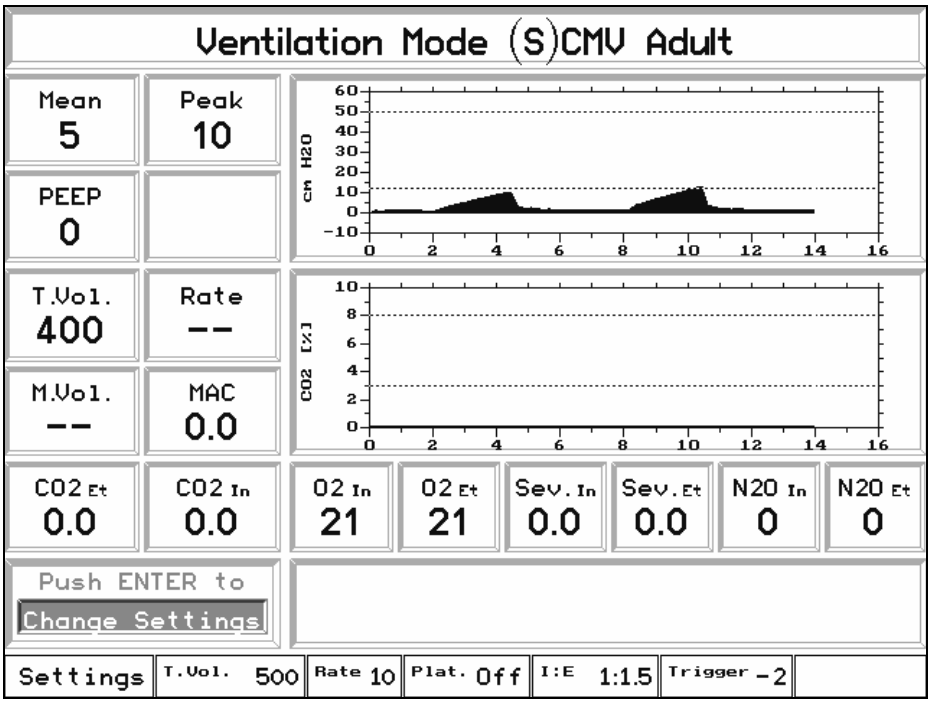


Fig. 79 "(S)CMV adult" ventilation mode display 2

In the measured value fields, the following is displayed:

CO2 Et	End Tidal CO_2 concentration of breathing gas in % or mmHg	CO2 In	Inspiratory CO_2 concentration of breathing gas in % or mmHg
O2 In	Inspiratory oxygen concentration of breathing gas in %	O2 Et	Expiratory oxygen concentration of breathing gas in %
Iso. In	Inspiratory Agent concentration of breathing gas in %	Iso. Et	Expiratory Agent concentration of breathing gas in %
N2O Et	Exspiratory Nitrous oxide concentration of breathing gas in %	N2O In	Inspiratory Nitrous oxide concentration of breathing gas in %

7.5.1.1 Changing parameter settings in (S)CMV adult mode

To change the current ventilation parameters, press the key “Change settings” in the “Push enter to” display field. A (S)CMV-Settings/Adult window replaces the graphical presentation.

The parameters are set as at the start of the ventilation mode with the aid of the operating panel encoder button. Additionally you have the possibility to change the ventilation mode in this window.

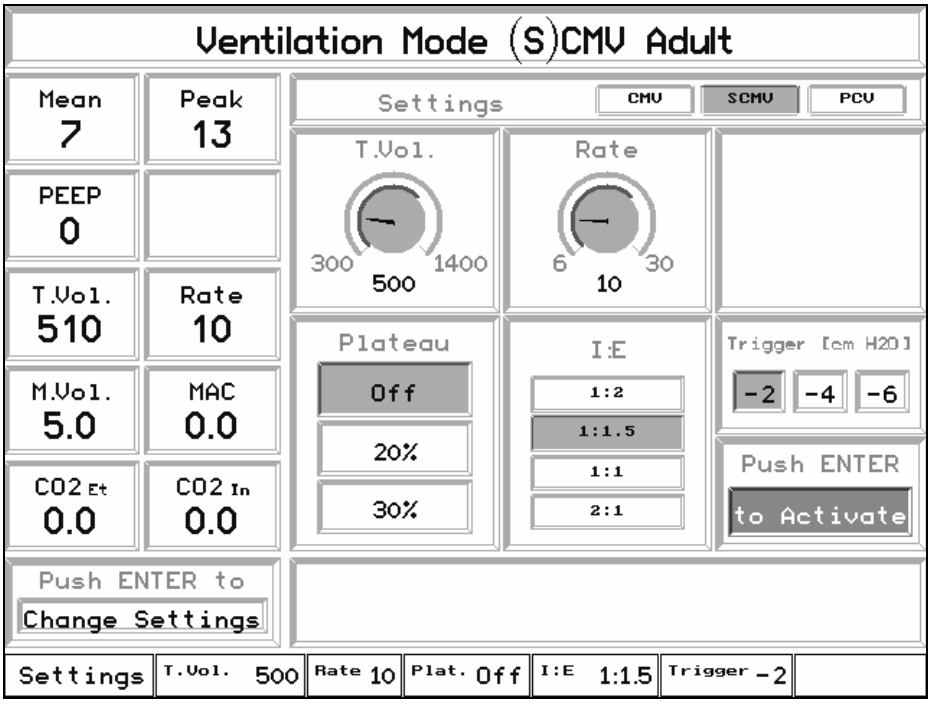


Fig. 80"Parameter setting during the (S)CMV adult" ventilation mode display

7.5.1.2 Alarm limits setting in (S)CMV adult mode

The alarm limits in the “(S)CMV Adult” ventilation mode are set by pressing the “Limits” key on the operating panel.

Above the graphics representation the "Alarm limits page 1 of 2" window is opened, showing the respective alarm parameters in pairs.

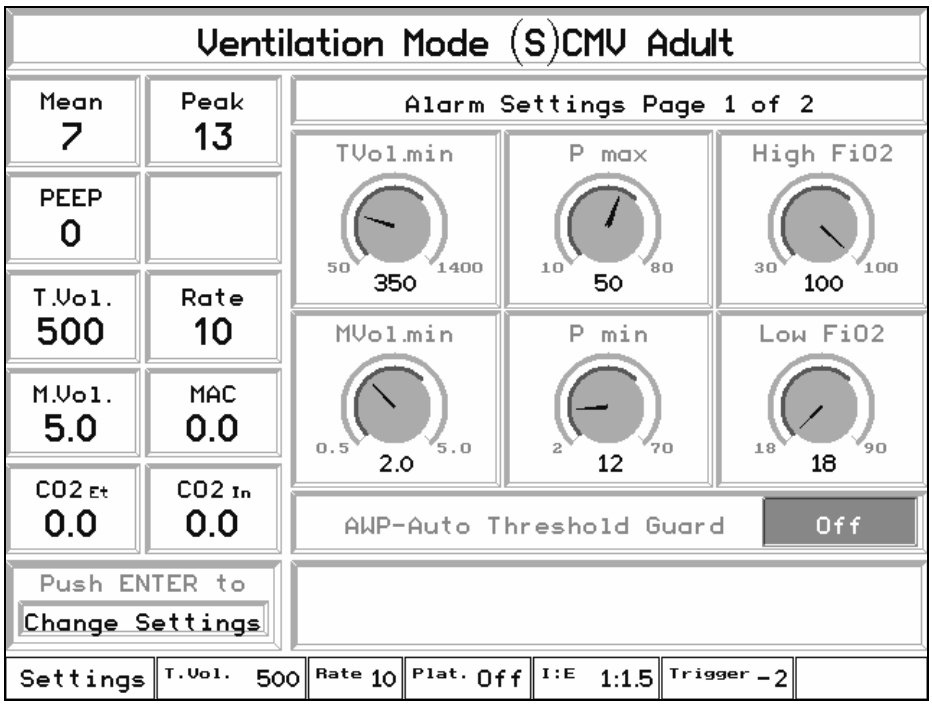


Fig. 81 "Alarm Settings" ventilation mode (S)CMV adult

The individual alarms mean:

T.Vol. min	Limit for min. tidal volume in ml	MVol. min	Limit for min. minute volume in l
P max	Maximum pressure limit (high pressure limit) in cmH2O	P min	Minimum pressure limit (lowest pressure limit)) in cmH2O
O_2 max	Limit for max. FiO_2 value in %	O_2 min	Limit for min. FiO_2 value in %

Automatic Pmin/Pmax setting	Special function to adapt the Pmin and Pmax limits automatically to the current airway peak pressure.

Alarm limits setting in (S)CMV adult mode (continued)

Through pressing the button “limits” a second time, the alarm limits for the gas module can be set.

Above the graphics representation the "Alarm limits page 2 of 2" window is opened, showing the respective alarm parameters in pairs.

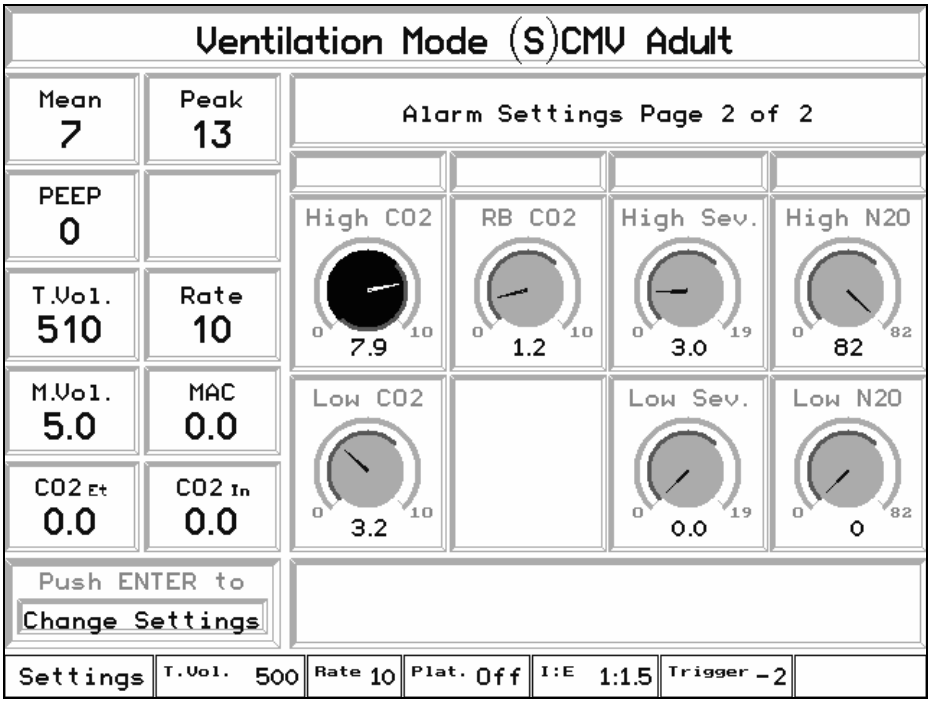


Fig. 82 Display “Alarm limits 2 in the (S)CMV Adult ventilation mode”

Explanation of individual alarms:

High CO_2	Limit for the maximum end CO_2 concentration	High Sev.	Limit for the maximum inspiratory anesthesia gas concentration
Low CO_2	Limit for the minimum end CO_2 concentration	Low Sev.	Limit for the minimum inspiratory anesthesia gas concentration
RB CO_2	Maximum difference between the inspiratory and expiratory value of CO_2	High N_2O	Limit for the maximum inspiratory N_2O concentration
		Low N_2O	Limit for the maximum inspiratory N_2O concentration

Alarm limits setting in (S)CMV adult mode (continued)

The alarm limits are selected and changed with the aid of the encoder. The alarm limit window is closed by activating the “Limits” key for the second time.

To change the individual alarm parameter, it is selected with the encoder.

The rotary display button is activated by pressing the encoder. The frame around the rotary button is highlighted.

The alarm limit value is decreased by turning the encoder anti-clockwise and increased by a clockwise rotation.

The alarm limit settings of the parameters offer different value graduations.

The changed setting is stored by pressing once again on the encoder, and the frame around the rotary button returns to normal.

By pressing the “Limits” key again, the alarm setting window is closed. The window otherwise closes automatically after 10 seconds.

Table of adjustable alarm limits in the (S)CMV adult mode				
Parameter	**default for ON/OFF**	**default setting**	**value graduation**	**adjustable values**
T.Vol. min	On	350 [ml]	50 [ml]	50 – 1400 [ml]
MVol. min	On	2 [l]	0.5 [l]	0.5 – 5 [l]
Rate max.	---			
Rate min.	---			
P max	On	50 [cmH2O]	5 [cmH2O]	10 – 80 [cmH2O]
P min	On	12 [cmH2O]	2 [cmH2O]	2 – 70 [cmH2O]
High FiO_2	On	100 [%]	5 [%]	30 – 100 [%]
Low FiO_2	On	18 [%]	2 [%]	18 – 90 [%]
High CO_2	On	7,9 [%]	0,2 [%]	0-10 [%]
Low CO_2	On	3,2 [%]	0,2 [%]	0-10 [%]
RB CO_2	On	1,2 [%]	0,2 [%]	0-10 [%]
High HAL/ENFL /ISO/ SEV	On	3,0 [%]*	0,2 [%]	1-19 [%]
Low HAL/ENFL /ISO/SEV	On	0,0 [%]	0,2 [%]	0-19 [%]
High N_2O	On	82 [%]	2 [%]	0-82 [%]
Low N_2O	On	0 [%]	2 [%]	0-82 [%]

Fig. 83 Alarm limits in the (S)CMV Child ventilation mode

* The default setting for the Desflurane high alarm is 8 %

7.5.1.3 Alarm limits setting in (S)CMV child mode

Table of adjustable alarm limits in the (S)CMV child mode				
Parameter	**default for ON/OFF**	**default setting**	**value graduation**	**adjustable values**
T.Vol. min	On	100 [ml]	10 [ml]	20 – 400 [ml]
MVol. min	On	1 [l]	0.5 [l]	0.5 – 1 [l]
Rate max.	---			
Rate min.	---			
P max	On	50 [cmH2O]	5 [cmH2O]	10 – 80 [cmH2O]
P min	On	12 [cmH2O]	2 [cmH2O]	2 – 70 [cmH2O]
High FiO_2	On	100 [%]	5 [%]	30 – 100 [%]
Low FiO_2	On	18 [%]	2 [%]	18 – 90 [%]
High CO_2	On	7,9 [%]	0,1 [%]	0-10 [%]
Low CO_2	On	3,2 [%]	0,1 [%]	0-10 [%]
RB CO_2	On	1,2 [%]	0,1 [%]	0-10 [%]
High HAL/ENFL /ISO/ SEV	On	3,0 [%]*	0,1 [%]	1-19 [%]
Low HAL/ENFL /ISO/SEV	On	0,0 [%]	0,1 [%]	0-19 [%]
High N_2O	On	82 [%]	1 [%]	0-82 [%]
Low N_2O	On	0 [%]	1 [%]	0-82 [%]

Fig. 84 Alarm limits in the (S)CMV Child ventilation mode

* The default setting for the Desflurane high alarm is 8 %

7.6 Ventilation mode PCV

For the controlled ventilation the anesthesia system NARKOMAT+ offers the ventilation modes PCV child and PCV adult.

With the Pressure Controlled Ventilation a pre-set maximum inspiratory pressure will be kept. The change to expiration is time regulated.
The tidal Volume is a result of the inspiratory time, pre-set pressure limit, flow and pulmonary resistance. The advantage is the avoiding of pressure peaks, so that it is mainly used in the pediatric, but also increasingly used to ventilate adults e.g. severe lung failure or lung leakage.

7.6.1 PCV adult ventilation mode

(The screen titles change according to the ventilation modes Adult / Child)

Set the operating panel selection switch to “CMV adult” for the controlled ventilation of adults.

In the appearing display the requested ventilation mode “PCV - adult” can be selected through turning and pressing the encoder button.

The ventilation modes (S)CMV and PCV are options. The appearance of this window depends on the apparatus configuration.

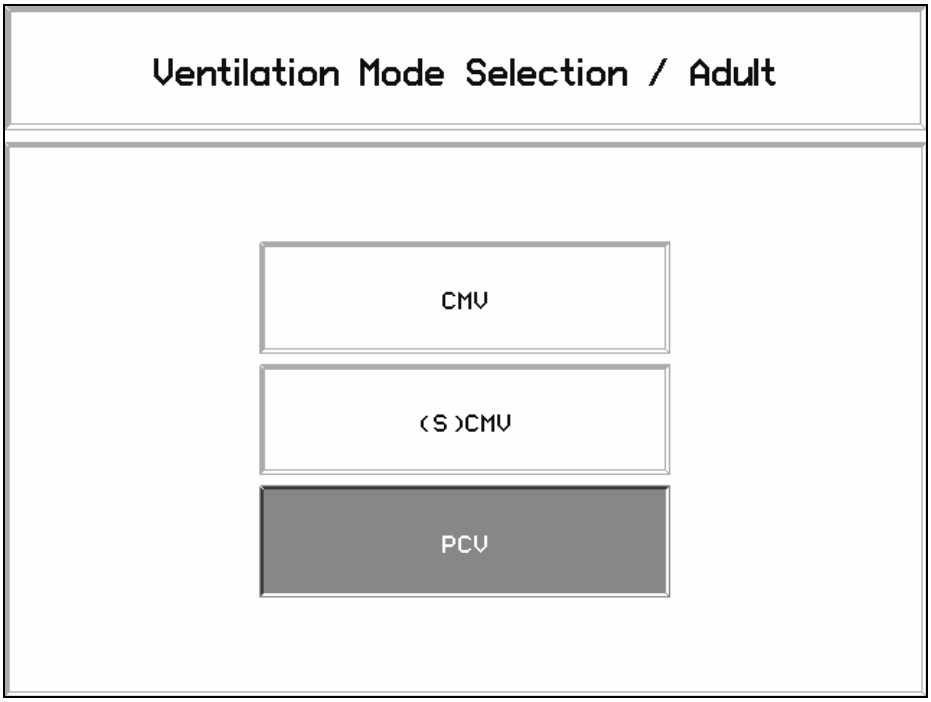


Fig. 85 Display “ventilation mode adult”

PCV adult ventilation mode (continued)

The parameters for the machine ventilation of adults can be determined and controlled on the display. The figure shows the standard setting for this patient group.

To implement a controlled ventilation, these parameters must be confirmed with the encoder button by pressing the "Push ENTER to Activate" display key.

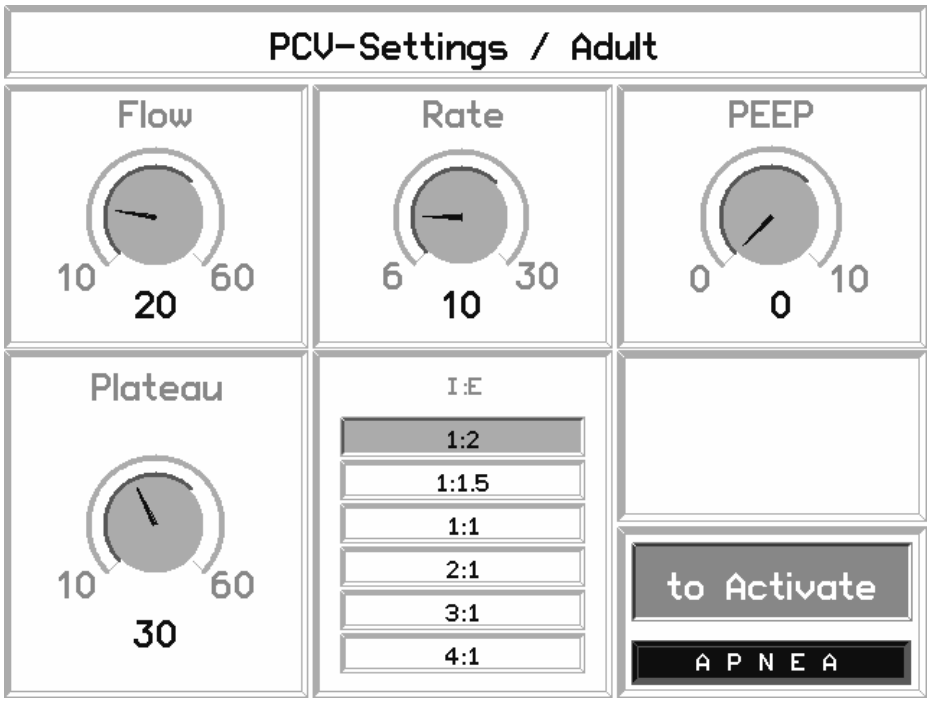


Fig. 86 "PCV -Settings / Adult" display

The parameter setting fields determine the following:

Flow	Maximum inspiratory flow in l/min	Plateau	The pre-set maximum inspiratory pressure in cmH2O
Rate	Ventilation rate in 1/min	I:E	Ventilation time ratio of inspiration and expiration
PEEP	Setting of a PEEP in cmH2O		

PCV adult ventilation mode (continued)

Parameter settings ventilation mode PCV Adult / Child

Parameter	Ventilation Mode					
	CMV	(S)CMV	PCV	CMV	(S)CMV	PCV
	Child			Adult		
Tidal Volume [ml]	20-400 (200)			300-1400 (500)		
Flow [l/min]			10-60 (20)			10-60 (10)
Frequency [1/s]	10-60 (20)			6-30 (10)		
I:E	1: 3 1: 2 1: 1,5 1: 1 2: 1 3: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 3: 1 4: 1 (1: 2)	1: 3 1: 2 1: 1,5 1: 1 2: 1 3: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 (1: 2)	1: 2 1: 1,5 1: 1 2: 1 3: 1 4: 1 (1: 2)
PEEP [cmH2O]	0-15 (0)		0-10 (0)	0-15 (0)		0-10 (0)
Plateau [cmH2O]	20%, 30%, OFF (OFF)		10-60 (20)	20%, 30%, OFF (OFF)		10-60 (20)
Sigh	ON, OFF (OFF)			ON, OFF (OFF)		
Trigger [cmH2O]		-2, -4, -6 (-2)			2, -4, -6 (-2)	

() The values inside the brackets are the default values

PCV adult ventilation mode (continued)

During the PCV adult ventilation mode, the display shows the measured pressure, volume, ventilation rate as well as the gas concentration values.

Alarms are displayed below the real-time graphic diagrams.

The set parameters are displayed in the bottom line of the display.

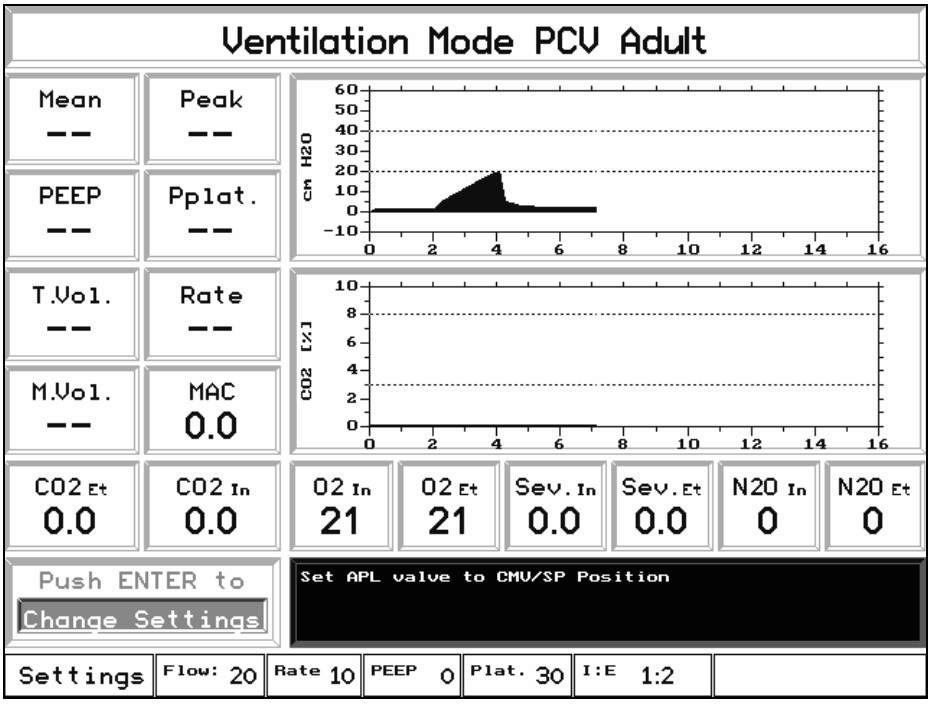


Fig. 87 "Start in PCV adult" ventilation mode display

In the measured value fields, the following is displayed.

Mean	Average pressure in cmH2O	Peak	Peak airway pressure value in cmH2O
PEEP	Positive end expiratory pressure in cmH2O	Plat	plateau pressure in cmH2O
T. Vol.	Tidal volume in ml	Rate	Ventilation rate in 1/min
M. Vol.	Minute volume in l	MAC	Minimum alveolar concentration

PCV adult ventilation mode (continued)

After the parameter settings have been confirmed, an alarm such as, for instance, the warning message for setting the ventilation pressure valve (APL) is displayed. This message alarm automatically disappears after approx. 15. sec.

In the graphical representation of the ventilation pressure, the set Pmax and Pmin limits appear as thin lines.

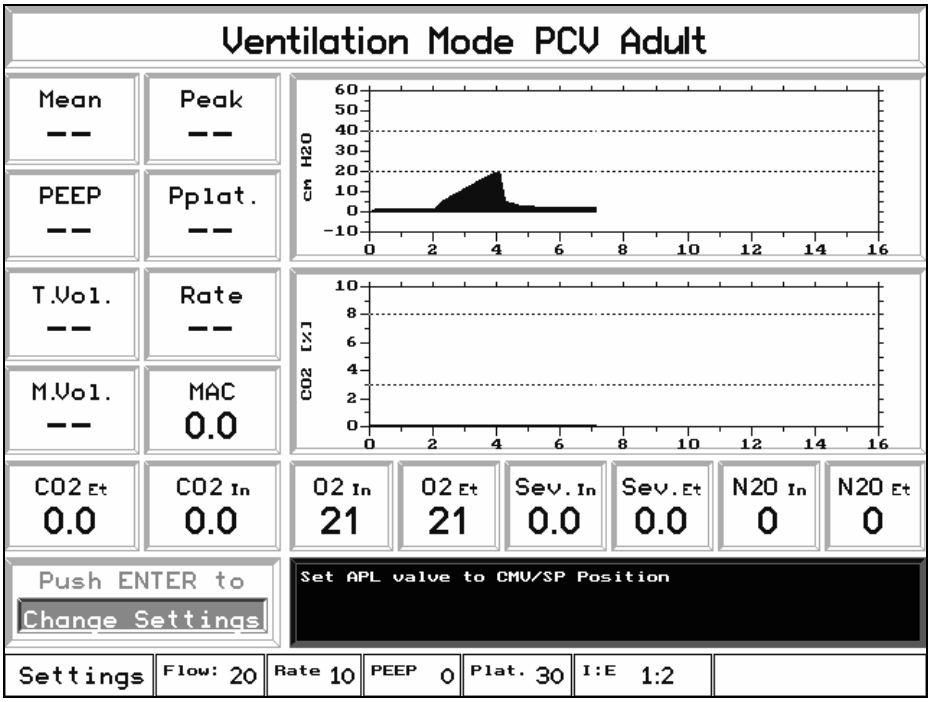


Fig. 88 "PCV adult" ventilation mode display

In the measured value fields, the following is displayed:

CO2 Et End Tidal CO_2 concentration of breathing gas in % or mmHg

O2 In Inspiratory oxygen concentration of breathing gas in %

Sev In Inspiratory Agent concentration of breathing gas in %

N2O Et Exspiratory Nitrous oxide concentration of breathing gas in %

CO2 In Inspiratory CO_2 concentration of breathing gas in % or mmHg

O2 Et Expiratory oxygen concentration of breathing gas in %

Sev Et Expiratory Agent concentration of breathing gas in %

N2O In Inspiratory Nitrous oxide concentration of breathing gas in %

7.6.1.1 Changing graphic settings in PCV Adult mode

To change the current ventilation parameters, press the key “Change settings” in the “Push enter to” display field. A PCV-Settings/Adult window replaces the graphical presentation.

The parameters are set as at the start of the ventilation mode with the aid of the operating panel encoder button. Additionally you have the possibility to change the ventilation mode in this window.

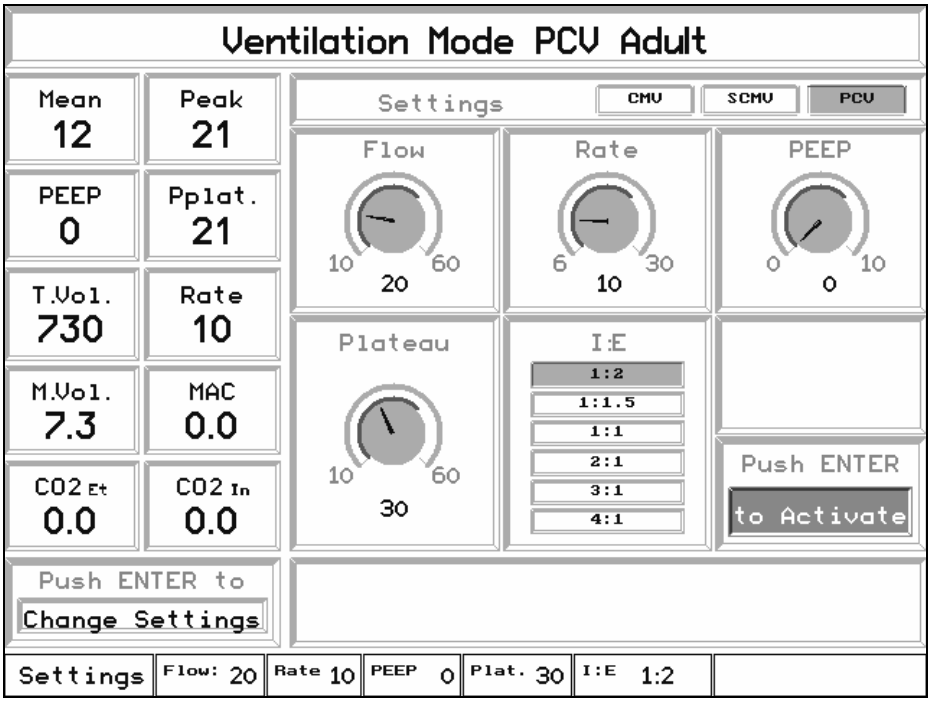


Fig. 89 "Parameter setting during the PCV adult" ventilation mode display

7.6.1.2 Alarm limits setting in PCV adult mode

The alarm limits in the “PCV adult” ventilation mode are set by pressing the “Limits” key on the operating panel.

Above the graphics representation the "Alarm limits page 1 of 2" window is opened, showing the respective alarm parameters in pairs.

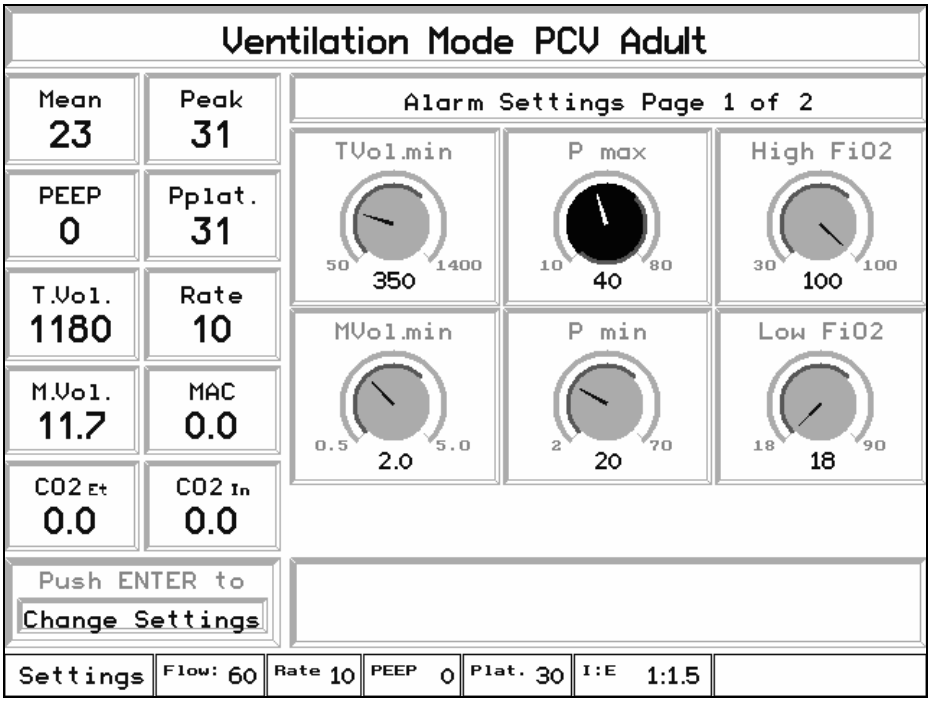


Fig. 90 Display “Alarm limits 1 in the PCV adult ventilation mode”

The individual alarms mean:

T.Vol. min	Limit for min. tidal volume in ml
P max	Maximum pressure limit (high pressure limit) in cmH2O
O_2 max	Limit for max. FiO_2 value in %
MVol. min	Limit for min. minute volume in l
P min	Minimum pressure limit (lowest pressure limit)) in cmH2O
O_2 min	Limit for min. FiO_2 value in %

Alarm limits setting in PCV adult mode (continued)

Through pressing the button “limits” a second time, the alarm limits for the gas module can be set.

Above the graphics representation the "Alarm limits page 2 of 2" window is opened, showing the respective alarm parameters in pairs.

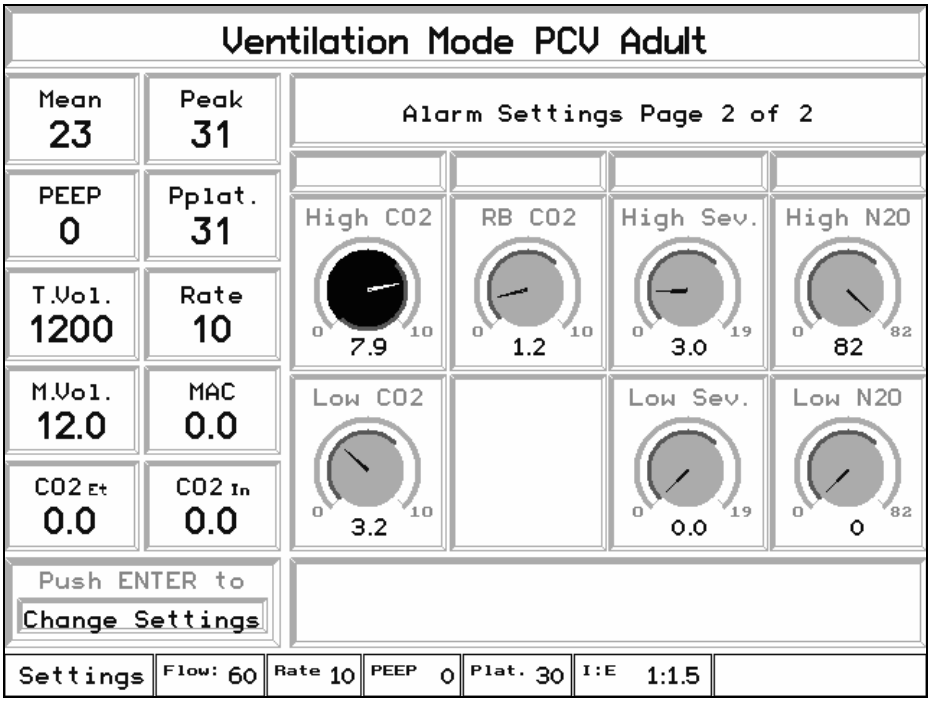


Fig. 91 Display “Alarm limits 2 in the PCV adult ventilation mode”

Explanation of individual alarms:

High CO_2	Limit for the maximum end CO_2 concentration
Low CO_2	Limit for the minimum end CO_2 concentration
RB CO_2	Maximum difference between the inspiratory and expiratory value of CO_2
High Sev	Limit for the maximum inspiratory anesthesia gas concentration
Low Sev	Limit for the minimum inspiratory anesthesia gas concentration
High N_2O	Limit for the maximum inspiratory N_2O concentration
Low N_2O	Limit for the maximum inspiratory N_2O concentration

Alarm limits setting in PCV adult mode (continued)

The alarm limits are selected and changed with the aid of the encoder. The alarm limit window is closed by activating the “Limits” key for the second time.

To change the individual alarm parameter, it is selected with the encoder.

The rotary display button is activated by pressing the encoder. The frame around the rotary button is highlighted.

The alarm limit value is decreased by turning the encoder anti-clockwise and increased by a clockwise rotation.

The alarm limit settings of the parameters offer different value graduations.

The changed setting is stored by pressing once again on the encoder, and the frame around the rotary button returns to normal.

By pressing the “Limits” key again, the alarm setting window is closed. The window otherwise closes automatically after 10 seconds.

Table of adjustable alarm limits in the PCV adult mode				
Parameter	**default for ON/OFF**	**default setting**	**value graduation**	**adjustable values**
T.Vol. min	On	350 [ml]	50 [ml]	50 – 1400 [ml]
MVol. min	On	2 [l]	0.5 [l]	0.5 – 5 [l]
Rate max.	---			
Rate min.	---			
P max	On	50 [cmH2O]	5 [cmH2O]	10 – 80 [cmH2O]
P min	On	12 [cmH2O]	2 [cmH2O]	2 – 70 [cmH2O]
High FiO_2	On	100 [%]	5 [%]	30 – 100 [%]
Low FiO_2	On	18 [%]	2 [%]	18 – 90 [%]
High CO_2	On	7,9 [%]	0,2 [%]	0-10 [%]
Low CO_2	On	3,2 [%]	0,2 [%]	0-10 [%]
RB CO_2	On	1,2 [%]	0,2 [%]	0-10 [%]
High HAL/ENFL /ISO/ SEV	On	3,0 [%]*	0,2 [%]	1-19 [%]
Low HAL/ENFL /ISO/SEV	On	0,0 [%]	0,2 [%]	0-19 [%]
High N_2O	On	82 [%]	2 [%]	0-82 [%]
Low N_2O	On	0 [%]	2 [%]	0-82 [%]

Fig. 92 Alarm limits in the PCV adult ventilation mode

* The default setting for the Desflurane high alarm is 8 %

7.6.1.3 Alarm limits setting in PCV child mode

Table of adjustable alarm limits in the PCV child mode				
Parameter	**default for ON/OFF**	**default setting**	**value graduation**	**adjustable values**
T.Vol. min	On	100 [ml]	10 [ml]	20 – 400 [ml]
MVol. min	On	1 [l]	0.5 [l]	0.5 – 1 [l]
Rate max.	---			
Rate min.	---			
P max	On	50 [cmH2O]	5 [cmH2O]	10 – 80 [cmH2O]
P min	On	12 [cmH2O]	2 [cmH2O]	2 – 70 [cmH2O]
High FiO_2	On	100 [%]	5 [%]	30 – 100 [%]
Low FiO_2	On	18 [%]	2 [%]	18 – 90 [%]
High CO_2	On	7,9 [%]	0,1 [%]	0-10 [%]
Low CO_2	On	3,2 [%]	0,1 [%]	0-10 [%]
RB CO_2	On	1,2 [%]	0,1 [%]	0-10 [%]
High HAL/ENFL /ISO/ SEV	On	3,0 [%]*	0,1 [%]	1-19 [%]
Low HAL/ENFL /ISO/SEV	On	0,0 [%]	0,1 [%]	0-19 [%]
High N_2O	On	82 [%]	1 [%]	0-82 [%]
Low N_2O	On	0 [%]	1 [%]	0-82 [%]

Fig. 93 Alarm limits in the PCV Child ventilation mode

* The default setting for the Desflurane high alarm is 8 %.Alarm Suppression Key

By pressing the alarm suppression key on the operating panel, all acoustic alarms are muted for a maximum period of 2 minutes.

The muting is cancelled by pressing the key again before the expiration of the period and in the case that another alarm occurs.

8 Dismantling and Reassembling

8.1 Patient module

To remove the patient module, first the CO_2 absorber and then the bag-in-bottle system are removed. The patient module can be pulled out of its seat after releasing it from the apparatus.

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

Note: The expiratory flow sensor can be replaced without removing the patient module cover.

8.1.1 CO_2 absorber canister

To release the absorber canister from the patient module, turn the unit anti-clockwise and unscrew the unit together with the connecting pipe. Next, the soda lime can be removed from the absorber.

Refill the absorber with new soda lime up to approx. 4 cm under the rim of the canister. Check that the absorber contains the mesh plate and that the connecting pipe contains no soda lime granules.

Spent soda lime changes in color. Replace the soda lime if approx. 2/3 of the absorber content is discolored.

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 malabsorbant. The soda lime should therefore be replaced after longer utilization, i.e. every second day.

CAUTION: After changing the soda lime, carry out a fresh-gas system leak test.

8.1.2 Bag-in-bottle system

Unscrew the patient dome from the bayonet fitting by turning it anti-clockwise. The dome can be pulled out from below.

Now the bellows can be pulled off the connection cone.

Dismantling and reassembling (continued)

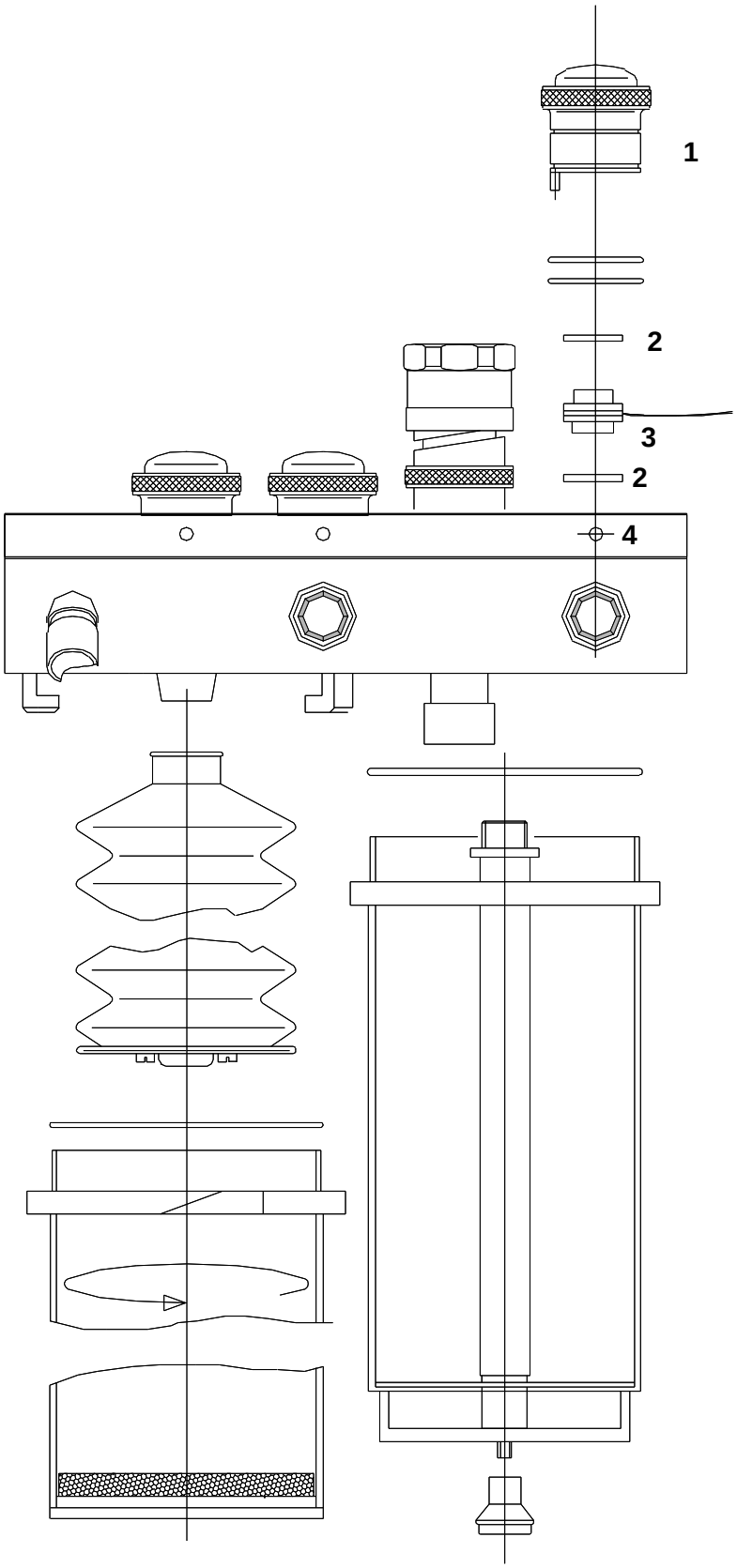


Fig. 94 Dismantling of the patient module, front view

8.1.3 Replacing the expiratory flow sensor

To replace the flow sensor (3), the expiration valve body (4) must be removed.

- Remove the fixing screw (4) from the front and pull the valve body out of the cover.

- The flow sensor can now be removed and replaced after undoing the plug-in connection.

- Slide the plug-in connection and supply back into the recess in the bottom section.

- The flow sensor and the sealing mats (2) is placed into the recess with the larger connection facing downwards.

- The expiration valve is placed back into the cover and secured with the screw at the front.

CAUTION: Carry out a sensor test after replacing the flow sensor.

8.1.4 Dismantling the ventilation pressure valve (APL)

- To dismantle the ventilation pressure valve unscrew the union nut. The top section can now be removed.

- The membrane can be removed from the bottom section and replaced, if necessary.

- The membrane is placed back into the bottom section with the metal place facing upwards.

- Replace the top part of the ventilation pressure valve and secure with union nut.

CAUTION: The spring in the top of the ventilation pressure 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.

Dismantling and reassembling (continued)

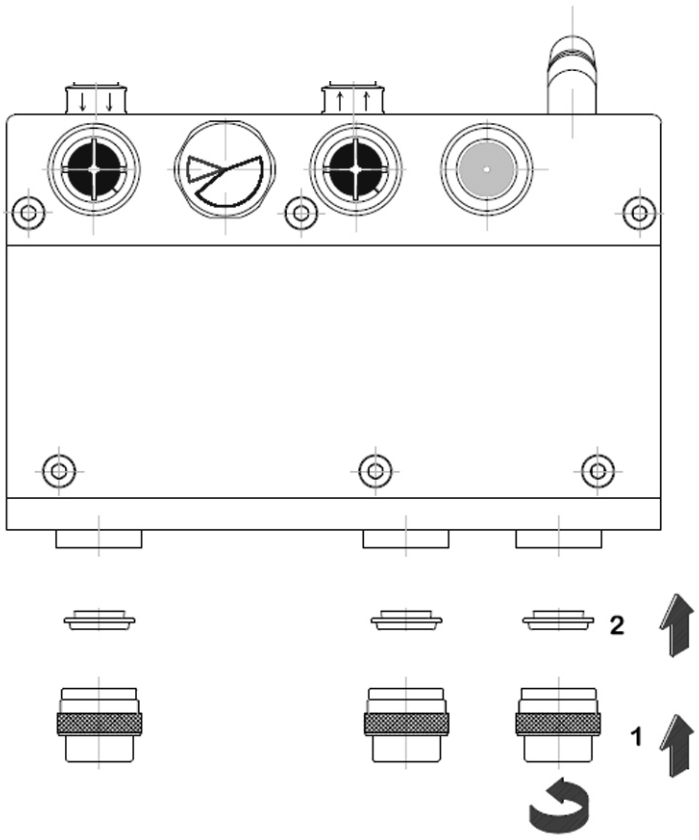


Fig. 95 Dismantling of the patient module, top view

Dismantling and reassembling (continued)

8.1.5 Replacing the diaphragm valves

- To replace the diaphragm valves (6) at the rear of the patient module, undo the coupling nut (2).
- The diaphragm valves are removed from the patient module together with the valve connection plate (3) and the coupling nut.
- After unscrewing the small fixing nut (1), the diaphragm valves can be pressed out of the valve connection plate.
- Assemble in reverse order.
- During reassembling, it should be observed that the flat packing (5) has been pushed onto the diaphragm valve connection.
- When attaching the valves to the patient module the additional membrane (7) at the expiration diaphragm valves must be inserted in the valve seat.

Dismantling and reassembling (continued)

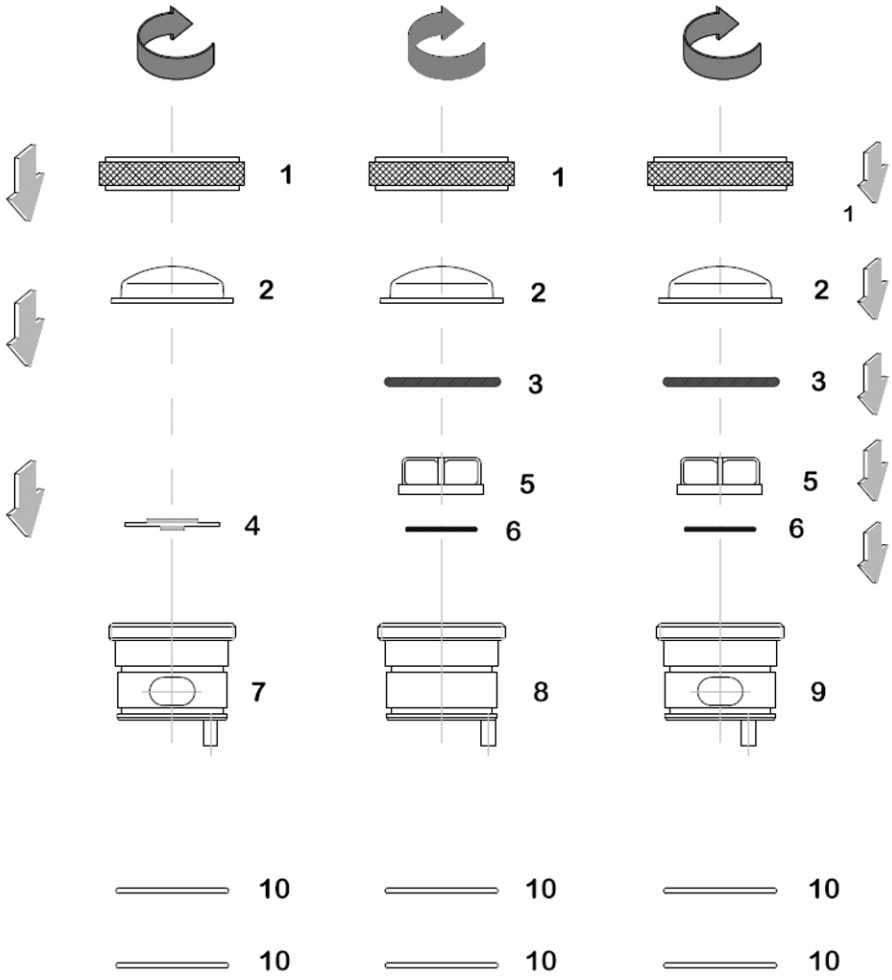


Fig. 96 Dismantling of the valve bodies

Dismantling and reassembling (continued)

8.1.6 Valves (emergency air, inspiration, and expiration valve)

- To dismantle the valves, the coupling ring (1) must be unscrewed from the valve body (7,8,9). The valve cover (2,2a) can now be removed.
- The O ring (3) and the metal baskets (5) in the expiration or inspiration valve can now be removed. The valve plate (6) can be removed. Assemble in reverse order.
- The membrane of the emergency air valve (4) can be carefully removed from the valve body after removing the coupling ring and the valve cover. Assemble in reverse order.
- The O-rings (10) of the valve bodies have only to be exchanged if the valves were pulled out of the patient module top.

8.2 Connecting and disconnecting of the vaporizers

- To connect the vaporizers place them carefully on the vaporizer mounting device.
- Lock the vaporizer with the locking lever and check for proper seat.

WARNING: Only vaporizers with Interlock-System have to be used with the unit.

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

CAUTION: To drain and fill the vaporizer remove it from the unit and place it for example on a table.

9 Cleaning

9.1 Cleaning and sterilizing the apparatus

WARNING: Electric shock and fire hazard! Before cleaning, switch off apparatus and disconnect from mains.

9.1.1 Cleaning the housing

The apparatus housing can easily be cleaned with a cloth slightly wetted with a liquid cleaning agent. To avoid abrasion, the cloth must be moist. If additional cleaning is required, use a usual surface disinfecting agent.

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

9.2 Patient module

9.2.1 Sterilizing the patient module

The patient module can be autoclaved with a temperature of up to 134℃. For this purpose, the bag-in-bottle system and the absorber must be removed. The patient module requires, however, no further dismantling.

The transportation protection should be installed at the rear of the patient module.

CAUTION: The patient dome of the bag-in-bottle systems 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, however, not use alcohol.

The bellows, absorber canister can also be autoclaved at 134℃. In order to enhance the life of sealing materials, a temperature of 121℃ would be preferential. The patient hoses with y-piece and hand mode bag can be autoclaved at 121℃.

The upper part of the ventilation pressure valve (APL) should be dismantled before autoclaving.
Please autoclave the APL upper part and the membrane as **separated parts** with the patient module.

10 Preventive Maintenance and Servicing

10.1 General

In order to ensure the fault-free operation of the apparatus, the following service work should be carried out in predetermined intervals.

WARNING
Not servicing the unit according to the following instructions and intervals will lead to a loss of the warantee

Note: After completion of the service work, the initial ventilator unit tests and the respective calibration should be carried out. Without these final tests/calibrations the apparatus may not be used on patients. See also the respective sections of these Operating Instructions.

10.1.1 Preventive Maintenance by a qualified technician

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.

10.1.1.1 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 tactile 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 & AIR: 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

10.1.1.2 12 Month Service Interval

- ☐ Perform all the points of the 6 month service interval
- ☐ Inspect and if necessary, replace the locking bolt of the breathing circuit
- ☐ 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 bellow valves (3 x 323-0100)
- ☐ Replace the bellow 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 cmH2O; 3 PSI) pressure reducers for the solenoid valve block
- ☐ Check the electrical and pneumatic function of the solenoid valves MV1 to MV4

10.1.1.3 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)

CAUTION: Carry out an initial examination after each servicing and before clinical use.

10.2 Servicing the Vaporizer

For servicing the vaporizer, please refer to the operating and service instructions of the used anesthetic agent vaporizers.

10.3 Other Servicing

Other service work on the gas processing unit, fresh gas dosing etc. are carried out by the service department. Please see the **HEYER NARKOMAT+** service instructions for further information and a detailed description of the work.

11 Specifications

Test mark: CE 0044

General specification:

Dimensions

Height:	1540 mm
Width:	915 mm
Depth:	795 mm
Weight:	approx.. 136 kg (without vaporizer)
Drawers	2
Writing Tray	1, Deject able

Electrical connection:

Power supply	230 V+/-10% / 50 Hz	120 V+/-10% / 60 Hz
Current input	Connection value 12 A of which 7 A (max.) for additional sockets	Connection value 12 A of which 7 A (max.) for additional sockets
Power input	Approx. 210 VA	Approx. 210 VA
Battery supply	approx. 30 minutes, battery capacity 6.5 Ah, 12 V	approx. 30 minutes, battery capacity 6.5 Ah, 12 V
Battery charging period at most 7 hours, if apparatus is activated.		
Additional sockets	2 each with 2 x 5 AT fuses	Up to 4, with one 10 A fuse
Electrical protection	Protection class I appliances Type B devices, Electrical main switch	

Pneumatic connection data:

Central gas supply (can vary due to different standards)

O_2:	500 kPa ± 150 kPa
AIR:	500 kPa ± 150 kPa
N_2O:	500 kPa ± 150 kPa

Ambient conditions:

Storage temperature: -5 - + 50℃

Operating temperature: +10 - + 35℃

Humidity (rel. humidity)

Storage:	15 - 95 % , non-condensing
Operation:	15 - 95 % , non-condensing

Fresh gas dosing: 6 x measuring tube block

Standard measuring tubes: (Illuminated)

O_2:	0.05 - 1 / 1.5 - 10 l/min
N_2O:	0.1 - 1 / 1.5 - 10 l/min
AIR:	0.1 - 1 / 1.5 - 10 l/min

"Ratio" system:	integrated with automatic N_20 cutoff when O_2 fails
Specifications (continued)	
(min. of 25 vol.% O_2 in fresh gas)	N_20 cutoff activation level 1,9 kPa x 100

Seat for anesthesia vaporizer: "Selectatec" compatible, double support

Breathing circuit /circular system:

Internal volume		approx. 2.5 l
Absorber volume		approx. 1.4 l; 1.6 kg
Absorber system		conventional filling
Condensation block		heated breathing circuit (36 +/- 2°C)
Processing		autoclavable at 134°C
System compliance		approx. 4.5 ml/Pa x 100 with standard hoses, is automatically compensated
Flow resistance at	60 L/min	2.9 Pa x 100
	30 L/min	1.6 Pa x 100
	5 L/min	2.2 Pa x 100
Fresh gas decoupling		automatic during inspiration, allowing constant volume ventilation

Materials used in the breathing circuit

Breathing circuit	Aluminum anodized
Breathing bag	Silicon
Hoses	Silicon
Valve plate	Silicon
Valve plate seals	Silicon
Valve bellows	Silicon
Heating blanket	Silicon
Absorber container	Polysulfone
Absorber insert	Chromium plated brass
Ventilation bellow	Silicon

AGS System

Extract flow of scavenging system	45 ± 10 L/min
max. pressure difference between breathing circuit and scavenging system	2 Pa x 100

Ventilator model:

Ventilator control (CMV):	time control, pressure limited, constant volume
Ventilator control (PCV) *:	time control, pressure control
Ventilation types:	Manual ventilation, spontaneous ventilation, CMV child, CMV adult, PCV child *, PCV adult *, S(CMV)
Tidal volume:	20 - 1400 ml (+/- 10%),
CMV child:	20 - 400 ml,
CMV adult:	300 - 1400 ml

Ventilation frequency:	4 - 60 1/min
CMV child:	10 - 60 1/min
CMV adult:	4 - 30 1/min
Resp. minute volume:	max. 20 l/min
I: E ratio:	1:1; 1:1.5; 1:2, 1:2.5; 1:3; 1:4; 1:5
inverse I:E Ratio	2:1, 3:1 and 4:1 (PCV)
Insp. Pause	max. 5 s
Exsp. Pause	max. 30 s
Plateau (end insp.)	20 % or 30% of insp. period
PEEP	0 - 15 +/- 2 Pa x 100
Max. insp. pressure:	80 Pa x 100
manual pressure control	4 - 60 Pa x 100
Compliance test	automatic
Leak tests	circular system, automatic after confirmation fresh gas system, automatic after confirmation
Oxygen monitor*	Type: Fuel cell FiO_2 display 0- 99 vol% O_2
Pressure monitor	Real-time graphics
Numerical pressure values for	PEEP, Pmean, Ppeak
Ventilator monitor	Real-time graphics
Numerical values for	Tidal volumes, breathing frequency, minute volumes

Gas module

The accuracy of all gas measurements corresponds to the requests of the ISO 11196 (Accuracy of the indicated reading for Anesthetic agents) and ISO 9918 (Capnometers for use with humans, requirements) the latest 4 min after switching on the unit.

Gas analysis

CO_2	Display: 0-10%, 0-76 mmHg or 0-10 kPa Accuracy: ± 0.5 Vol% or ±12% rel. reaction time: <500 ms 150ml/min
N_2O	Display: 0-100% Accuracy: ± 2% or + 8% rel. reaction time: <500 ms 150ml/min
O_2	Display: 0-100% Accuracy: ± 3.0% reaction time: <500 ms 150ml/min

* Option

Anesthesia Gas

Measured anesthesia gas:	Halothane, Isoflurane	Display: 0-8,5 Vol%
	Enflurane, Sevoflurane	Display: 0-10 Vol%
	Desflurane	Display: 0-22%
	Accuracy: 0-0.15%: or + 15% rel.	
	reaction time: <500 ms 150 ml/min	
Sample flow rate	150 ml/min	

Ambient conditions during operation

Temperature:	+10 ℃ - +45 ℃
Humidity:	5% - 90%
Air pressure	570 cmH2O – 1100 cmH2O

Accuracy of the measurements

Pressure		±5% of the measured value, at least 1 Pa x 100*
O_2		±5% of the measured value
Volume -	Adult mode	±10% of the measured value*
Child mode		±10% of the measured value, at least 10 ml*
Flow tubes		±3% of the scale value*
Rate		±1 / min*

*ATPD

Subject to alterations, issued May 2009

12 Warranty

Warranty declaration by HEYER Medical AG

In addition to the legal warranty acc. to HBG §377, HEYER MEDICAL AG shall grant a warranty of 12 months for the purchase of a new apparatus from the HEYER product range. The warranty period begins with the date of invoice and is subject to the following conditions:

1. Within the warranty period we will eliminate free of charge any defects or damages on the device that are shown to be caused by a manufacturing or material error. The warranty does not include easily breakable parts, e.g. glass or consumable parts.

2. Warranty services can only claimed upon submission of a delivery note (bill of delivery or invoice); the type and method of damage remedy (repair or replacement) shall be at the discretion of HEYER MEDICAL AG. Warranty services do not result in an extension of the warranty period, nor do they entail a new warranty being granted. There is no independent warranty period for installed spare parts.

3. Excluded from the warranty are: Damages caused by improper use, operating errors, mechanical stress or non-observance of the operating instructions, as well as damages caused by force majeure or by extraordinary environmental conditions.

4. Warranty services may only be claimed if proof is submitted to confirm that all service and maintenance work has been carried out by authorized staff.

5. The warranty includes all faults that impair a faultless functioning of the device on the basis of technical defects of individual components. The warranty obligation can only be recognized by us if the device has been used properly and according to its intended use and no repair attempts have been undertaken by the client himself or by third parties. The warranty claim does not include faults caused by mechanical damages or if the device is being operated with accessories originating from third parties.

6. The warranty is also void if changes, alterations or repairs are made to the device by persons not authorized to do this.

7. The warranty claim only applies to customers of HEYER MEDICAL AG; it cannot be transferred to third parties.

8. The rejected device is to be shipped back to our plant postage free. In case of a request by our customer service department, the costs for shipping to the plant are to be initially generally borne by the customer. After successful repair, we will send the device back freight collect. If HEYER MEDICAL AG confirms the existence of a warranty claim, the customer will receive reimbursement for the costs of delivery and/or transport of the apparatus. Repair parts that do not fall under the warranty claim will be billed by us. The shipping of the device to us always counts as a complete assignment to eliminate all faults and/or replace missing parts, unless the customer expressly excludes partial services. Additional claims to transfer or reduce and replace damages of any kind in particular also of damages not incurred on the object of delivery itself are excluded.

Our service address:

HEYER Medical AG
Carl-Heyer-Straße 1-3
D-56130 Bad Ems - Germany
Tel.: (02603)791-3
Fax: (02603)70 424

Subject to technical changes!
Rev. No.: 3.1 dated 05.2009

Notes:

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