User's manual

MAQUET

VENTILATOR SYSTEM
SERVO-i V3.0

CRITICAL CARE

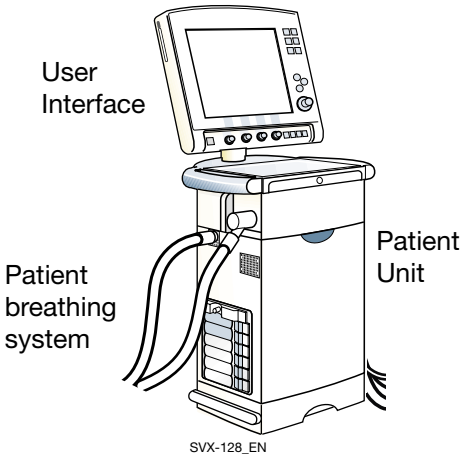
Contents

1 • Introduction

1.1 Device Description

This section provides general information about the Servo-i Ventilator System along with guidelines for appropriate use.

1.1.1 Device Diagram



1.1.2 Device Components

The Servo-i Ventilator System consists of the following components:

- User Interface—for setting ventilation modes, displaying patient data, and indicating alarms
- Patient Unit—for mixing gases
- Patient Breathing System—for delivering and exchanging gases

1.1.3 Intended Use

The Servo-i Ventilator System is intended for treating and monitoring patients with respiratory failure or respiratory insufficiency.

1.1.4 Intended User

The Servo-i Ventilator System should be used only by those who:

- are a professional health care provider, *and*
- have received training in the use of this system, *and*
- have experience with ventilation treatment.

1.1.5 Intended Use Environment

The Servo-i Ventilator System should be used only:

- in hospitals
- in facilities whose primary purpose is to provide health care
- during transport of a patient within or between hospitals or health care facilities

1.1.6 Servicing Guidelines

- Regular Service

  The Servo-i Ventilator System must be serviced at regular intervals by professionals who have received specialized training.
- Complete Service Records

  All service performed on the Servo-i Ventilator System must be recorded in a service log in accordance with hospital procedures and local and national regulations.
- Service Contract Strongly Recommended

  We strongly recommend that all service on the Servo-i Ventilator System be performed as part of a service contract with MAQUET.

1.1.7 Disclaimers

- Improper Use

  MAQUET has no responsibility for the safe operation of Servo-i Ventilator System if the *Intended Use* requirements specified in this document are not followed.

- Improper User

  MAQUET has no responsibility for the safe operation of Servo-i Ventilator System if the *Intended User* requirements specified in this document are not followed.
- Improper Use Environment

  MAQUET has no responsibility for the safe operation of Servo-i Ventilator System if the *Intended Use Environment* requirements specified in this document are not followed.
- Nonprofessional Servicing

  MAQUET has no responsibility for the safe operation of the Servo-i Ventilator System if service or repairs are performed by persons without the appropriate professional training.

1.2 Warnings

Follow these safety guidelines. Additional warnings appear in context throughout this document.

1.2.1 General

- This manual summarizes the functions and safety features of the Servo-i Ventilator System. It is not all-inclusive and should not be construed as a substitute for training.
- Always perform a *Pre-use Check* before connecting the ventilator to a patient.
- If any of the following occurs, discontinue use of the ventilator and contact a service technician:
  - Unfamiliar pop-up windows on the screen
  - Unresolvable alarms
  - Unfamiliar sounds
  - Any unfamiliar or unexplained event
- Keep the ventilator upright during use.
- When the ventilator is connected to a patient:
  - Do not leave the patient unattended.
  - Make sure a resuscitator is readily available.
  - Do not lift the expiratory cassette.
  - Continuously monitor the settings and measurements displayed on the screen.

1.2.2 Power Supply

- The power cord should be connected only to a properly grounded AC electrical outlet.
- Do NOT use antistatic or electrically conductive tubing with this system.
- Make sure there are at least two fully charged batteries installed at all times.
- Avoid contact with external electrical connector pins.

- Unused module compartments should always contain an empty module to protect the electrical connector pins from spillage and dust.

1.2.3 Fire Hazard

- Keep the system and its gas hoses clear of all ignition sources.
- Do not use the system with worn or frayed hoses or hoses that have been contaminated by combustible materials such as grease or oil.
- Oxygen-enriched gas is extremely flammable: if you detect a burning odor, disconnect the oxygen supply to the ventilator and turn off the system.

1.2.4 Gases

- The gases used in the system must be free from particles.
- The gases used in the system must conform to the following standards for concentrations of water vapor and oil:
  - Air: $H_2O < 7\ g/m^3$; Oil < 0.5 mg/m^3
  - Oxygen: $H_2O < 20\ mg/m^3$
- The system is not intended to be used with any anesthetic agent.

1.2.5 Auxiliary Equipment

- Accessories, supplies, and auxiliary equipment used with the ventilator should:
  - be recommended by MAQUET
  - meet IEC 60601-1-1 standards
  - meet IEC standards as a whole system
- If a scavenging system (*i.e.*, gas evacuation) is connected to the ventilator, it must conform to ISO8835-3 guidelines for subatmospheric pressure and induced flow.
- Measurements of parameter values that have been processed by auxiliary equipment:
  - may be inaccurate if equipment not authorized by MAQUET is used
  - should be discounted if they conflict with information on the ventilator screen
  - must not substitute for therapeutic or diagnostic decisions

1.3 Version & Configurations

This manual applies to version 3.0 of the Servo-i Ventilator System, which can be delivered in three configurations: *Servo-i Infant*; *Servo-i Adult* and *Servo-i Universal* (Basic or Extended edition). Tables 1.1 and 1.2 provide details about each configuration.

1.3.1 Configurations

The following safety feature is implemented ONLY in the *Universal* and *Infant* configurations:

- The Main Rotary Dial and Direct Access Knobs become inoperative for 2 seconds when the user reaches a defined safety limit for the parameter being adjusted.

Table 1.1 shows the patient weight ranges served by each configuration; Table 1.2 lists the available functions and accessories and indicates whether they are included or optional with each configuration.

Table 1.1: Weight Ranges

Configuration	Weight Range (normal modes)	Weight Range (NIV PC+PS Infant)	Weight Range (NIV Nasal CPAP)
Servo-i Infant	0.5 kg – 30 kg	3 kg – 30 kg	0.5 kg – 10 kg
Servo-i Adult	10 kg – 250 kg	Not Applicable	Not Applicable
Servo-i Universal	0.5 kg – 250 kg	3 kg – 30 kg	0.5 kg – 10 kg

NIV = Non-Invasive Ventilation

Table 1.2: Servo-i Ventilator Configurations

Function or Accessory				
			Basic	Extended
Alarm output connection option	t	t	t	t
Automode, pressure	t	t	t	%
Automode, PRVC	t	t	t	%
Automode, volume	t	t	t	%
Bi-Vent	t	t	t	t
CO_2 Analyzer	t	t	t	t
NIV (Non Invasive Ventilation)	t	t	t	t
Nasal CPAP	t	-	t	t
Open Lung Tool	t	t	t	%
Pressure Control	%	t	%	%
Pressure Support	%	%	%	%
PRVC (Pressure Reg. Volume Control)	t	t	t	%
SIMV (PC) + Pressure Support	%	t	%	%
SIMV (PRVC) + Pressure Support	t	t	%	%
SIMV (VC) + Pressure Support	t	%	%	%
Suction Support	%	%	%	%
Upgrade to universal (all patient categories)	t	t		
Volume Control	t	%	%	%
Volume Support	t	t	t	%
Y Sensor measuring	t	t	t	t

% : standard
t : optional

Infant configuration

Adult configuration

Universal configuration

1.4 About this Manual

Chapter 1 – Introduction
Contains information about the proper and safe use of the system as well as version and configuration information.

Chapter 2 – System Overview
Contains numbered diagrams corresponding to the system as a whole, the user interface, and the patient unit. Provides procedures for basic user interface navigation.

Chapter 3 – Power Supply
Contains information about the three methods of powering the ventilator. Describes the proper use of the battery modules. Describes power supply-related alarms.

Chapter 4 – Operation Overview
Provides brief procedures for the complete use of the ventilator including the preforming the Pre-use Check, entering patient data, setting ventilation mode, and disconnecting the patient.

Chapter 5 – Monitoring and Recording
Provides procedures for displaying the patient breathing data as it is collected by the ventilator. Provides procedures for saving and recording data.

Chapter 6 – Ventilation Modes
Lists all available ventilation modes along with important reminders applicable to each mode. Lists settings required for each mode and defines the breathing parameters.

Chapter 7 – Alarms
Provides general procedures for responding to alarms and for viewing and setting alarm limits. Lists and categorizes the alarms related to breathing parameters and provides a table with the allowed range and default setting for each alarm limit.

Chapter 8 – Accessories
Provides procedures for using the following optional accessories: Servo Ultra Nebulizer, CO_2 Analyzer, and Y Sensor.

Chapter 9 – System Messages
Contains tables listing all alarms, Pre-use Check messages, CO_2 Analyzer calibration error messages, and technical error messages. Describes possible causes and remedies for error messages.

Chapter 10 – Specifications
Contains system specifications including default settings for breathing parameters and alarm limits.

Chapter 11 – Definitions
Contains definitions of terms used in the manual.

Appendix
Contains diagrams providing an operational overview of the entire system.

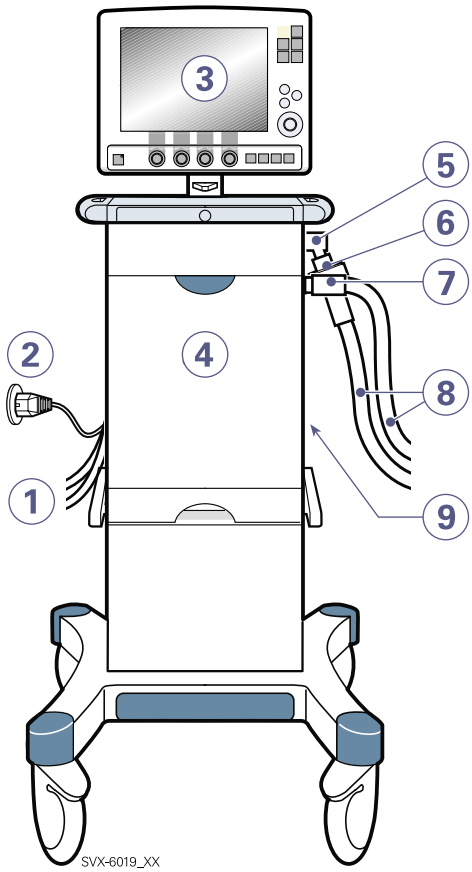
2 • System Overview

2.1 Ventilator

The User Interface controls ventilator settings. Settings may be adjusted using touchpads on the screen or a rotary dial.

Breathing parameters are continuously measured by transducers and controlled by a feedback system in the Patient Unit. The ventilator responds to a difference between the actual measured value of a parameter and the preset or calculated value by adjusting gas delivery to achieve the target value.

The system has two gas modules, one for air and one for O_2. Gases may be supplied by a medical pipeline system, a compressor, or by gas tanks.



1. Air and O_2 supply
2. Power cable
3. User Interface
4. Patient Unit
5. Expiratory inlet
6. Servo guard, viral/bacterial filter
7. Inspiratory outlet
8. Patient system
9. Module compartment

2.2 User Interface

The User Interface includes:

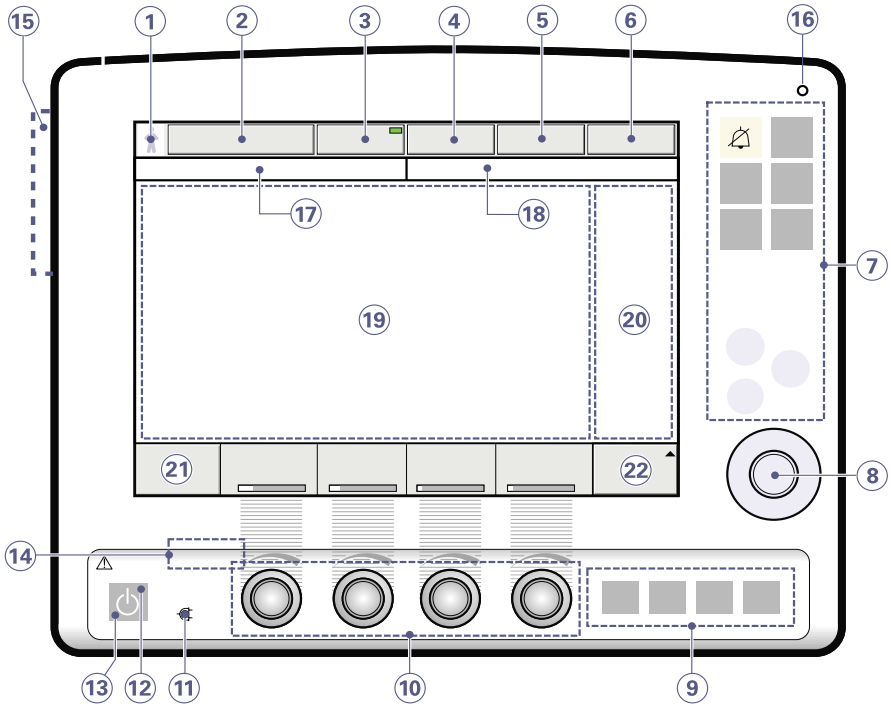
- a screen with active touch pads
- fixed keys
- rotary dials

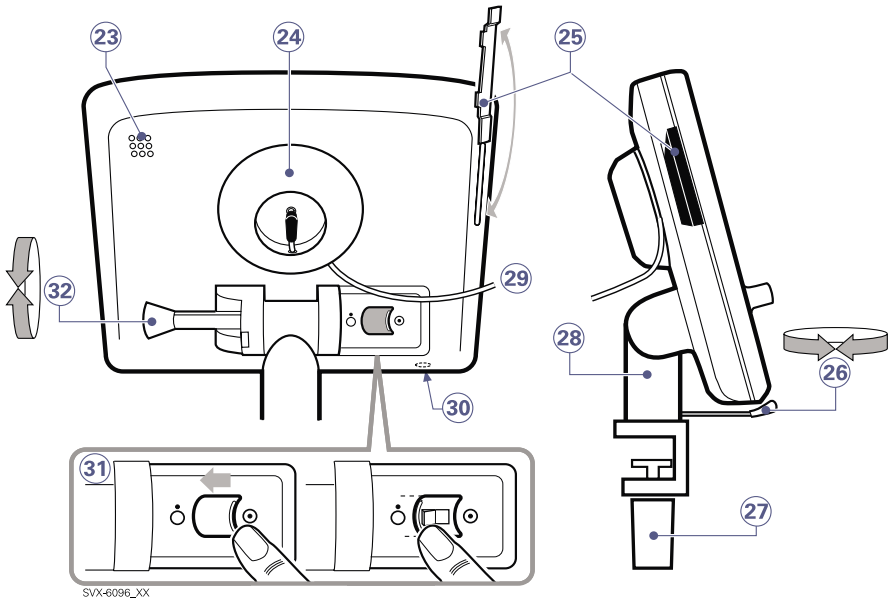
2.2.1 User Interface Components

Refer to the User Interface Diagram for locations of the following numbered components:

1. Patient category
2. Active mode of ventilation
3. ✗ Automode On/Off
4. Admit patient/Entered patient data and admission date
5. ✗ Nebulizer On/Off
6. System status parameters
7. Fixed keys
8. Main Rotary Dial—used to select a menu touch pad or parameter box, to adjust values, and to confirm settings
9. Special Function Keys—used to start special ventilatory functions
10. Direct Access Knobs—used for immediate adjustment of breathing parameters
11. AC Power indicator (green)
12. Standby indicator (yellow)
13. Start/Stop (Standby) ventilation key
14. On/Off switch (rear side)
15. Slot for Ventilation Record Card
16. Luminescence detector—for automatically adjusting screen brightness
17. Informative text messages, which include a purple symbol when triggered by the patient
18. Alarm messages
19. Waveform area—for monitoring two to four individually scaled parameters, including a pressure/flow loop
20. Measured values and alarm limits display (customizable)
21. Additional settings
22. Additional measured values
23. Loudspeaker
24. Cable reel for the control cable
25. Slot for Ventilation Record Card
26. Screen rotation locking lever
27. Locking screw for alternative cart mounting
28. Panel holder for positioning on the Mobile Cart
29. Control cable (2.9 meters long)
30. Service connector
31. On/Off switch (Set to On; when off, battery continues to charge)
32. Locking arm for tilting the screen

2.2.2 User Interface Diagram





2.2.3 User Interface Symbols

Audio off—silence or confirm an alarm

Alarm off

1:58 **Audio pause**—silence or confirm an alarm

Fixed key reserved for future use

Save **Save**—save a recording or copy screen

Attention—consult documentation
Note: This symbol may be different depending on panel version

Standby/Start ventilation—yellow indicates Standby

Power indicator—green indicates AC power connected

Battery—indicates ventilator is using battery power, with estimated minutes remaining

ON/OFF switch

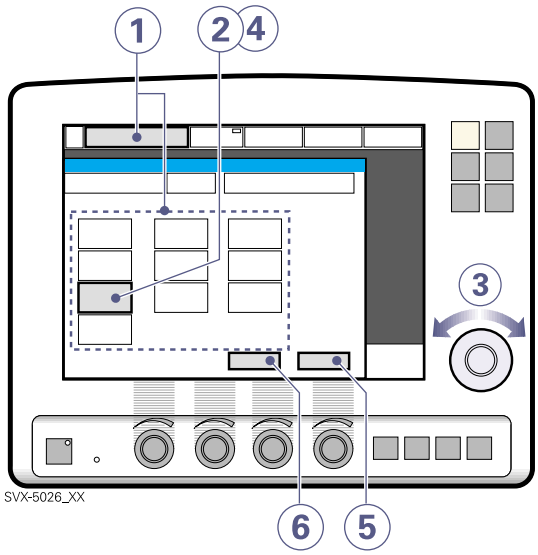
Trigger indication—appears in the message/alarm field when the patient triggers a breath

X **NIV symbol**—appears in the *Mode* pad field during Non-Invasive Ventilation.

2.3 Navigating the User Interface

The following subsections provide general procedures for working with the user interface. More detailed procedures for specific tasks are found in later chapters and in the *Appendix*.

2.3.1 Touch Screen



To adjust ventilator settings:

1. Activate the desired menu by touching one of the pads at the top of the screen.
2. Activate the desired parameter by pressing its touch pad.

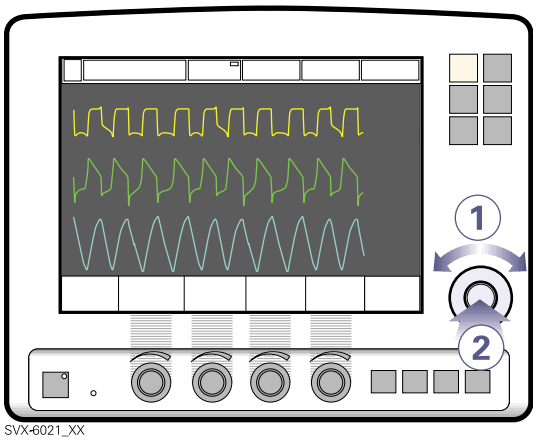
The pad is now highlighted in white with a blue frame and it is possible to enter a new value.

3. Turn the Main Rotary Dial to the desired value or line.
4. Confirm your setting by pressing the parameter touch pad or by pressing the Main Rotary dial.

The parameter touch pad turns blue again indicating the new setting has been entered.

5. Touch *Accept* to activate your settings.
6. Press *Cancel* to start over.

2.3.2 Main Rotary Dial



To use an alternative method for adjusting ventilator settings once you've activated the desired menu:

1. Turn the Main Rotary Dial until the desired menu touch pad is marked with a blue frame.
2. Press the Main Rotary Dial to confirm.

The menu touch pad is highlighted in white with a blue frame, indicating you can enter a new value.

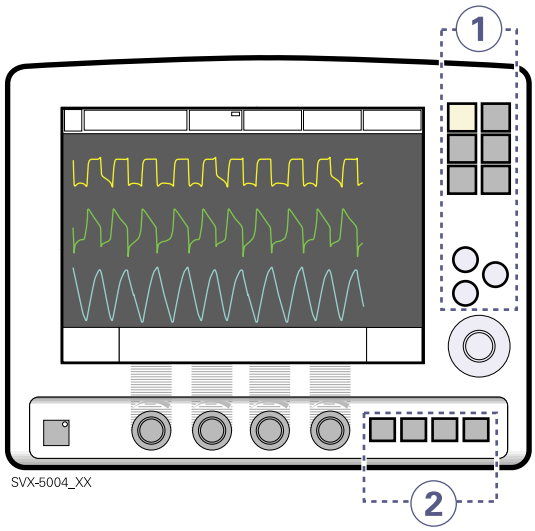
3. Turn the Main Rotary Dial to the desired value or line.
4. Confirm the setting by pressing the Main Rotary Dial.

The parameter touch pad turns blue again indicating a new setting has been entered.

5. Touch *Accept* to activate your settings, or *Cancel* to start over.

Note: When you reach the defined safety limits for a given parameter, the Main Rotary Dial becomes inoperative for 2 seconds to indicate that a limit has been reached. This feature is implemented only in the *Universal* and *Infant* versions of the Servo-i.

2.3.3 Fixed Keys



There are two groups of fixed keys on the user interface screen:

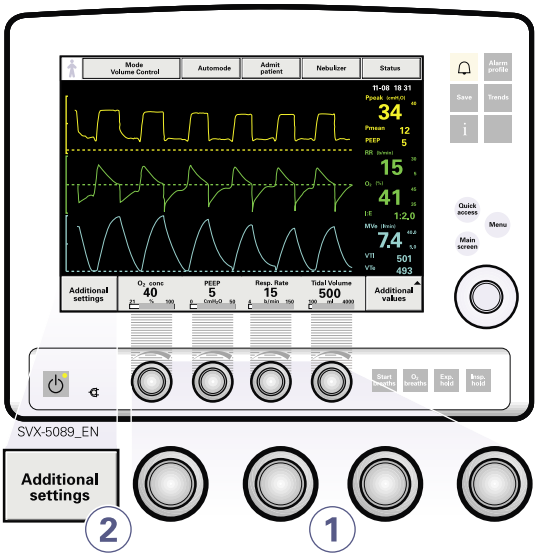
- The keys in group 1 activate user interface functions such as *Save* and access various screens such as *Menu*.
- The keys in group 2 start special ventilatory functions

Important: The special ventilatory functions require continuous supervision.

2.3.4 Direct Access Knobs

The four dials along the bottom of the User Interface screen are the Direct Access Knobs. They permit direct control of four breathing parameters, which are automatically selected depending on ventilation mode.

2.3.4.1 Using Direct Access Knobs

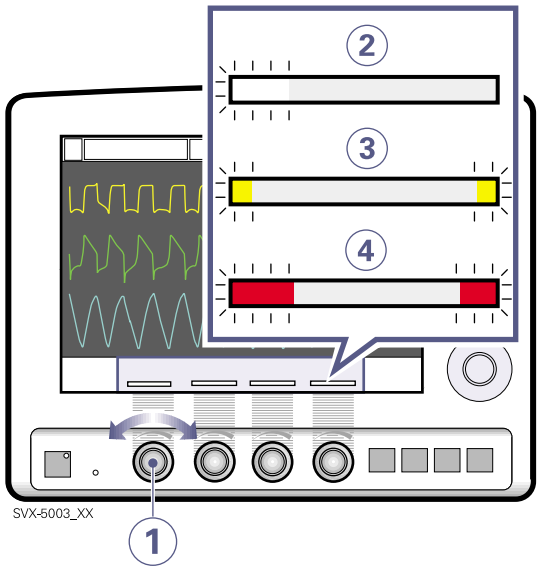


To adjust a breathing parameter directly:

1. Turn the Direct Access Knob corresponding to the parameter you wish to change until the desired value is displayed on the screen.
2. Confirm your setting by pressing the Direct Access Knob.

Note: When you adjust a breathing parameter using a Direct Access Knob, the parameter will change immediately starting with the next breath; no additional confirmation is required.

2.3.4.2 Direct Access Knobs - Safety



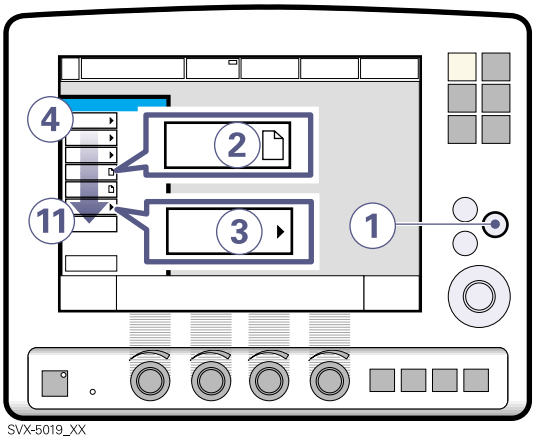
The four Direct Access Knob parameters are displayed at the bottom of the screen with color-coded bars that indicate whether the parameter values are within generally-recognized safety limits.

The figure above shows the following components.

1. A Direct Access Knob
2. A white bar indicating the corresponding parameter value is within generally recognized safety limits.
3. A yellow bar indicating the corresponding parameter value is outside safety limits; advisory information is displayed.
4. A red bar indicating the corresponding parameter value is *significantly* outside safety limits; an advisory warning is displayed accompanied by an audible signal.

Note: When you reach the defined safety limits for a given parameter, the Direct Access Knob becomes inoperative for 2 seconds to indicate that a safety limit has been reached. This feature is implemented only in the *Universal* and *Infant* versions of the Servo-i.

2.3.5 Menu Key



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To access the user interface windows:

1. Press the fixed key *Menu*.

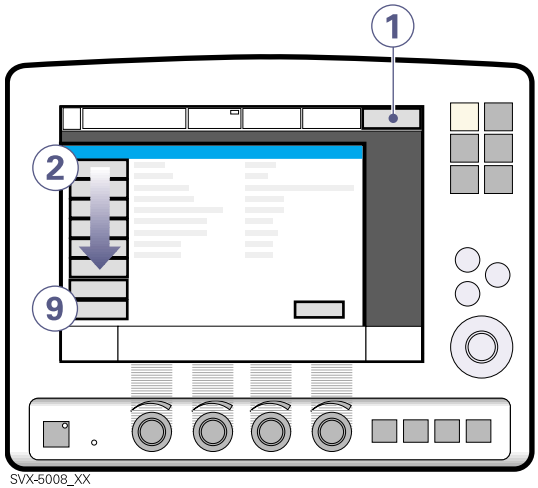
Touchpads leading to the user interface windows appear.

2. If the touchpad shows a sheet icon, press the touchpad to open a user interface window, OR
3. If the touchpad shows an arrow icon, press the touchpad to display the submenu.

Press any of the following touchpads.

4. *Alarm*
   Submenus: *Profile, History, Mute*
5. *Review*
   Submenus: *Trends, Recorded waveform, Event log, View configuration*
6. *Options*
7. *Circuit compliance compensation*
8. *Copy* (to Ventilation record card)
9. *Biomed*
   Submenus: *Service, Edit configuration, copy configuration, Set date and clock, Change access code*
10. *Panel lock*
11. x *Change patient category*

2.3.6 Status Touchpad



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The *Status* touchpad indicates the power supply currently being used by the ventilator (AC power, battery power, or external 12V DC power). If the ventilator is running on battery power, the estimated remaining battery time in minutes is shown.

Caution: When using an external 12 V DC supply, there must be at least one installed battery module to ensure proper operation.

To access the status window:

1. Press the *Status* touchpad.

Touchpads leading to status windows appear.

Press any of the following touchpads.

2. General system information
3. Status of O_2 cell / O_2 Sensor
4. Status of expiratory cassette
5. Status of batteries
6. Status of X CO_2 module (if available)
7. Status of X Y Sensor measuring (if available)
8. Installed options
9. Status of Pre-use Check

2.4 Patient Unit

The patient unit consists of the following components:

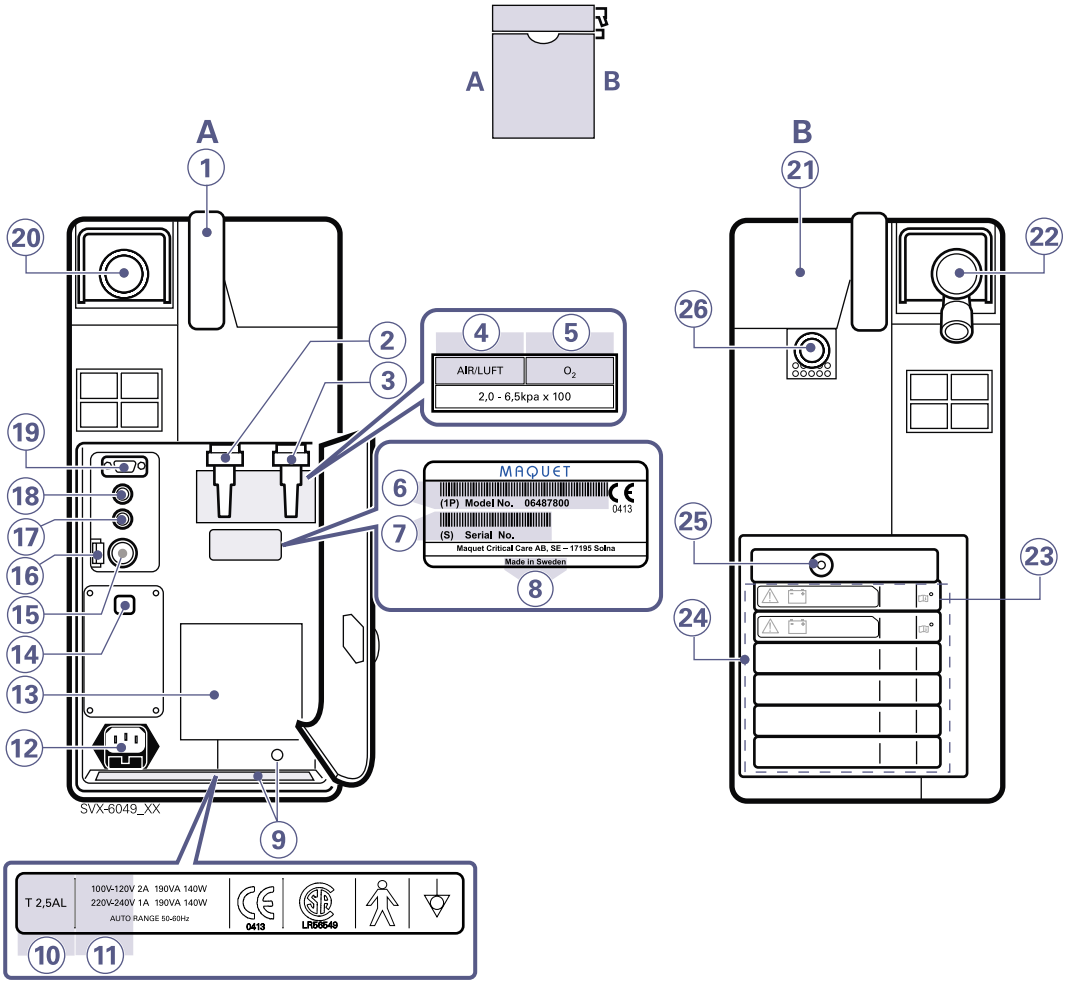
- gas supplies and their connectors
- power supplies and their connectors
- connectors for accessories

2.4.1 Patient Unit Components

Refer to the Patient Unit Diagram for locations of the following numbered components:

1. Handle
2. Gas inlet for air
3. Gas inlet for O_2
4. Air / Luft
5. O_2
6. Model number
7. Serial number
8. Manufacturing information
9. Equipotentiality terminal, label
10. Fuse label *T 2.5AL*
11. AC power supply voltage
12. AC power supply connector with fuse
13. Cooling fan with filter
14. Alarm output connection option
15. External +12V DC inlet
16. Fuse for external DC power supply
17. Optional connector
18. User interface connector
19. RS232 connector
20. Expiratory outlet
21. Cover, inspiratory channel
22. Expiratory inlet
23. Battery lock
24. Module compartment
25. Nebulizer connector (only for Servo Ultra Nebulizer)
26. Inspiratory outlet

2.4.2 Patient Unit Diagram



2.4.3 Patient Unit Symbols

CE label—indicates compliance with the requirements of the Medical Device Directive 93/42/EEC

CSA label—Indicates compliance with Canadian standards

Class I equipment, Type B—indicates classification according to IEC 60601-1/EN 6060-1

Equipotentiality terminal

Nebulizer Connector

RS 232 / Serial port—connector for data communication.
Note: This symbol may be different depending on panel version

User Interface connector / Panel
Note: This symbol may be different depending on panel version

Optional connector / Expansion
Note: This symbol may be different depending on panel version

10A
Fuse for external DC power supply.

12V DC / Ext. bat 12V—External 12V DC input
Note: This symbol may be different depending on panel version

Caution: When an external 12 V DC supply is used, there must be at least one installed battery module to ensure proper operation.

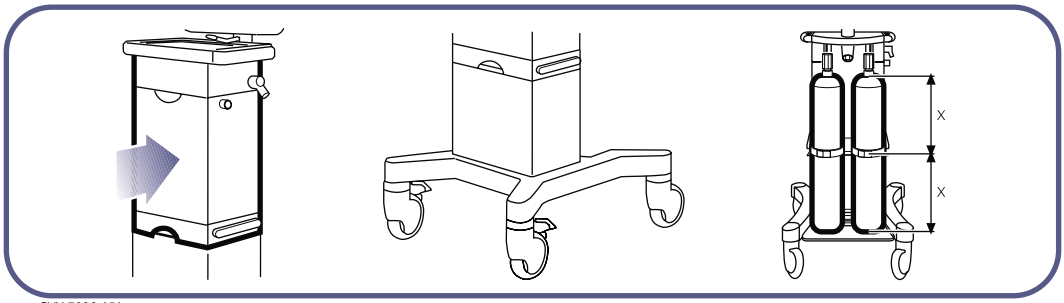
Expiratory label—gas flow from patient.

Inspiratory label—gas flow to patient.

Gas exhaust port label—exhaust gas flow from ventilator
Note: This port should not be connected to a spirometer because the volume through the exhaust port is not equal to the expired volume from the patient.

X Alarm output connection option—external alarm output communication

2.5 Transport and Storage



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2.5.1 Before Transport

Before transporting the ventilator with or without a patient connected, follow facility guidelines and:

- Be sure the patient unit and the user interface panel are securely attached and locked.
- Be sure all accessories such as modules, gas cylinders, and humidifier are securely attached and locked.
- Be sure the gas cylinders are connected and have sufficient gas.
- Be sure the batteries are fully charged.

Important: At least two batteries should be connected during transport.

- Inspect the resuscitator.
- Inspect the Mobile Cart for damage.
- Be sure the straps are firmly wrapped across the center of the gas cylinders so that the cylinders do not move during transport.

2.5.2 During Transport

While transporting the ventilator with or without a patient connected, follow facility guidelines and:

- Use the handles on the Mobile Cart.
- Transport the bed and the ventilator slowly, and watch the patient connection carefully to see that no pulling or other movement occurs.
- When moving the Support Arm or changing position, watch the patient connection carefully to see that no pulling or other movement occurs.
- Be careful not to tip the Mobile Cart when crossing an obstacle like a doorstep.

2.5.3 Storage

- If battery modules are in place during storage, keep the ventilator plugged in so that the batteries maintain a full charge.
- Do not dispose of battery modules and O_2 cells with ordinary waste.
- Be sure the system is not exposed to temperatures below -25 ^{o}C (-13 ^{o}F) or above +60 ^{o}C (140 ^{o}F).
- Be sure the system is not exposed to a relative humidity above 95 percent.

3 • Power Supply

3.1 Introduction

The Servo-i Ventilator System is equipped with an AC power supply with automatic range selection. The ventilator will automatically operate properly using 100-120 Volt AC or 220 - 240 Volt AC outlets.

The ventilator comes equipped with at least two battery modules which automatically supply 12 Volt DC power in case of an AC power failure, ensuring that ventilator settings and stored data remain intact in the event of an AC power failure.

Note: Batteries can be added to available slots during operation.

The ventilator also comes equipped with an input jack for an external 12 Volt DC power supply. This power supply activates automatically in case of an AC power failure, and ventilator settings and stored data remain intact.

3.1.1 Power Supply Specifications

Power supply, automatic range selection
100-120V ±10%, 220-240 V ±10%, AC 50-60Hz.

Battery backup
Two to six battery modules, each 12 V, 3.5 Ah, 3-hour recharge time, providing up to three hours of backup operation.

External 12V DC
12.0 V - 15.0 V DC, 10A

Caution: When using external 12 V DC, at least one installed battery module is required to ensure proper operation.

Maximum power consumption
At 110-120V: 2A, 190VA, 140W.
At 220- 240V: 1A, 190VA, 140W.

Alarms and Messages

See *Alarms and Safety* later in this chapter.

3.1.2 Battery Data Summary

Lifetime	2.5 years from manufacture date
Minimum modules installed	2
Maximum modules installed	6
Running time per fully charged module	30 minutes
Running time with *n* fully charged modules installed	*n* x 30 minutes
Module recharge time	3 hours
Recommended storage temperature (disconnected battery)	15 - 20°C
Maximum storage time (disconnected battery)	1 week

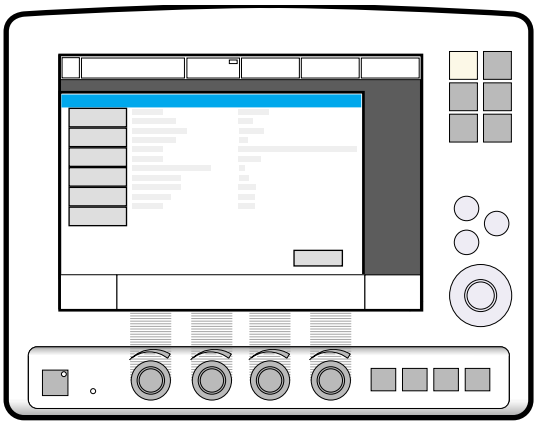
3.2 Viewing Battery Status

When operating from batteries, the estimated remaining battery time in minutes is displayed in the upper right corner of the screen on the *Status* touch pad.

WARNING! If the remaining battery time on the *Status* touchpad is displayed in red, the battery modules have very little operational time left and at least one battery module must be replaced. If possible, connect the ventilator to AC power.

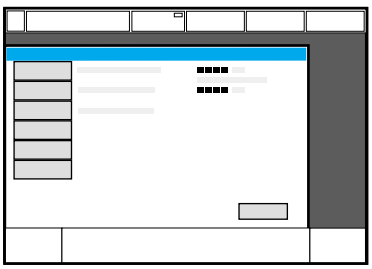
Detailed battery status information is available via the Battery Status Window:

1. Press the *Status* touchpad at the top-right of the user interface to display the *Status Window.*



SVX-9033

2. Press the *Batteries* touch pad to display the *Battery Status Window.*



SVX-9032

The following information is displayed for each mounted battery module:

- Slot number
- Serial number
- Charge indicator, where
  0 boxes filled = < 10% relative charge
  1 box filled = 10-25% relative charge
  2 boxes filled = 26-50% relative charge
  3 boxes filled = 51-75% relative charge
  4 boxes filled = 76-100% relative charge,
- Remaining operating time in minutes
- Activity Instruction—an instruction may be displayed next to the remaining operating time in minutes:

Activity Instruction	Response
Expires soon	Order a new battery module.
Replace battery	The battery no longer reliable; replace it immediately.

Note: The total usable backup time is the sum of the estimated operation time displayed for each battery module minus 10 minutes.

Note: If the *Replace battery* or the *Expires soon* Activity Instruction is displayed, the battery has become unreliable or will soon become unreliable, regardless of the operating time displayed in the Battery Status Window. In this situation, replace the battery even when the status window indicates significant operating time remains.

3.3 Alarms and Safety

The status of the battery modules is continuously monitored by the ventilator. If the status is unsatisfactory, four types of messages may be displayed at the top of the user interface:

- Technical Error Message
- High Priority Alarm Message
- Medium Priority Alarm Message
- Informative Text Message

This section describes the sequence of alarms that are triggered in the event of an AC power failure or disconnection from AC power; warnings that should be heeded to ensure a reliable back-up power supply; and status messages relevant to battery operation.

WARNING! If a battery status message is displayed on the user interface, check the battery status as soon as possible. If no action is taken, the ventilator may eventually shut down.

3.3.1 AC Power Failure

In the event of an AC power failure or disconnection, the ventilator switches to battery operation and activates the following medium priority alarm:

- *Battery operation*

The remaining battery capacity is displayed in the status menu on top of the screen.

When less than 10 minutes of battery power remain, the ventilator will activate the following high priority alarm:

- *Limited battery capacity*

Insert a fresh battery module or connect to AC power as soon as possible.

If less than three minutes of battery power remain or if there is an AC power failure with no charged battery module connected, the ventilator will activate the following high priority alarm:

- *No battery capacity.*

Complete loss of power is imminent or has already occurred. If this happens, the inspiratory and expiratory valves will open to allow for breathing through the ventilator. All settings will saved until the ventilator is powered again.

3.3.2 Warnings

- To guarantee reliable battery backup, two fully charged battery modules should be installed at all times.
- Always replace batteries when the ventilator software notifies you of imminent expiration or of diminished operating capacity.
- Do not disconnect and store battery modules over long periods of time because this will degrade their capacity. If battery modules need to be stored for short periods of time (up to one week), then store them fully charged in a cool (15-20°C), dry environment.
- Batteries that have been stored or disconnected should be recharged before use.
- Dispose of batteries according to local regulations and not with ordinary waste.
- After a new battery module is installed, display the Battery Status Window to ensure safe battery operation.
- When delivered, the battery modules may not be fully charged. Check the status of the batteries via the user interface and, if necessary, charge the battery before use by connecting the ventilator to the power supply.
- Always recharge discharged batteries.
- When not in use, the ventilator should always be connected to the power supply to ensure fully charged batteries.
- When the ventilator is running on batteries, the Servo Ultra Nebulizer is disabled to reduce power consumption.

3.3.3 Status Messages

Message (message type)	Meaning	Remedy
Technical error no. 1 - 6, 29, 10001 (technical error)	Power failure.	Contact a service technician.
Check battery status (Informative Text Message)	There is a problem with the battery modules. One or more battery modules must be replaced.	Open the Battery Status Window for information. Replace and discard defective battery module(s).
Battery mode! Nebulizer switched off (Medium Priority Alarm)	Ventilator is running on batteries and the Servo Ultra Nebulizer has been disabled to reduce the power consumption.	If it is necessary to use the Nebulizer, connect to AC power.
Battery operation (Medium Priority Alarm)	AC power is off line due to a power failure or disconnection.	Check the connection to AC power.
Limited battery capacity (High Priority Alarm)	Less than 10 minutes left of battery operation.	Insert new battery modules or connect to AC power.
No battery capacity (High Priority Alarm)	Less than 3 minutes left of battery operation.	Insert new battery modules or connect to AC power.
Low battery voltage (High Priority Alarm)	Battery voltage too low. Cannot guarantee continued ventilator operation.	Insert new battery modules or connect to AC power. This alarm may indicate worn out or damaged batteries (requiring replacement with new ones) if it appears in isolation; if this alarm appears after a *Limited battery capacity* or *No battery capacity* alarm, then the batteries only need to be recharged.

4 • Operation Overview

4.1 Work Flow Summary

The following summary procedure provides an overview of the operation of the Servo-i Ventilator System.

1. Turn on the ventilator and perform a Pre-Use Check.
2. If necessary, perform a Patient Circuit Test.
3. Access the Start-Up Configuration and edit it as needed.
4. In the Start-Up Configuration, select the patient category: *Adult* or *Infant*.
5. In the Start-Up Configuration, select the type of ventilation: *Invasive* or *NIV* (Non-Invasive Ventilation).
6. Enter data for the new patient, including height and weight.
7. Set the ventilation mode.
8. Check, and if necessary, adjust, the alarm profile.
9. Start ventilation.
10. During ventilation, use the Additional Settings touchpad to review and, if necessary, adjust settings.
11. During ventilation, if necessary, use Suction Support.
12. During ventilation, if necessary, adjust the O_2 cell.
13. When appropriate, disconnect the patient.

The following sections describe each of the above steps in more detail.

4.2 Pre-Use Check

The Pre-Use Check includes tests and measurements of:

- internal technical functionality
- internal leakage
- pressure transducers
- O_2 cell / O_2 sensor
- flow transducers
- safety valve
- battery modules
- patient breathing system leakage
- circuit compliance

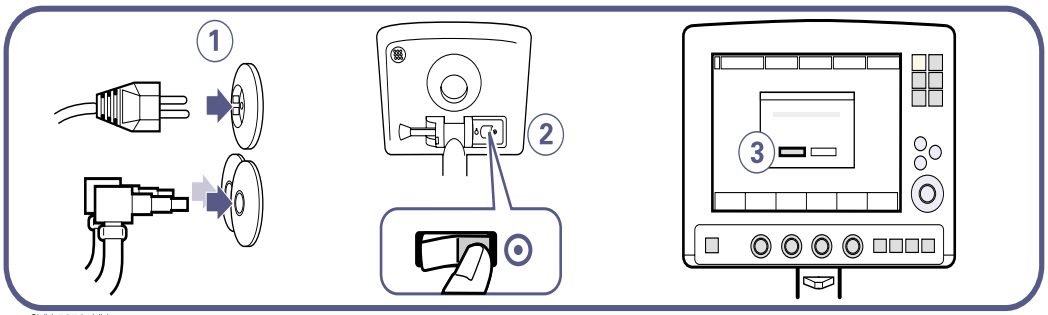
WARNINGS!

- Always perform a Pre-Use Check before connecting the ventilator to a patient.
- The separate Patient Circuit Test that can be performed in Standby mode does not replace the Pre-Use Check.
- If any malfunctions are detected during the start-up procedure, refer to the *System Messages* chapter for more information.
- Do not connect the ventilator to a patient while a malfunction persists.
- Do not lift the expiratory cassette while the ventilator is in operation; instead, lift the cassette while in Standby mode.

Important: If you change the breathing circuit after calculating the circuit compliance compensation factor, perform a new Pre-Use Check.

4.2.1 Performing a Pre-Use Check

Start-up

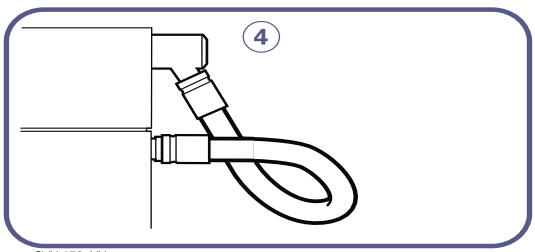


SVX-5073_XX

1. Connect power and gas supplies:
   - Power: AC outlet
   - Gas: Air and O_2
2. Turn the ventilator on.
3. Start the automatic test by pressing *Yes*.

Follow the on-screen instructions.

Internal Tests

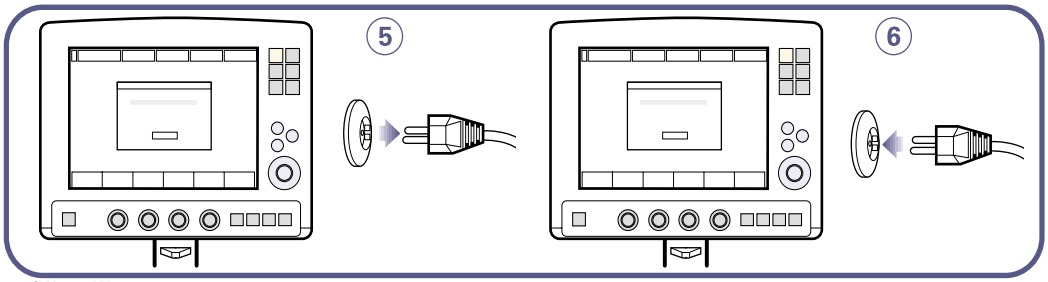


SVX-152_XX

4. Connect the blue test tube between the inspiratory outlet and the expiratory inlet.

Important: Use only the MAQUET blue test tube.

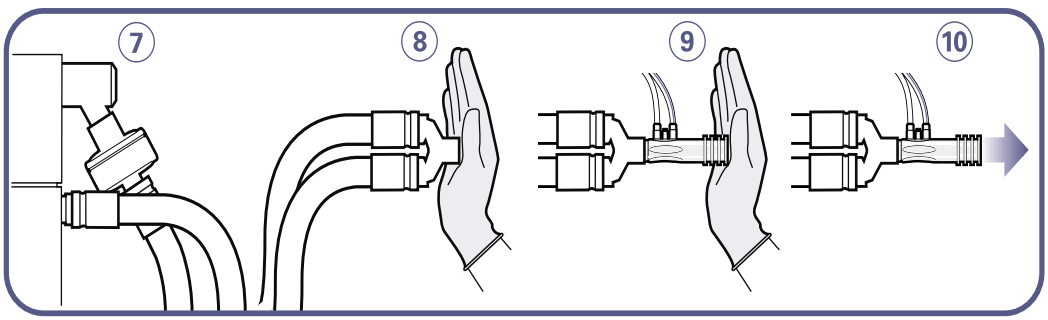
Check Switch Between AC and Battery
If a battery module is connected, you should test the ventilator's ability to switch between AC and battery power when AC power is lost and restored.



SVX-5074_XX

5. When the on-screen instruction appears, disconnect the ventilator from AC power.
6. When the on-screen instruction appears, reconnect the ventilator to AC power.

Check Patient Breathing System/Y Sensor



SVX-155

7. Connect a complete breathing system including (if available) a humidifier and a Servo Ultra Nebulizer.

Important: When blocking the Y piece or ✗ Y Sensor, make sure there is no leakage. Leakage will affect the circuit compliance compensation calculation.

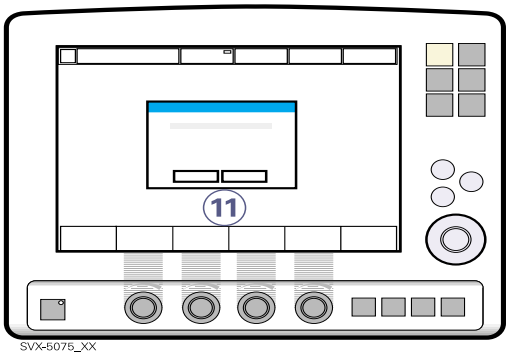
If no Y Sensor is connected then:

8. Block the Y piece and follow the online instructions. The circuit compliance is automatically measured. Go to step 11.

If a Y Sensor is connected then:

9. Block the Y Sensor and follow the on-screen instructions.
10. Unblock the Y Sensor and follow the on-screen instructions. The circuit compliance is automatically measured. Go step 11.

Compensate for Circuit Compliance



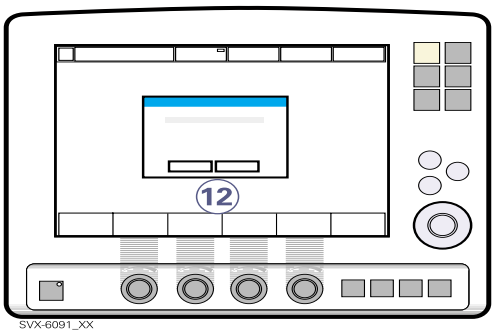
11. When the *Compensate for circuit compliance?* dialog appears on the screen, do one of the following:
    - To add the compensation, press *Yes*,
    - To refuse the compensation, press *No*.

Important: If you replace the patient tubing, a new circuit compliance compensation must be performed.

Note: Circuit compliance compensation is not available in X NIV modes.

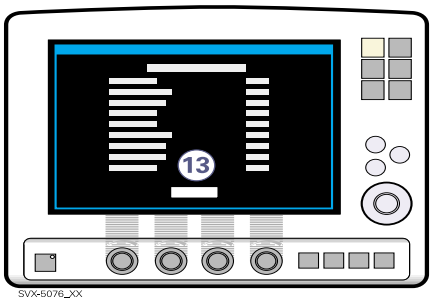
Test Alarm Output Connection Option

If the Alarm Output Connection option is installed, a dialog for the external alarm system test appears on the screen.



12. Do one of the following:
    - To perform the test, press *Yes* and follow the on-screen instructions.
    - To cancel the test, press *No*.

Complete the Pre-Use Check



13. Press *OK* to confirm and to have the Pre-Use Check tests logged. The ventilator now switches to Standby mode.

Note: After the Pre-Use Check is completed (or skipped), you'll be prompted to keep or discard old patient-related data.

4.2.2 Pre-Use Check Messages

Message	Meaning	Remedy
Cancelled	The test was cancelled by the user.	MAQUET recommends performing a Pre-Use Check before connecting the ventilator to a patient.
Failed	The test did not pass.	Check all connections and the expiratory cassette. Repeat the Pre-Use Check. If the problem persists, contact a service technician.
Not completed	The test was not completed.	The test case passed with some reservations. This message appears when: A battery module is installed and the battery capacity is less than 10 minutes. OR The test could not be completed due to missing gas. **Note:** The ventilator may still be used if the message *Not completed* is shown. If the missing gas is supplied a Pre-use Check must be performed from the beginning.
Passed	The test case has passed.	The function is working according to the test specification.
Running	A test is in process (message flashing).	None required.

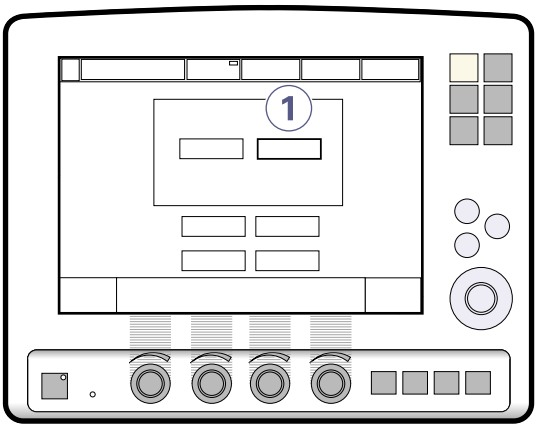
4.2.3 Pre-Use Check Tests

Test	Description	Remedy if test fails
Alarm state	Checks that no Technical error alarms are active during the Pre-Use Check.	Refer to service technician.
Barometer	Checks the barometric pressure measured by the internal barometer.	Check the barometric pressure value in the Status Window.
Battery switch	If battery modules are installed, tests switching to battery power when AC power is lost and back to AC power when it is restored.	Check that the total remaining time for the connected battery modules are at least 10 minutes. If not, replace the discharged battery with a fully charged battery and repeat the test.
Flow transducer	Checks the inspiratory flow transducers. Calibrates and checks the expiratory flow transducer.	Check that the connected gas supply pressure (air and O_2) is within the specified range. Check that the cassette is correctly seated in the cassette compartment.
Gas supply pressure	Checks that the gas supply pressures (air and O_2) measured by the internal gas supply pressure transducers are within the specified range.	Check that the gas supply pressure (air and O_2) is within the specified range.
Internal leakage	Checks for internal leakage, with test tube connected, using the inspiratory and expiratory pressure transducers. Allowed leakage: 10ml/min at 80 cmH_2O.	If message *Leakage* or *Excessive leakage* appears: • check that the test tube is correctly connected, • check all connections for the expiratory cassette and inspiratory channel • make sure the expiratory cassette and the inspiratory channel are clean and dry, OR • contact a service technician.
Internal	Audio test and other internal tests (memory and safety-related hardware).	Make sure the patient unit front cover and the user interface rear cover are correctly mounted.
O_2 cell / sensor	Calibrates and checks the O_2 cell / sensor at 21% O_2 and 100% O_2. Checks if the O_2 cell is worn out. Because different gas mixtures are required for this test, it will not be performed if one gas is missing.	• Check that the connected gas supply pressure (air and O_2) is within the specified range. • Replace the O_2 cell. • Replace gas modules (air and/or O_2).

Test	Description	Remedy if test fails
Patient circuit leakage	Checks the patient circuit leakage, with patient tubing connected, using the inspiratory and expiratory pressure transducers. Allowed leakage: 80 ml/min at 50 cmH_2O. Will allow the system to calculate a compensation for circuit compliance (if the leakage requirements are met).	If the internal leakage test has passed, the leakage is located in the patient circuit. Check for leakage or replace the patient circuit.
Y Sensor	Checks the pressure and flow measurement of the Y Sensor.	Check Y module and Y Sensor. If the problem persists, change the Y Module/Sensor.
Pressure transducer	Calibrates and checks the inspiratory and expiratory pressure transducers.	If the Internal leakage test passed (see above): • check/replace inspiratory or expiratory pressure transducer • check that there is no excess water in the expiratory cassette
Safety valve	Checks and if necessary adjusts the opening pressure for the safety valve to 117 ± 3 cm H_2O.	Check the inspiratory section: • check that the safety valve membrane is correctly seated in the inspiratory pipe • check that the inspiratory pipe is correctly mounted in inspiratory section • check that the safety valve closes properly when the Pre-Use Check is started (distinct clicking sound from the valve)

4.3 Patient Circuit Test

In Standby mode, the Patient Circuit Test may be performed separately from the Pre-Use Check. This is useful, for example, when changes are made to the circuit or additional accessories are connected. The test evaluates circuit leakage and measures the circuit compliance.



SVX-9042

1. Press the *Patient circuit test* touch pad and follow the on-screen instructions.

WARNINGS!

- A Pre-Use Check must always be done before connecting the ventilator to a patient.
- The Patient Circuit Test does not replace the Pre-Use Check.

Note: Considerable leakage may occur around the endotracheal tube if it is uncuffed. The combination of small tidal volumes, leakage around the tube, and activated compliance compensation may trigger the *Low Expiratory Minute Volume* alarm due to a very low expiratory flow passing from the patient through the expiratory channel. By observing the difference between the Vti and Vte values presented on the user interface, a leakage can be detected and its extent easily controlled. The first time an unacceptably large leakage occurs around the tube, correct this problem to avoid triggering the *Low Expiratory Minute Volume* alarm. If the leakage persists, adjust the alarm limit down to its lowest level (10 ml)—if this step is clinically appropriate. Finally, if the leakage still has not been remedied, deactivate the compliance compensation to avoid triggering the alarm. If the compliance compensation is deactivated while in Pressure Control, Pressure Support, or SIMV (Pressure Control) ventilation modes, then no further settings need to be adjusted. However, in volume-related modes, the set volumes must be adjusted.

4.4 Start-up Configuration

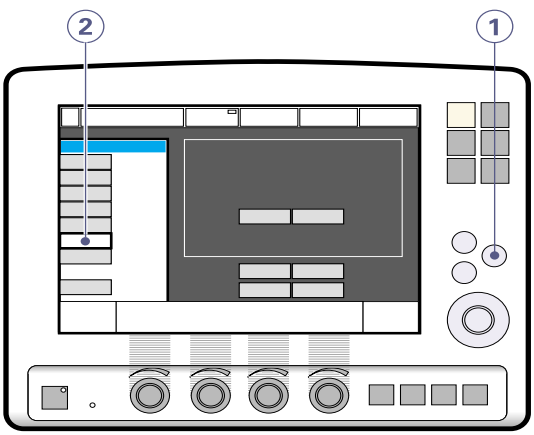
The ventilator will always start up with the previous Start-Up Configuration. The Start-Up Configuration can be edited, copied, and saved.

You can edit the following Start-Up Configuration settings:

- Patient category (*Adult* or *Infant*)
- Type of ventilation (*Invasive* or *NIV*)
- Volume setting
- Breath cycle setting
- Pre/post oxygenation concentration above set O_2 concentration (%)
- Mode of ventilation (including parameter settings)

This section provides instructions for accessing and editing the start-up configuration, changing the patient category, and changing the type of ventilation.

4.4.1 Accessing the Start-Up Configuration



SVX-9046

Note: The ventilator must be in Standby mode.

1. Press the fixed key *Menu*.
2. Press the *Biomed* pad and enter the access code (the factory setting is 1973).

The *Biomed* submenu consists of the following touchpads:

- *Service*
- *Edit configuration*
- *Copy configuration*
- *Set date and clock*
- *Change access code*

To alter ventilator settings, press the appropriate touchpad and follow on-screen instructions.

4.4.2 Editing the Start-up Configuration

To edit the Start-up Configuration.

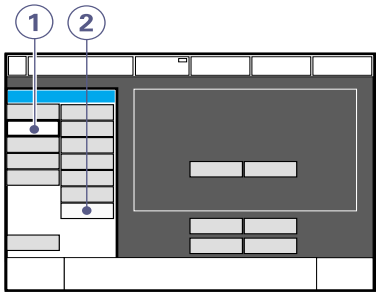
1. Press the *Edit configuration* touchpad in the *Biomed* submenu.
2. Press the *Start-up configuration* touchpad.
3. Press the touchpad for desired start-up setting.
4. Press *Next* to continue to ventilation mode settings.
5. Press the appropriate touchpad to change the settings.

Note: Press *Restore mode settings* to restore factory default settings.

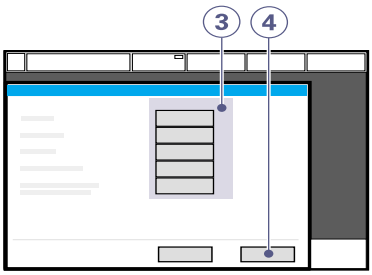
6. Press *Next* to view a summary of the start-up configuration
7. Press *Accept* to save the start-up settings.

Note: The ventilator must be restarted to activate the new settings.

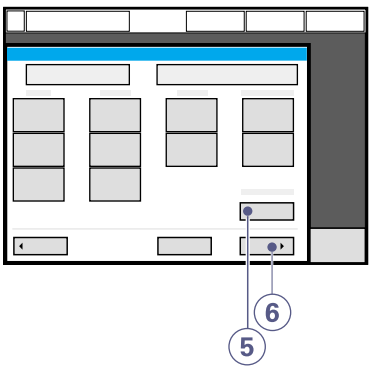
Procedure Diagram: Editing the Start-Up Configuration

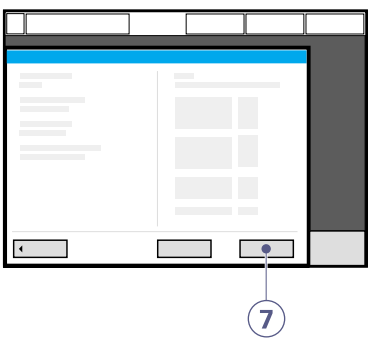


SVX-9045



SVX-9047





4.4.2.1 Changing the Patient Category

If you have the Servo-i Universal model, you can select the patient category (*Adult* or *Infant)* while editing the Start-Up Configuration. You can also change the patient category when the ventilator is in Running mode.

To change patient category while editing the Start-up Configuration:

- After pressing *Menu>Biomed>Edit configuration>Start-up configuration*, press the *Patient category* touchpad and follow the on-screen instructions.

To change the patient category in Running mode (during ventilation):

1. Press the fixed key *menu*.
2. Press the *Change patient category* touchpad.
3. Press *Yes* to confirm.

OR

4. Press *No* to cancel.

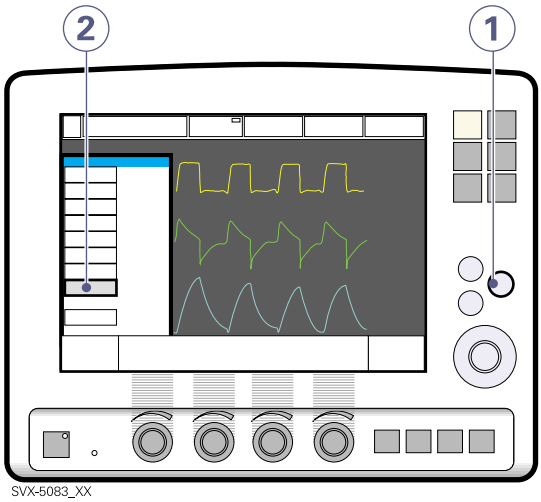
Note: Changing the patient category affects the following settings:

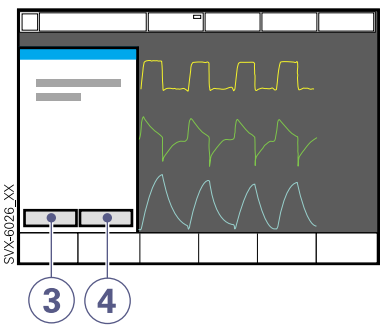
- default values for alarm limits
- allowed ranges for alarm limits
- default values for breathing parameters
- allowed ranges for breathing parameters
- pressure and flow regulation
- scaling

Note: The factory default values for the *Adult* and *Infant* patient categories may have been changed by a previous user.

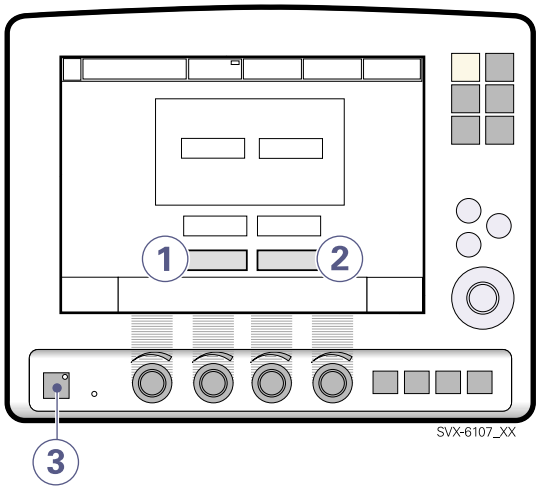
Important: Always check the alarm settings after changing the patient category.

Procedure Diagram: Changing the Patient Category in Running Mode





X 4.4.2.2 Selecting the Type of Ventilation



To change the type of ventilation press *Menu>Biomed>Edit configuration>Start-up configuration* and follow these steps.

1. Press *Invasive ventilation*

OR

2. Press *NIV (Non-Invasive Ventilation)*

Note: The background color on the touch pads changes when NIV is activated.

3. After confirming the start-up configuration, press the *Standby* key when ready to start ventilation.

Note: Changing the ventilation type affects the following settings:

- default values for alarm limits
- allowed ranges for alarm limits
- default values for breathing parameters
- allowed ranges for breathing parameters
- pressure and flow regulation
- scaling

Note: The factory default values may have been changed by a previous user.

4.5 Entering Patient Data

To enter data for a new patient press *Menu>Biomed>Edit configuration>Start-up configuration* and follow these steps.

1. Press the *Admit patient* touchpad.
2. Activate touchpads by turning and pressing the Main Rotary Dial or by pressing the appropriate touchpads.

Note: The Main Rotary Dial may also be used to adjust values.

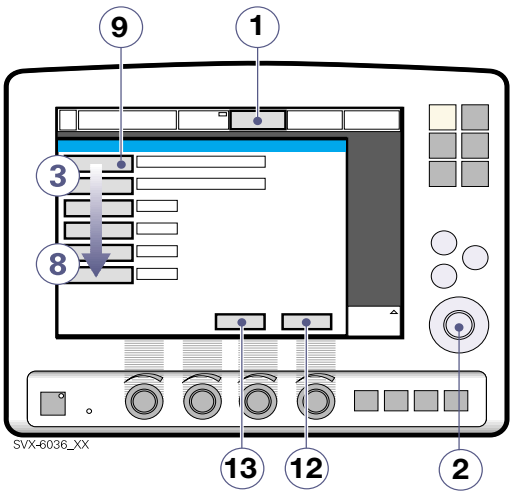
Enter/edit the following characteristics:

3. Patient name
4. Identity number
5. Date of birth
6. Date of admission
7. Body height
8. Body weight
9. Press, for example, *Name* to enter the patient's name.
10. Press *Close keyboard* when entry is complete.
11. When the *ID* touchpad is pressed, a keypad appears in the window.
12. Press *Accept* to confirm new data.
13. Press *Cancel* to cancel new data.

Important:

- *Adult* weights are in kilograms.
- *Infant* weights are in grams.
- Copy patient data before you enter a new name or ID, otherwise all data corresponding to the previous patient will be lost.
- The calculation of tidal and minute volume is based on entered body weight. If you omit this data, default values will be used for ventilation. An automatic calculation of Tidal Volume (based on body weight and immediately executed) will be performed only if the system is configured for "Tidal Volume based on body weight" (refer to Service Manual).

Procedure Diagram: Entering Patient Data



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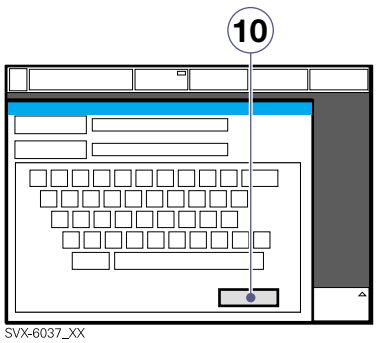
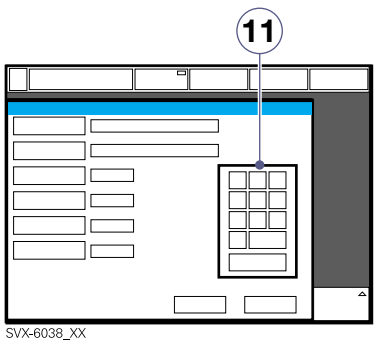




4.6 Setting Ventilation Mode

To set the ventilation mode outside of the Start-up Configuration:

1. Press the *Mode* touchpad.
2. Press the arrow at the active *Mode* pad.

Available ventilation modes appear.

3. Press the touch pad for desired mode of ventilation.

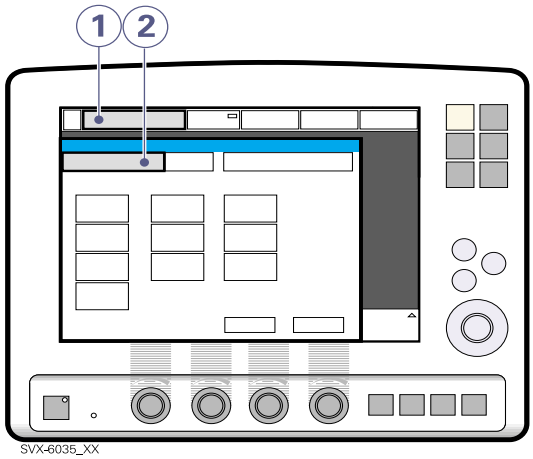
Note: If the type of ventilation is set to NIV, the only available modes are *NIV Pressure Support*, *NIV Pressure Control* and *Nasal CPAP*.

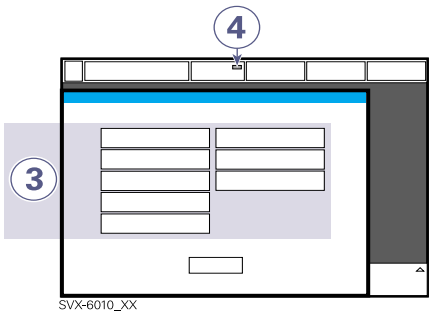
4. If *Automode* is selected, a green indicator mark will appear.

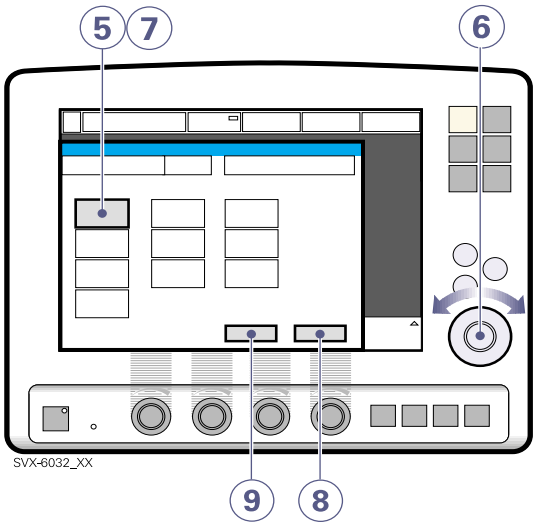
Note: Automode is not available in NIV.

5. When a ventilation mode has been selected, all related parameters can be set in the same window. Calculations are also displayed in this window.
6. Values are adjusted by turning the Main Rotary Dial.
7. Confirm each setting by pressing the parameter touch pad or pressing the Main Rotary Dial.
8. To activate all settings in the window, press *Accept*.
9. To cancel the settings, press *Cancel*.

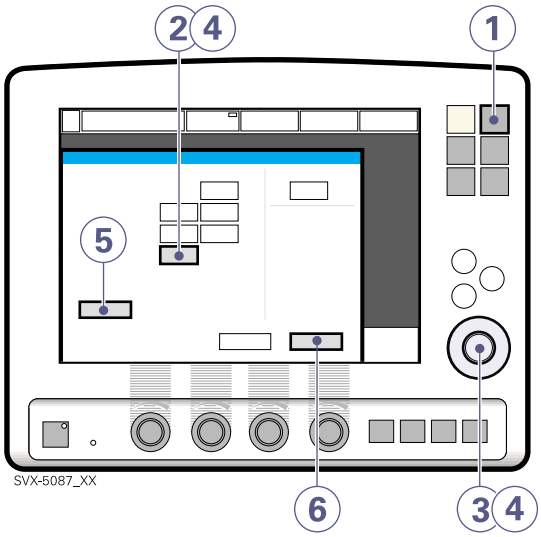
Procedure Diagram: Setting Ventilation Mode







4.7 Setting Alarm Limits



To set alarm limits:

1. Press the fixed key *Alarm Profile*.
2. Press the touchpad corresponding to the alarm limit you want to adjust or press the *Alarm sound level* touchpad.
3. Turn the Main Rotary Dial to adjust values.
4. Confirm each setting by pressing the parameter touchpad or Main Rotary Dial.
5. Press *Autoset*, if desired, to get a proposal for alarm limits in VC, PC, and PRVC modes.

Important: Before accepting *Autoset* values, make sure they are appropriate for the patient. If not, enter settings manually.

6. Press *Accept* to activate *Autoset* limits.

Notes:

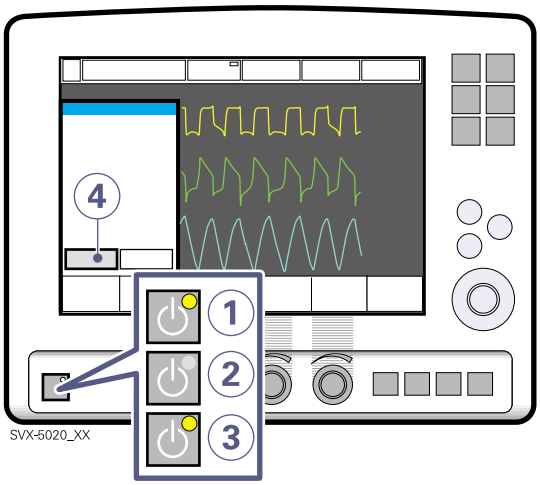
- *Autoset* is not possible in Standby mode because the ventilator requires patient values in order to propose alarm limits.
- *Autoset* is not available in ✗ *NIV* modes.
- Current alarm limits are displayed during ventilation in smaller figures to the right of the parameter display.

Note: When you reach the maximum or minimum allowed value for a given alarm setting, the Main Rotary Dial becomes inoperative for 2 seconds. This feature (implemented only in the Universal and Infant versions of the Servo-i) alerts you that a safety limit has been reached.

4.8 Starting Ventilation

The fixed key *Standby* is used to start and stop both invasive and noninvasive ventilation.

4.8.1 Starting Invasive Ventilation

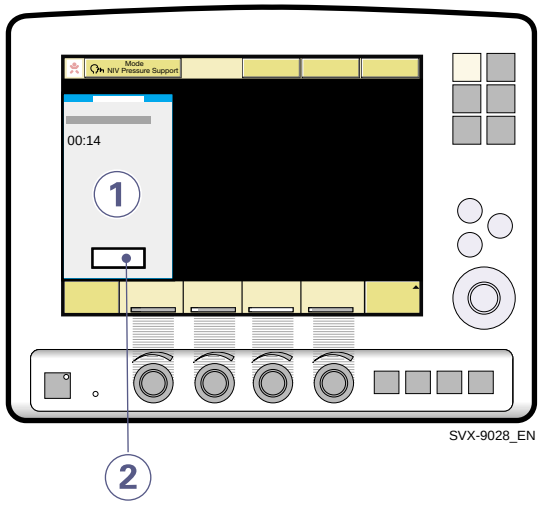


When the system is configured for invasive ventilation press the fixed key *Standby* to start ventilation.

1. Ventilator is in Standby mode.
2. Ventilator is warming up.
3. Pre-Use Check completed, ventilator is ready to operate. Push the fixed key *Standby* to start ventilation.
4. Press *Yes* to confirm and start ventilation.

Note: The *Standby* key is a start/stop toggle switch.

✗ 4.8.2 Starting Noninvasive Ventilation (NIV)



1. When the *Standby* key is pressed and the Servo-i is configured for NIV, a waiting position dialog is shown.

Note: All patient-related alarms are turned off for 120 seconds.

2. Press the *Start ventilation* touchpad.

Note: Ventilation starts automatically upon patient effort.

4.9 Additional Settings Window

To adjust breathing parameters during ventilation, press the *Additional settings* touchpad to open the Additional Settings Window.

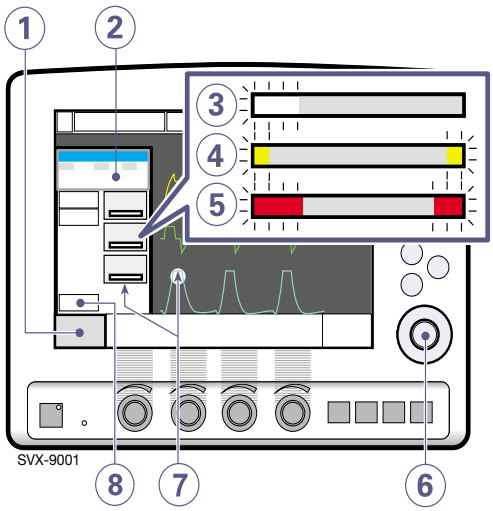
1. The *Additional settings* touchpad is in the lower left corner of the screen.
2. Values derived from settings such as inspiration time in seconds and calculated inspiratory flow are displayed.
3. A white bar indicates that the selected setting is within generally recognized safety limits.
4. A yellow (advisory) bar indicates that the selected setting is beyond generally recognized safety limits.
5. A red (warning) bar indicates that the selected setting is significantly beyond generally recognized safety limits (this warning is accompanied by an audio signal and text message).
6. Turning and pressing the Main Rotary Dial allows you to select settings and adjust values.

Note: New settings are effective from the first breath after adjustment (when the touch pad is deactivated).

7. The waveforms and measured values are displayed. Thus, the effects of the adjustments made can be checked immediately.
8. The *Close* touchpad closes the Additional Settings Window.

Note: The trigger sensitivity bar has different colors based on the setting. A green bar indicates a normal setting for flow triggering. The risk of self-triggering increases when the bar is red. A white bar indicates that pressure triggering is required.

Components Diagram: The Additional Settings Window



4.10 Using Suction Support

The Suction Support function makes it possible to automatically inhibit the ventilator from cycling during a tracheal suction procedure without activating alarms.

Suction Support includes:

- preparation phase
- disconnect phase
- post-oxygen phase

WARNING! Suction Support is not intended to be used together with closed-suction systems.

WARNING! The minimum PEEP level during suction support is 3 cmH_2O. The ventilator will adjust to minimum level if the PEEP level is below 3 cmH_2O in order to detect disconnection of the patient.

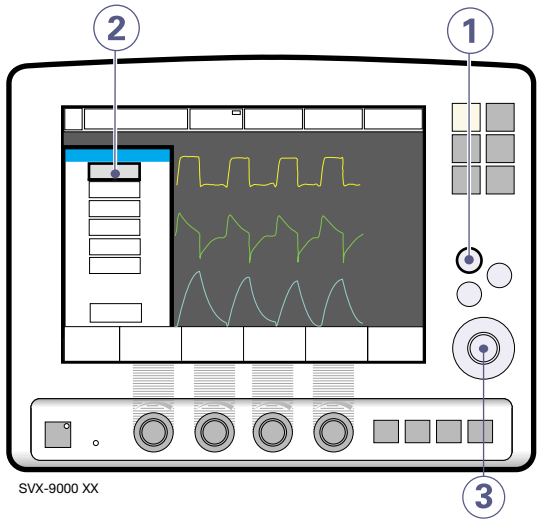
Important: Alarms are turned off during the disconnect phase for a maximum of 60 seconds. If the patient has not been reconnected within 60 seconds, all alarms are activated.

Note: Suction Support is not available in NIV mode or when the *O_2 Breaths* function is activated.

Note: During the disconnect phase in Suction Support, the nebulizer is temporarily paused.

Note: When only one gas is connected, an elevated oxygen level cannot be set during the preparation phase. In this case, the post-oxygen phase will be skipped.

4.10.1 Preparation Phase



To enter the preparation phase:

1. Press the fixed key *Quick access*.
2. Press the *Suction Support* touchpad.
3. Set the desired pre-oxygen value by turning and pressing the Main Rotary Dial.

The following alarms are turned off:

- *Check tubing*

The maximum duration of the preparation phase is 120 seconds. After 120 seconds, the system automatically returns to ventilation using the previous oxygen setting.

Note: The *Cancel* pad will close the Suction Support program.

4.10.2 Disconnect Phase

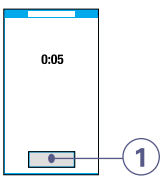
The system automatically enters the disconnect phase when the patient is disconnected during the preparation phase.

During the disconnect phase the following alarms are turned off for up to 60 seconds:

- Apnea
- Minute volume
- Frequency alarm
- $EtCO_2$
- PEEP

When the patient is reconnected, the system automatically enters the post-oxygen phase and restarts ventilation.

It is also possible to restart the ventilation manually:



1. Press the *Start ventilation* touchpad to restart ventilation manually.

4.10.3 Post-Oxygen Phase

After reconnection, the ventilator will deliver the same oxygen concentration as in the preparation phase for 60 seconds.

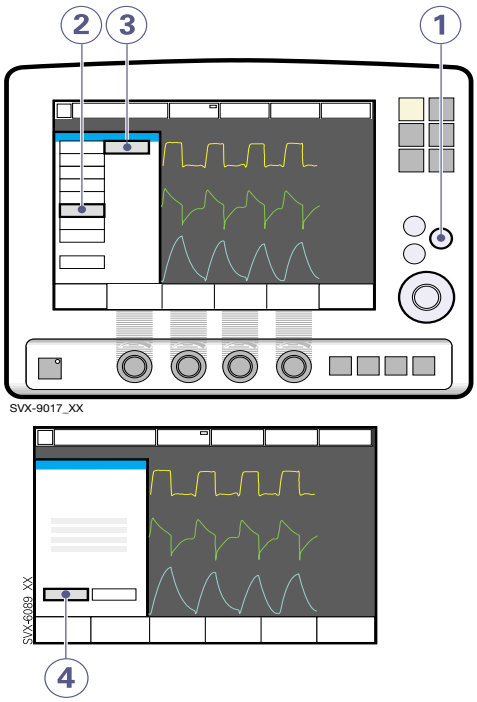
After 60 seconds the system automatically returns to ventilation using the previous oxygen setting.

4.11 Recalibrating the Oxygen Cell

If the ventilator has been in continuous use for an extended period, the measured O_2 concentration may drop due to normal degradation of the oxygen cell. In order to avoid nuisance alarms in this situation, it is possible to temporarily adjust the O_2 cell during ventilation.

When you activate the *O_2 cell adaptation* function, the oxygen cell is recalibrated so that the current measured O_2 concentration is equal to the O_2 concentration set by the user. This temporary adjustment will be valid until the ventilator is switched off.

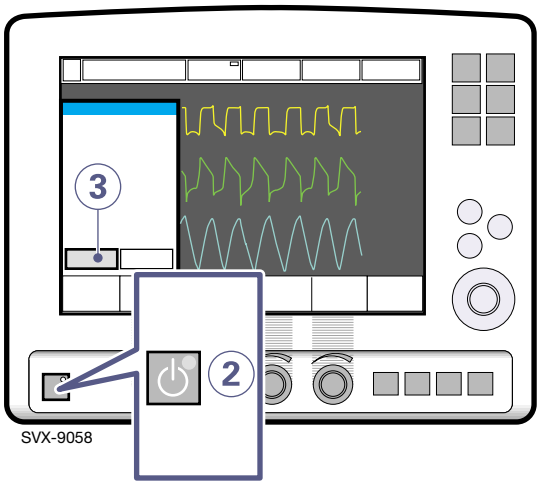
Important: Before using the Servo-i, always perform a Pre-Use Check to make sure the O_2 cell is properly calibrated.



To recalibrate the O_2 cell:

1. Press the fixed key *Menu*.
2. Press the *Biomed* touchpad.
3. Press the *O_2 cell adaptation* touchpad.
4. Press the *Yes* touchpad to perform the O_2 cell adaptation.

4.12 Disconnecting the Patient



To disconnect and stop ventilation:

1. Physically disconnect the patient from the ventilator.
2. Press the fixed key *Standby*.
3. Press *Yes* to stop ventilation.
4. Turn the ventilator off using the On/Off switch behind the user interface.

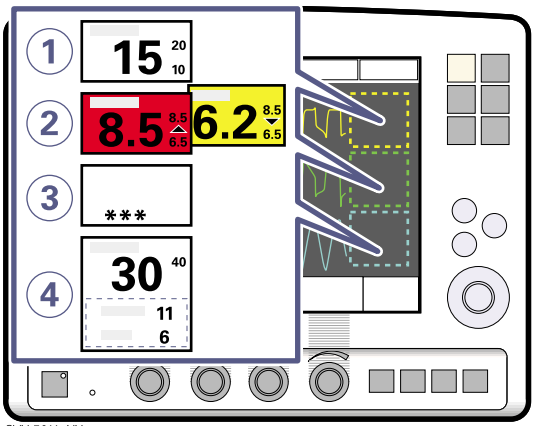
Note: The battery modules will recharge as long as the ventilator is connected to AC power. It is not necessary to leave the ventilator turned on.

5 • Monitoring and Recording

5.1 Measured Values Display

During ventilation, measured or calculated values of breathing parameters are displayed. This section describes the display, gives the procedure for displaying additional pages of parameters, and lists all viewable parameters.

5.1.1 Description



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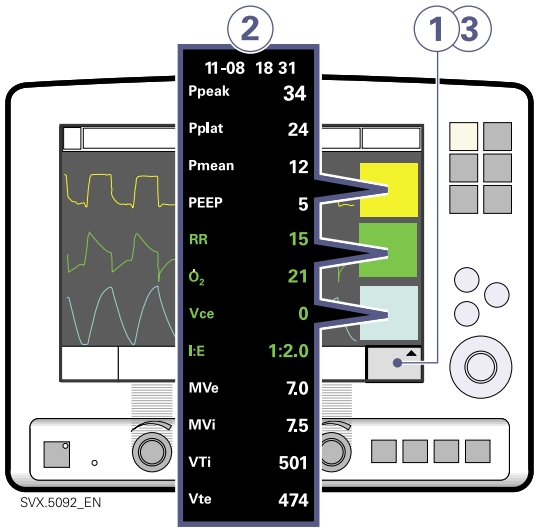
Breathing parameter values are displayed on the right side of the screen.

- Units are displayed.
- Alarm limits are displayed.
- If a high priority alarm limit is exceeded, the box turns red.
- If a medium priority alarm limit is exceeded, the box turns yellow.
- An up or down arrow indicates whether the upper or lower alarm limit has been exceeded.
- Off-scale values are indicated by ****.
- It is possible to change which parameter values are displayed in the measured value boxes.

5.1.2 Displaying Additional Pages



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To view more parameters:

1. Press the *Additional values* touchpad in the lower right corner of the screen.
2. View desired values.
3. Press the *Additional values* touchpad again to view the next page of values.

Notes:

- In NIV mode there is only one page of parameter values.
- In Nasal CPAP mode no parameter values are displayed.

5.1.3 Parameter List

Parameters in **boldface** are shown on the first page by default.

Ppeak	Maximum inspiratory pressure
Pplat	Pressure during end-inspiratory pause
Pmean	Mean airway pressure
PEEP	Total positive end expiratory pressure
CPAP	Continuous Positive Airway Pressure (NIV Nasal CPAP only)
RR	Respiratory Rate
O_2	Oxygen concentration in vol.%
Ti	Inspiration time
Tc	Time constant
I:E	Inspiration to expiration ratio (during controlled ventilation)
Ti/Ttot	Duty cycle or ratio of inspiration time to total breathing cycle time (during spontaneous breathing and Bi-Vent).
MVe sp	Spontaneous expiratory minute volume (Bi-Vent)
MVe sp / MVe	The relation between spontaneous expired minute volume and total expired minute volume (Bi-Vent).
MVi	Inspiratory Minute Volume
MVe	Expiratory Minute Volume
Leakage	Leakage % (NIV)
VTi	Inspiratory Tidal Volume
VTe	Expiratory Tidal Volume
$\dot{V}ee$	End expiratory flow
O_2	Measured Oxygen concentration
etCO_2	End tidal carbon dioxide concentration (X CO_2 Analyzer)
$\dot{V}CO_2$	Volume of expired CO_2 per minute (X CO_2 Analyzer)
VTCO_2	CO_2 tidal elimination (X CO_2 Analyzer)
Cdyn	Dynamic characteristics
Cstatic	Static compliance, respiratory system
E	Elastance
Ri	Inspiratory resistance
Re	Expiratory resistance
WOB v	Work of breathing, ventilator
WOB p	Work of breathing, patient
P0.1	Indicator for respiratory drive
SBI	Shallow Breathing Index

5.2 Waveform Display

If the optional CO_2 Analyzer is connected, the following color-coded waveforms are shown on the user interface screen by default:

- pressure vs. time
- flow vs. time
- volume vs. time
- CO_2 concentration vs. time.

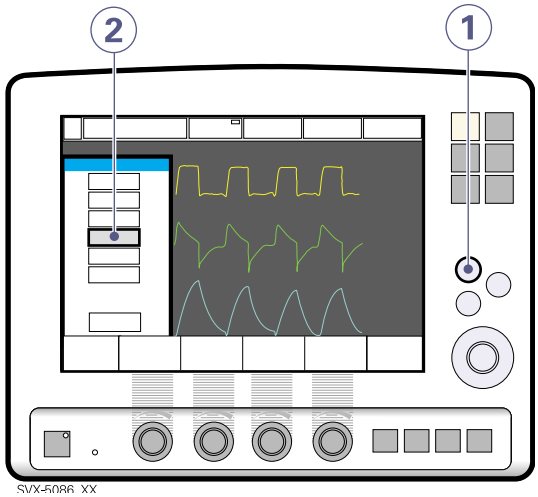
This section describes the waveform display, provides a procedures for hiding/displaying the volume and CO_2 waveforms and for adjusting the sweep speed and scale of the waveforms.

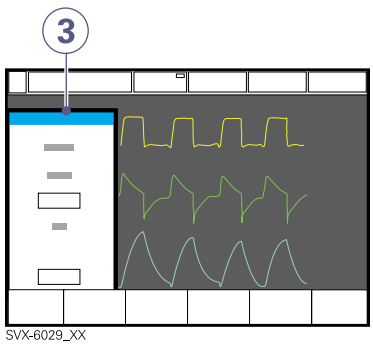
5.2.1 Description

The default waveform display has the following characteristics:

- The value of a measured parameter vs. time is displayed.
- The displayed parameter and the scale are indicated on the y-axis.
- The pressure vs. time display is dark yellow.
- The flow vs. time display is green.
- The volume vs. time display is light blue.
- The CO_2 concentration vs. time display is light yellow.

5.2.2 Showing and Hiding





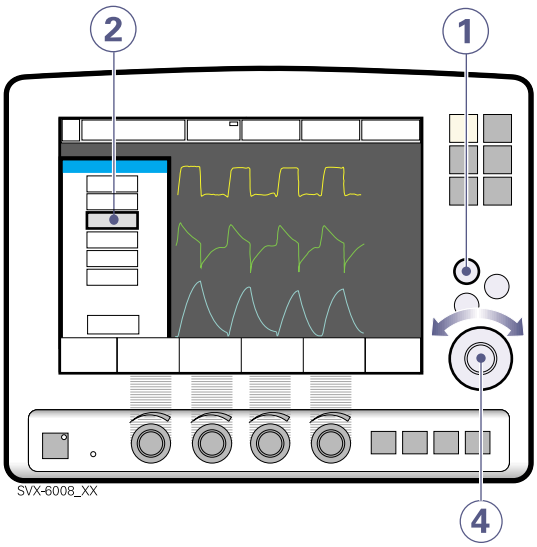
To show or hide the volume waveform or the CO_2 waveform display:

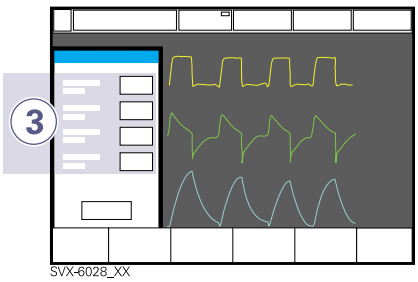
1. Press the fixed key *Quick access*.
2. Press the *Waveform configuration* touchpad.
3. Press the touchpad corresponding to the waveform you wish to show or hide.

Note: The pressure waveform and the flow waveform are always displayed. The volume and x CO_2 waveforms may be hidden. Thus, 2, 3, or 4 waveforms may be displayed.

Note: When you hide a waveform, the remaining waveforms are expanded to use all available screen space.

5.2.3 Adjusting Scale/Sweep Speed



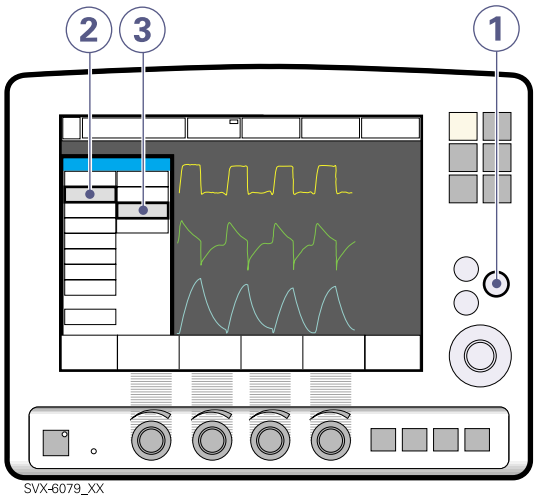


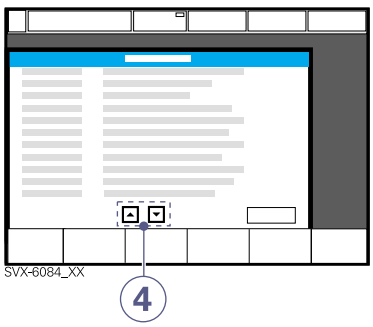
To set the sweep speed and amplitude for displayed waveforms:

1. Press the fixed key *Quick access*.
2. Press the *Scales* touchpad.
3. Press the touchpad corresponding to the waveform whose scale you wish to change or select a sweep speed (6, 10 or 20 mm/s).
4. To adjust the scale of a waveform, turn the Main Rotary Dial to the desired value or use auto scale (press *Auto*).

Important: MAQUET does not recommend using auto scale in Bi-Vent mode, when patient breathing is spontaneous on both levels.

5.3 Showing the Event Log



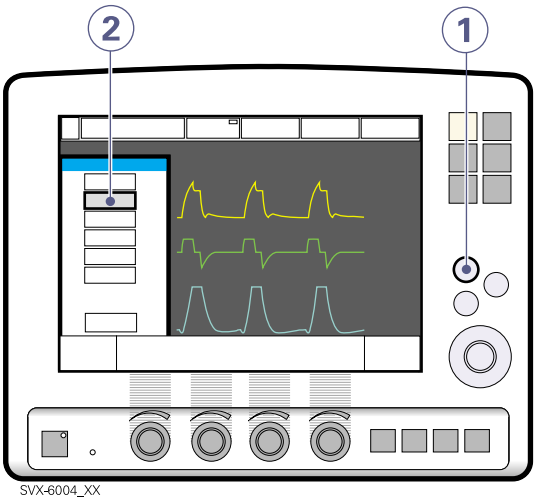


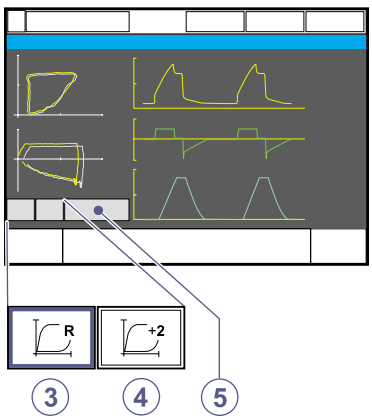
To view the Event Log:

1. Press the fixed key *Menu*
2. Press the *Review* touchpad
3. Press the *Event log* touchpad to view all logged events.
4. Use the arrows to scroll.

5.4 Showing Loops

The *Loops* function provides a graphical representation of the relationship between flow-volume and pressure-volume.



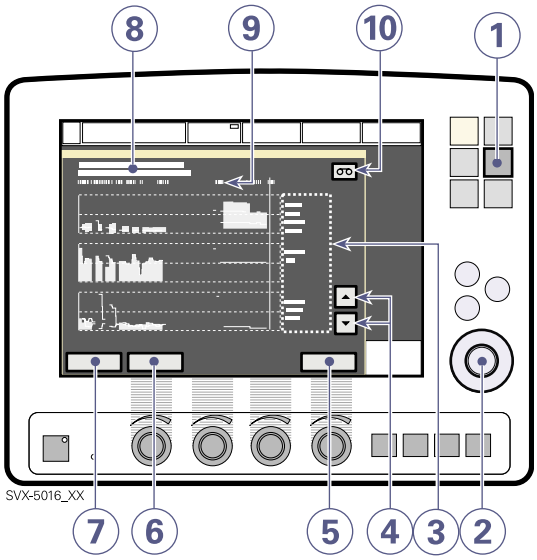


To activate the *Loops* function:

1. Press the fixed key *Quick access*.
2. Press the *Loops* touchpad
3. Press [reference loop] to store a reference loop.
4. Press [overlay loops] to see the two previous loops simultaneously.
5. To close the window, press *Close*.

5.5 Showing Trends

Trend values are stored every 60 seconds and retained as far back as 24 hours. Stored events and system changes are shown as event stamps.



To show trends:

1. Press the fixed key *Trends*.
2. Use the Main Rotary Dial to adjust display parameters.
3. View trended measured values.
4. Use the up and down arrows to scroll.
5. To quit the Trends Window press *Close*.
6. To adjust the time resolution press the *Hours* touchpad and turn the Main Rotary Dial.
7. Activate the *Cursor*. Move it back and forth on the time axis using the Main Rotary Dial or touch screen.
8. Move the cursor to display the time, event type, and ventilation mode. For event stamps, an explanation appears.
9. View logged event stamps.
10. If a recording is saved at a time corresponding to the cursor position, a recording button is shown. To view the recording, press the button.

5.6 The Open Lung Tool

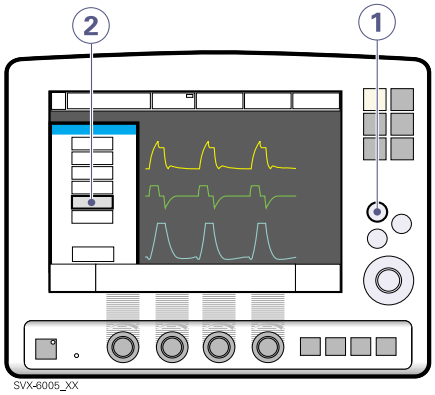
The *Open Lung Tool* provides breath-by-breath graphical presentation of the following parameters:

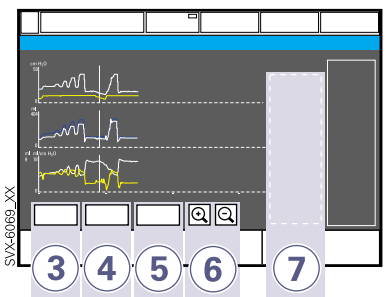
- End inspiratory pressure
- PEEP
- V_T
- Dynamic compliance
- Tidal CO_2 elimination (with CO_2 Analyzer)

Note: The Open Lung Tool is not available in Bi-Vent and NIV modes.

Note: When the X Y Sensor Measuring function is active, the values recorded in the Open Lung Tool are based on values measured at the Y Piece. When this function is disabled or enabled, the compliance in the patient circuit may cause the values in the Open Lung Tool to change.

5.6.1 Using the Open Lung Tool





To use the Open Lung Tool:

1. Press the fixed key *Quick access*.
2. Press the *Open Lung Tool* touchpad.
3. Activate Cursor Mode by pressing the *Cursor* touchpad. Move the cursor using the Main Rotary Dial or touch screen.

Note: The cursor allows you to analyze the stored breath-by- breath data. When the *Cursor* touchpad is activated the cursor values will be shown in the value field.

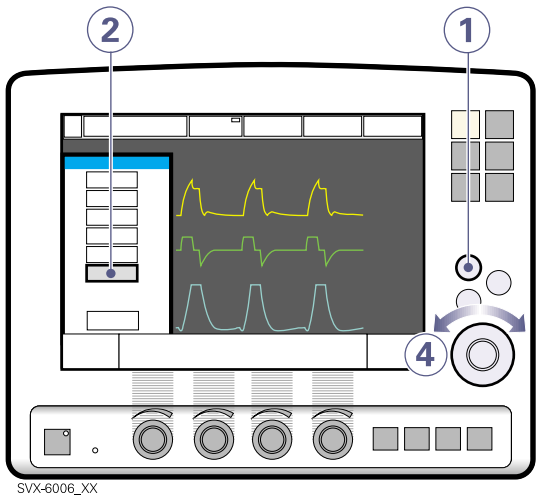
4. To clear all waveforms press the *Clear* touchpad.

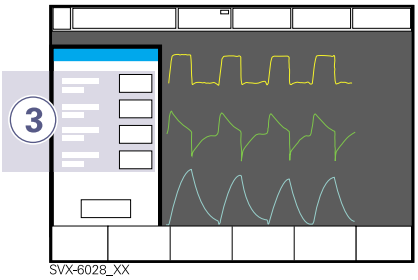
Note: The *Clear* touchpad is not active in Cursor Mode.

5. To close the Open Lung Tool Window, press the *Close* touchpad.
6. Alter the resolution on the time axis.
7. View the real-time value field.

Note: If additional windows such as loops are activated, the Open Lung Tool Window will be minimized and some function buttons will not be visible.

5.6.2 Adjusting Scales in the Open Lung Tool Display





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To set the amplitude for displayed waveforms:

1. Press the fixed key *Quick access*.
2. Press the *Open Lung Tool scales* touchpad.
3. Press the touchpad corresponding to the waveform whose scale you want to adjust.
4. Turn the Main Rotary Dial to the desired value.

Notes:

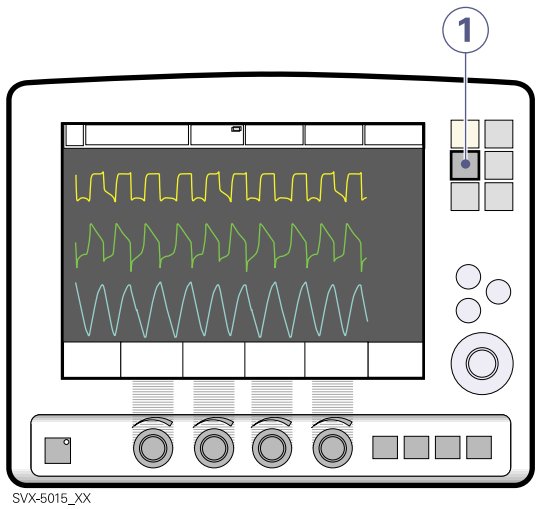
- When you reach a maximum allowed value, its display will flash.
- The time parameter displayed in the lower right corner of the user interface screen indicates how long it will take at the current settings for the waveform to complete one left-to-right sweep across the screen. Change the scaling with the zoom in/out function to speed up or slow down the screen-filling process.
- The breaths parameter displayed in the lower right corner of the user interface screen indicates the number of breaths at the current respiratory rate required for the waveform to fill the screen.

5.7 Saving Data

Waveforms and settings may be saved in the following ways:

- A 20-second recording may be taken for immediate on-screen analysis.
- Screen data or patient data may be written to an optional Ventilation Record Card for later analysis (file is readable by Microsoft Excel).

5.7.1 Recording Waveforms



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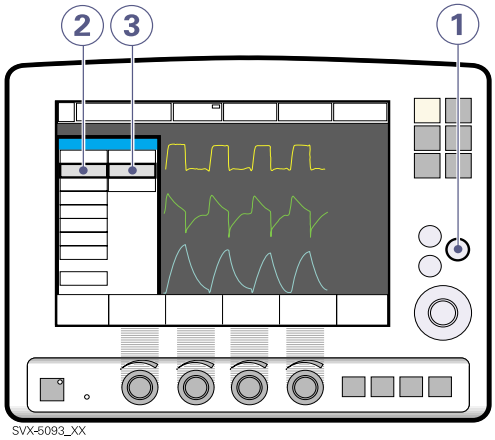
To save one recording of the current waveform along with breathing parameter values:

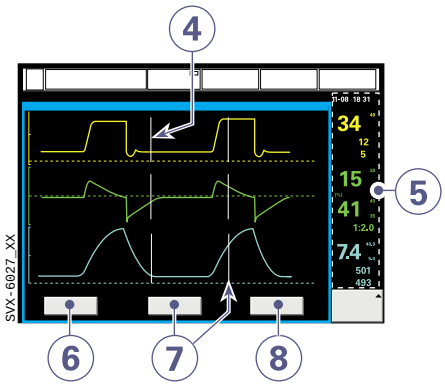
1. Press the fixed key *Save*.

A total of 20 seconds of data will be recorded—10 seconds before the *Save* key was pressed and 10 seconds after the *Save* key was pressed.

Note: If *Save* is pressed again, the previous recording will be erased. Using *Admit patient* also erases the previous recording.

5.7.2 Using Recorded Waveforms.





To view the data in a recorded waveform:

1. Press the fixed key *Menu*.
2. Press the *Review* touchpad.
3. Press the *Recorded waveform* touchpad.

Vertical gray lines indicate the time when the *Save* key was pressed.

4. View measured/calculated values next to the vertical gray lines.
5. Press the *Settings* touchpad to open the list of parameter settings in use at the time the *Save* key was activated.
6. Press the *Cursor* touchpad to activate the cursor. Move the cursor using the Main Rotary Dial.
7. Press *Close* to quit the Recorded Waveform Window.

5.7.3 X Ventilation Record Card

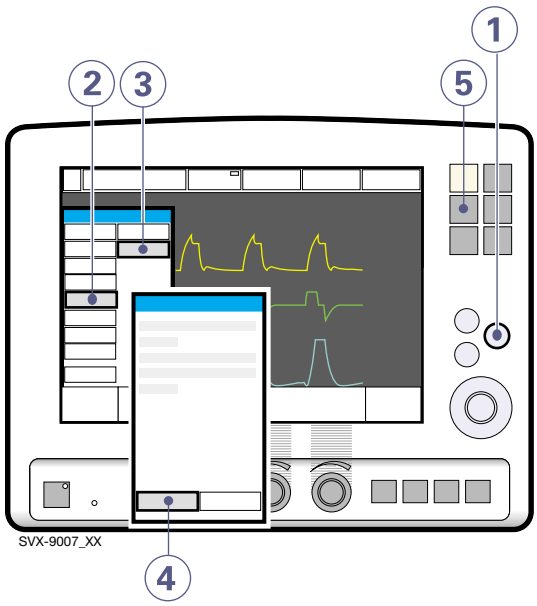
The Ventilation Record Card (VRC) can be used in Standby mode or during ventilation. The following data can be saved for analysis:

- screen data
- patient data

Important: Always handle the VRC and its contents in accordance with regulations and hospital routines.

5.7.3.1 Copying Screen Data to a Ventilation Record Card

To make a copy of the screen, a VRC must be inserted and the *Save* key must be configured. It is possible to copy multiple data sets to the same Ventilation Record Card.



After inserting the VRC:

1. Press the fixed key *Menu*.
2. Press the *Copy* touchpad.
3. Press the *Copy screen* touchpad.
4. Press *OK* to continue.
5. Press the fixed key *Save*.

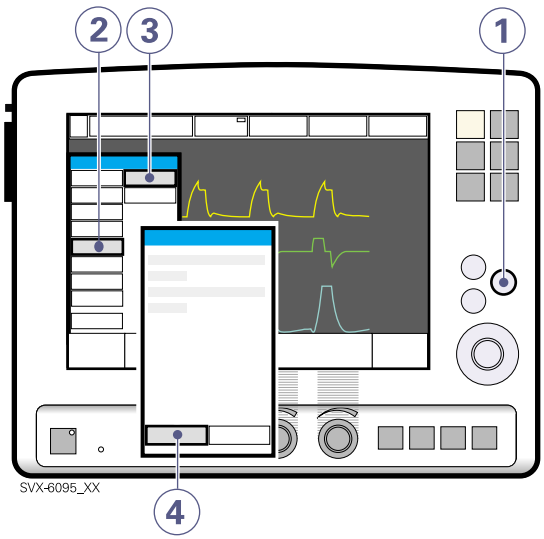
A copy of the screen is stored on the VRC.

Notes:

- To make another screen copy, press the *Save* key again.
- When the VRC is removed or the ventilator is restarted, the *Save* key is automatically reconfigured to save a recording.

5.7.3.2 Copying Patient Data to a Ventilation Record Card

The following patient data may be copied to a VRC: Event Log, Trends, Recordings, Open Lung Tool data, Patient Name, Patient ID, Ventilator Serial Number, and Pre-Use Check Status.



To copy patient data to a VRC:

1. Press the fixed key *Menu*.
2. Press the *Copy* touchpad.
3. Press the *Copy data* touchpad.

Insert the VRC.

4. Press the *Copy data* touchpad.

Remove the VRC.

6 • Ventilation Modes

6.1 Introduction

The Servo-i Ventilator System can operate in 14 different modes. This chapter describes the modes, their settings, and associated safety information.

It also summarizes special ventilatory functions, back-up ventilation, and breathing parameters.

See the *Specifications* chapter for default values and allowed ranges for the breathing parameters.

Note: The Servo-i is delivered preset with the following configuration options:

- Breathing parameters are determined using either I:E Ratio or Inspiration Time.
- Breathing parameters are determined using either Minute Volume or Tidal Volume.

6.1.1 Warnings

Note: Not all warnings apply to all modes.

- Be sure to set alarm limits as appropriate for each mode. It is especially important to check the limits on the following alarms:
  - Minute Volume Alarm
  - Apnea Alarm
- Self-triggering should be avoided. Do not set the trigger sensitivity too high.
- To protect the patient's lungs from excessive pressure it is important to set the upper pressure limit to a suitable value.
- The following warnings apply to Non-Invasive Ventilation (NIV) only:
  - Avoid high inspiratory pressure.
  - Use of the Nebulizer is not recommended.
  - Excessive leakage is possible in pressure-controlled and pressure-supported modes. A high-priority alarm will be triggered.
  - We recommend ventilator-independent monitoring for Nasal CPAP.

6.1.2 Settings

Ventilation Mode	Abbreviation	Settings [a]
Pressure Regulated Volume Control	PRVC	TV/MV; RR; PEEP; O2; IE/IT; IRT; TF/TP
Volume Control	VC	TV/MV; RR; PEEP; O2; IE/IT; PT; IRT; TF/TP
Pressure Control	PC	PC+; RR; PEEP; O2; IE/IT; IRT; TF/TP
Volume Support	VS	TV; PEEP; 02; IRT; TF/TP; ICO
Pressure Support	PS	PS+; PEEP; O2; IRT; TF/TP; ICO; PC+
Continuous Positive Airway Pressure	CPAP	PS+; PEEP; O2; IRT; TF/TP; ICO; PC+
Synchronized Intermittent Mandatory Ventilation (PRVC) + PS	SIMV (PRVC) + PS	TV/MV; SIMVR; O2; IE/IT; IRT; BCT; TF/TP; ICO; PS+
SIMV (VC) + PS	SIMV (VC) + PS	TV/MV; SIMVR; O2; IE/IT; IRT; BCT; TF/TP; ICO; PS+
SIMV (PC) + PS	SIMV (PC) + PS	TV/MV; SIMVR; O2; IE/IT; IRT; BCT; TF/TP; ICO; PS+
Bi-Vent	BV	P_HIGH; PEEP_LOW; O2; T_HIGH; T_PEEP; IRT; TF/TP; ICO; P_HIGH+; PS+
Non-Invasive Ventilation - PC	NIV - PC	PC+; RR; PEEP; O2; IE/IT; IRT
NIV - PS	NIV - PS	PS+; PEEP; O2; IRT; ICO; NIVR; BT
NIV - nasal CPAP	Nasal CPAP	CPAP; O2
Automode	Automode	

a. TV/MV = Tidal Volume or Minute Volume; RR = Respiratory Rate; PEEP = Positive End Expiratory Pressure; IE/IT = I:E Ratio or Inspiration Time; IRT = Inspiratory Rise Time; TF/TP = Trigg. Flow or Trigg. Pressure; PT = Pause Time; PC+ = Pressure Control Level Above PEEP; PS+ = Pressure Support Level Above PEEP; ICO = Inspiratory Cycle Off; SIMVR = SIMV Rate; BCT = Breath Cycle Time; P_HIGH = Maximum Pressure for Higher Pressure Level; PEEP_LOW = PEEP for the Lower Pressure Level; T_HIGH = Time at the Higher Pressure Level; T_PEEP = Time at the Lower Pressure Level; P_HIGH+ = Pressure Support Level Above Maximum Pressure

6.1.3 Summary

Ventilation Mode	Abbreviation	Notes[a]
Pressure Regulated Volume Control	PRVC	ALARM if target volume cannot be delivered due to setting of UPL; cm; eb; df
Volume Control	VC	IMPORTANT to set UPL; cm; eb; cf
Pressure Control	PC	IMPORTANT to set alarm limits for MVol; cm; eb; df
Volume Support	VS	ALARM if target volume cannot be delivered due to setting of UPL; IMPORTANT to set alarm limits for MVol, Apnea; pib
Pressure Support	PS	IMPORTANT to increase inspiratory rise time for patient comfort, set alarm limits for MVol, monitor TVol; pib
Continuous Positive Airway Pressure	CPAP	IMPORTANT to set alarm limits for MVol, Apnea; sb
Synchronized Intermittent Mandatory Ventilation (PRVC) + PS	SIMV (PRVC) + PS	comb. control and pressure support/spontaneous function
SIMV (VC) + PS	SIMV (VC) + PS	comb. control and pressure support/spontaneous function
SIMV (PC) + PS	SIMV (PC) + PS	comb. control and pressure support/spontaneous function
Bi-Vent	BV	IMPORTANT to set alarm limits for MVol, Auto Scale not recommended, Apnea alarm and back-up ventilation not available, two pressure levels and durations are set, alarms are handled for each Bi-Vent cycle
Non-Invasive Ventilation - PC	NIV-PC	for ALL NIV modes: avoid high inspiratory pressure, use of nebulizer not recommended, excessive leakage will cause a high-priority ALARM, trigger sensitivity and cycle off cannot be set; NIV - PC is a controlled breathing mode (cm)
NIV - PS	NIV-PS	pib
NIV - nasal CPAP	Nasal CPAP	IMPORTANT to have a ventilator-independent means of monitoring in place, no backup ventilation available, Apnea alarm can be turned off; sb
Automode	none	VC <--> VS or PRVC <--> VS or PC <--> PS; not in NIV

a. MVol = Minute Volume, UPL = Upper Pressure Limit, TVol = Tidal Volume, cm = controlled ventilation mode, pib = patient-initiated breathing mode, sb = spontaneous breathing mode, eb = patient can trigger extra breaths, df = decelerating inspiratory flow, cf = constant inspiratory flow

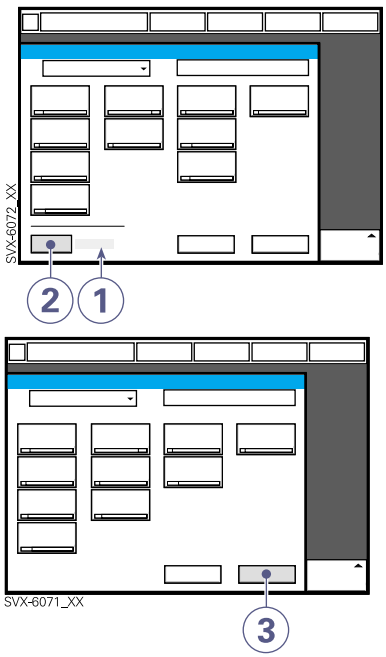
6.2 Ventilator Operation

This section contains information about setting the ventilation mode, recalling previous ventilation modes, using special ventilatory functions, and back-up ventilation functionality.

6.2.1 Setting Ventilation Mode

To set the ventilation mode, press the *Mode* touchpad in the upper left corner of the screen. See the *Operation Overview* chapter for details.

6.2.2 Recalling a Previous Ventilation Mode.



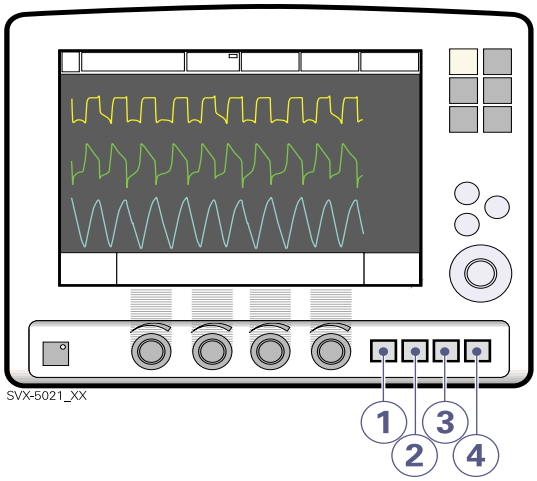
To recall a previous ventilation mode:

1. View the time when the previous mode was inactivated.
2. Press the *Show previous mode* touchpad to recall the previous accepted ventilation mode.
3. Activate the previous ventilation mode settings by pressing the *Accept* touchpad.

Notes:

- The previous ventilation mode function is not available after a Pre-Use Check, changing of patient category, admitting a new patient, using the same ventilation mode for more than 24 hours, or start-up (cold start) of the system.
- In backup ventilation, the ventilator shows the settings for the supported mode when previous mode is activated.
- A recall of previous settings is only possible after a change of ventilation mode.

6.2.3 Special Functions



Four fixed keys start special ventilatory functions.

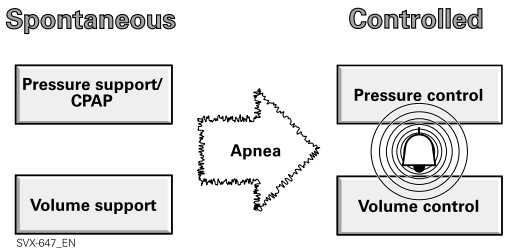
1. *Start breath*—The ventilator will initiate a new breath cycle according to the current settings.
2. *O_2 breaths*—Provides 100% oxygen for 1 minute. The O_2 concentration then returns to the preset value. Cancel by pressing the key again.
3. *Expiratory hold*—Expiratory and inspiratory valves close after expiration, while key is depressed, up to 30 seconds. Provides an exact measurement of the end expiratory

pause pressure. Use for static compliance measuring and to determine the total PEEP. The dynamic pressure is shown on the PEEP numerical value.

4. *Inspiratory hold*—Expiratory and inspiratory valves close after inspiration, while key is depressed, up to 30 seconds. Provides an exact measurement of the end inspiratory lung pressure. Use for static compliance measuring or during x-ray to determine plateau pressure.

Important: Special ventilatory functions require continuous patient supervision.

6.2.4 Backup Ventilation



Backup ventilation is available in all support modes except Automode and NIV Pressure Support mode.

The Backup function switches Volume Support to Volume Control, Pressure Support and CPAP to Pressure Control. During Backup ventilation default settings are used for I:E ratio, Respiratory Rate, and Inspiratory Rise Time. The Apnea alarm can be set in infant mode (5-45 seconds) and in adult mode (15-45 seconds). The Backup pressure level is adjustable: the minimum allowed value is 5 cmH_2O.

Note: Backup ventilation is not applicable in NIV Nasal CPAP.

6.3 Breathing Parameters

O_2 concentration (*O_2 Conc.*)—The gas mixture can be set from 21% O_2 to 100% O_2. There is an absolute minimum alarm limit of 18% O_2 which is independent of operating settings.

Respiratory rate (*RR*)—Rate of controlled mandatory breaths. Used for calculating target volume (b/min).

Tidal volume (*VT*)—Volume per breath or target volume (ml).

Minute volume (*Vmin*)—Volume per minute or target Minute volume (ml/min or l/min).

Note: Presentation can be configured to either tidal or minute volume.

PC above PEEP—Inspiratory pressure level for each breath (cmH_2O) in Pressure Control.

Important: In all pressure controlled modes, it is important to set alarm limits to adequate levels.

PS above PEEP—Inspiratory pressure support level for triggered breaths (cmH_2O) in Pressure Support.

Inspiratory rise time (T inspiratory rise)—Time to full inspiratory flow or pressure at the start of each breath, as a percentage of the breath cycle time (%) or in seconds (s).

Inspiratory rise time is set as a percent in PC, VC, PRVC, SIMV-VC, SIMV-PC, and SIMV-PRVC modes. The allowed range is:

- 0-20% of the respiratory cycle time.

Inspiratory rise time is set in seconds for Pressure Support, Volume Support, CPAP, and Bi-Vent modes. The allowed range is:

- Adults: 0-0.4 seconds
- Infants: 0-0.2 seconds.

Note: When the ventilator is configured for setting Inspiration time, the units for Inspiratory rise time automatically switches to seconds for all ventilation modes.

Note: Normally in supported modes the Inspiratory rise time should be increased from the default setting for patient comfort.

I:E ratio (*I:E*)—Ratio of Inspiration time + Pause time to Expiration time. See Note for Inspiration Time, below.

Inspiration time *(T_i)*—Time for active flow or pressure delivery to the patient (s).

Note: Breathing parameter settings can be configured in two different ways, based on:

- I:E ratio (independent of changes in *e.g.*, the breathing frequency) or,
- Inspiration time in seconds (independent of changes in *e.g.*, the breathing frequency), to better meet the requirements for infant care.

The configuration is done by a service technician with a service card.

Note: When the ventilator is configured to use Inspiration time, the Pause time and Inspiratory rise time are shown in seconds. The resulting I:E ratio for each setting is shown in the upper right information area of the Ventilation Mode Window. Because the inspiration time is explicitly set, a change of the Respiratory Rate, for example, will affect the I:E ratio. As a safety precaution, it will therefore be indicated when the resulting I:E ratio passes 1:1 in either direction.

Pause time (T_{pause})—Time for no flow or pressure delivery (% or s).

Trigger sensitivity—Determines the level of patient effort required to trigger inspiration. The sensitivity is set as high as possible without self-triggering. This ensures that triggering is patient initiated and avoids autocycling by the ventilator.

There are two types of triggering:

1) Pressure triggering—This is the pressure below PEEP which the patient must create to initiate an inspiration. The allowed range is:

- -20 to 0 cmH_2O.

2) Flow triggering—As the dial is advanced to the right (step wise from the green into the red area) the trigger sensitivity increases so that the inhaled fraction of the bias flow leading to triggering is reduced. The allowed range is:

- 100% to 0% of the bias flow.

Note: You can't set trigger sensitivity in NIV mode.

WARNING! If the trigger sensitivity is set too high, a self-triggering (autotriggering) condition may be reached. This condition can also be reached if there is leakage in the breathing system, *e.g.*, if an uncuffed endotracheal tube is used. Triggering will then be initiated by the system and not by the patient.This should always be avoided by decreasing the trigger sensitivity.

WARNING! The trigger sensitivity bar has different colors based on the setting. A green bar indicates a normal setting for flow triggering. The risk of self-triggering increases when the bar is red. A white bar indicates that pressure triggering is required.

PEEP—The Positive End Expiratory Pressure (PEEP) maintained in the alveoli. The allowed range is:

- Standard Modes: 0 - 50 cmH_2O
- NIV Modes: 2 - 20 cmH_2O.

Inspiratory cycle-off (%)—Fraction of maximum flow at which inspiration should switch to expiration.

Breath cycle time (Breath cycle T)—The breath cycle time is the total cycle time of the mandatory breath in SIMV modes. The allowed range is:

- Infants: 0.5 -15 seconds in half second steps
- Adults: 1-15 seconds in one second steps.

Note: The breath cycle time is set only if the ventilator is configured to use the I:E ratio to set breathing parameters.

SIMV rate—Rate of controlled mandatory breaths (b/min).

Trigger timeout—The maximum allowed apnea time in Automode before controlled ventilation is activated. The allowed range is:

- Infant 3-7 seconds
- Adult 7-12 seconds

Initially the ventilator uses a dynamic trigger timeout limit. This means that for the spontaneously triggering patient the

timeout increases successively during the first ten breaths

Time high (T_{High})—Time at P_{High} level in Bi-Vent (s).

Time PEEP (T_{PEEP})—Time at PEEP level in Bi-Vent (s).

Pressure Support above Pressure high (*PS above P_{High}*)—Inspiratory pressure support level for breaths triggered during the T_{High} period in Bi-Vent (cmH_2O).

Pressure Support above PEEP (*PS above PEEP*)—Inspiratory pressure support level for breaths triggered during the T_{PEEP} period in Bi-Vent (cmH_2O).

Pressure high (P_{High})—Positive End Expiratory Pressure at the upper level in Bi-Vent (cmH_2O).

Pressure low (P_{Low})—Positive End Expiratory Pressure at the lower level in Bi-Vent (cmH_2O).

7 • Alarms

7.1 Introduction

The Servo-i Ventilator System is equipped with an alarm system to help ensure patient safety. Visual and audible alarms warn about:

- patient breathing problems *e.g.*, apnea
- power problems *e.g.*, loss of AC power
- problems with gases *e.g.*, low supply pressure
- hardware problems *e.g.*, overheating
- software problems *e.g.*, memory failure

This chapter describes general responses to alarms, provides the procedure for setting alarm limits (see also the *Operation Overview* chapter), and lists breathing-related alarm settings along with their allowed ranges.

The *Power Supply* chapter describes power supply-related alarms.

The *System Messages* chapter lists all alarms along with possible causes and remedies.

WARNING! The default setting of the high airway pressure alarm is 40 cmH_2O. It is important to adjust this setting as appropriate to avoid excessive airway pressures.

Important: Those responding to alarms must be health care professionals who have experience in ventilation treatment and who have been trained in the use of the Servo-i Ventilator System.

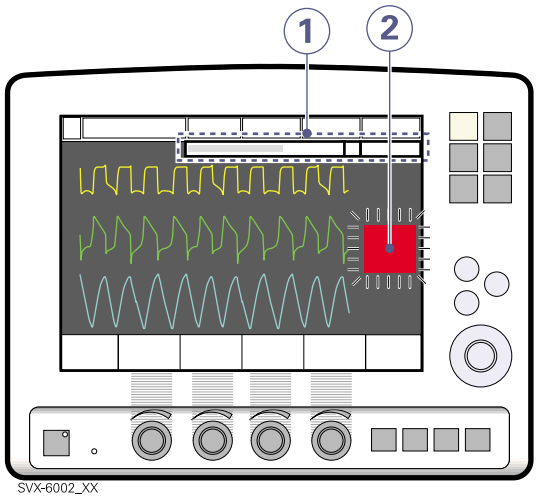
7.1.1 Alarm Output Connection Option

If your system is equipped with the alarm output connection option, high and medium priority alarms can be transferred to an external signal system. The alarm output signal is active as long as the audio alarm is active on the ventilator.

WARNINGS!

- Never leave the patient unattended; the external alarm is designed to alert those already in attendance.
- The alarm output is a nonguaranteed alarm according to IEC 60601-1-8 and it is recommended that users establish a Pre-Use Check routine for this application.

7.1.2 Visual Alarm Display



When an alarm is activated, the following information is supplied on the screen.

1. A text message explaining the cause of the alarm flashes in the alarm message area. The alarm with highest priority is displayed first.
2. The corresponding measured value or set value box flashes and an arrow points at the exceeded limit.

Note: Two bells in the alarm message area indicate that more than one alarm is activated.

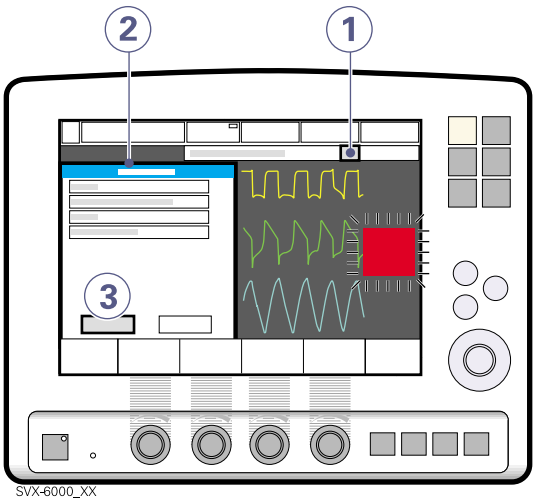
7.2 Handling Alarms

The system can signal four types of alarm:

- High Priority—red background
- Medium Priority—yellow background
- Low Priority—yellow background
- Technical—a numeric code

The following sections provide general information about viewing, responding to, silencing, and turning off alarms.

7.2.1 Viewing the Current Alarms Window.



If more than one alarm is active, view the Current Alarms Window by:

1. Press the bell(s) in the alarm message touchpad.

All alarms (up to 10 listed by priority) are shown in a dynamic window that will be updated if more alarms occur while the window is open.

2. View the current alarms.
3. Press the *History* touchpad.

The previous 16 alarm-dependent events are listed chronologically, with the most recent event at the bottom.

Note: For viewing more than the latest 10 alarms, use the Event log to view all logged alarms.

7.2.2 Resetting Latched Alarms

High Priority alarms are "latched"—the alarm message remains on the screen even if the alarm condition ceases. Medium and Low Priority alarms are not latched. The fixed key *Audio Pause* resets latched alarms and clears the alarm message from the screen.

The *Audio Pause* key is identified by the following symbol.

Note: The NIV alarm *Leakage out of range* is not latched.

7.2.3 Responding to Alarms

The procedure for responding to High Priority alarms differs slightly from that for Medium and Low Priority alarms. For both, refer to the *Using the Audio Pause Key* figure.

To respond to a High Priority alarm:

1. If desired, press the *Audio Pause* fixed key for less than two seconds to silence the alarm for two minutes.
2. Take action to resolve the alarm condition. The alarm may remain active if it is latched.
3. Press the *Audio Pause* key to reset the latched alarm and clear the message from the screen.

To respond to a Medium/Low priority alarm:

1. If desired, press the *Audio Pause* key for less than two seconds to reset the alarm even if the alarm condition remains.
2. Take action to resolve the alarm condition.

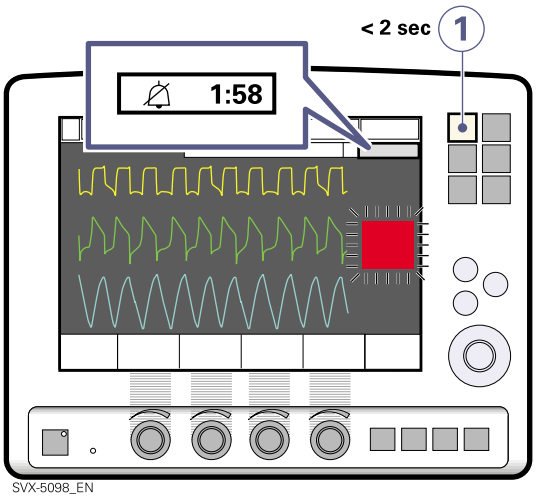
The alarm is automatically reset once the alarm condition ceases.

Note: The following Medium Priority alarms display an *Audio off?* message when activated:

- *Air Supply Pressure: Low*
- *O_2 Supply Pressure: Low*
- *Battery Operation*

For these alarms, you can silence the audio signal even if the alarm condition is not resolved. However, the system will eventually reactivate the alarm.

Using the Audio Pause Key



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Pressing the *Audio Pause* fixed key for less than two seconds has the following results:

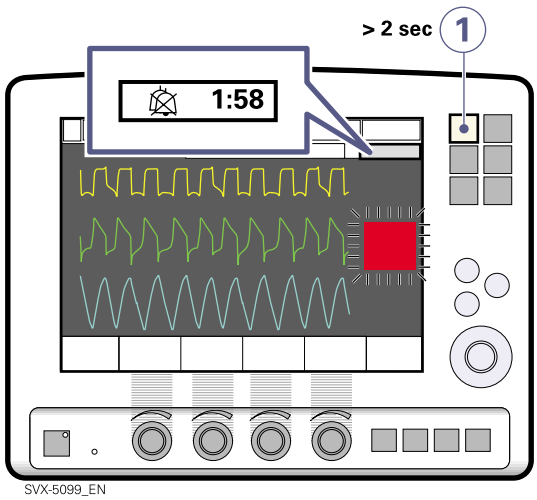
- Active alarms are silenced for two minutes.
- A crossed bell symbol along with the time remaining in the silent period are displayed in the message area.
- Each press of the *Audio Pause* key adds two minutes to the silent period.
- Latched alarms are reset if the alarm condition has ceased.

Note: The *No battery capacity* alarm and technical alarms cannot be silenced.

7.2.4 Presilencing Alarms

To silence most alarms (active and inactive) for two minutes, press and hold the *Audio Pause* fixed key for more than two seconds. This action has the following results:

- All alarms, active and inactive, are silenced for two minutes from the time the key was pressed.
- A double crossed bell symbol along with the time remaining in the silent period are displayed in the message area.
- Pressing the *Audio Pause* key again for less than two seconds will now prolong the silent period for two additional minutes.
- Latched alarms are reset if the alarm condition has ceased.



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Note: The *No battery capacity* alarm and technical alarms cannot be silenced.

7.2.5 Permanently Silencing Alarms

To permanently silence certain alarms in NIV mode:

1. Press the *Alarm Profile* fixed key.
2. Press the touchpad corresponding to one of the following alarms:
   - Minute Volume
   - Respiratory Rate
   - PEEP
   - End tidal CO_2 (X CO_2 Analyzer)
   - CPAP (X Nasal CPAP)
3. Press the bell-symbol touchpad.

The symbol changes to a crossed bell indicating audio is off.

Note: If the system returned to standby and used in an invasive mode, the NIV alarms will return to their default states.

7.2.6 Turning Off the Apnea Alarm

To turn off the apnea alarm in Nasal CPAP mode:

1. Press the fixed key *Alarm Profile*.
2. Press the touch pad corresponding to the apnea alarm.
3. Turn the control wheel until the time limit has reached its maximum.
4. Continue turning the control wheel.

A message is displayed indicating the apnea alarm is turned off.

7.2.7 Responding to Technical Alarms

In some cases, restarting the system may resolve a technical alarm. However, technical alarms often necessitate taking the ventilator out of operation and having it serviced. See the *Specifications* chapter for further details.

7.3 Alarm Settings for Breathing Parameters

This section discusses viewing and setting alarm limits, lists alarm settings, explains the conditions under which alarm limits are set to their default values, and provides a table of allowed values of alarm settings.

7.3.1 Viewing Alarm Limits

Alarm limits may be viewed in the Measured Values Display on the right side of the screen. See the *Monitoring and Recording* chapter for details on the Measured Value Display.

7.3.2 Setting Alarm Limits

To set alarm limits, touch the fixed key *Alarm Profile* in the upper right corner of the screen (see the *Operation Overview* chapter for details about setting limits).

7.3.3 List of Alarm Settings

There are 15 alarm settings related to breathing parameters:

Automatically Set—These settings are determined automatically by the ventilator based on the related parameter settings:

- *O2 concentration high* (based on O_2 concentration setting)
- *O_2 concentration low* (based on O_2 concentration setting)
- *High continuous pressure* (based on PEEP setting)

Upper Limit—These settings define an upper bound on a condition that is monitored by the ventilator:

- *P_{aw} high* (airway pressure too high)
- *Apnea* (maximum time exceeded)

Breathing Parameter Alarms—These settings define an allowed range for a breathing parameter:

- *Expired minute volume* (high and low)
- *Respiratory rate* (high and low)
- *PEEP* (high and low)
- *etCO_2* (high and low)
- *CPAP* (high and low)

7.3.4 Conditions Leading to Default Alarm Settings

Alarm limits become set to their default values when:

- restarting the ventilator
- admitting a new patient
- changing X type of ventilation
- changing X patient category

7.3.5 Alarm Ranges and Defaults

Alarm (priority)[a]	Allowed Range; (Factory Default Value)	Audio Off
O_2 concentration high (HP)	NA; (Set Value+6vol%)	No
O_2 concentration low (HP)	NA; (Set Value-6vol% or ≤ 18vol%)	No
High continuous pressure (HP)	NA; (Set PEEP level+15 cmH_2O for > 15 sec)	No
P_{aw} high (HP)[b]	Adult: 16 - 120 cmH_2O; (40, 20 in NIV) Infant: 16 - 90 cmH_2O; (40, 20 in NIV)	No
Apnea (HP)	Adult: 15 - 45 sec;(20) Infant: 5 - 45 sec; (10)	No
Expired minute volume high (HP)	Adult: 0.5 - 60 l/min; (40) Infant: 0.01 - 30 l/min; (5)	Yes
Expired minute volume low (HP)	Adult: 0.5 - 40 l/min; (5) Infant: 0.01 - 20 l/min; (2)	Yes
Respiratory rate high (MP)	Adult: 1 - 160 b/min; (30) Infant: 1 - 160 b/min; (50)	Yes
Respiratory rate low (MP)	Adult: 1 - 160 b/min; (5) Infant: 1 - 160 b/min; (20)	Yes
PEEP high (MP)	0 - 55 cmH_2O; (10)	Yes
PEEP low (MP)[c]	0 - 47 cmH_2O; (10)	Yes
$etCO_2$ high (MP)[d]	0.5 - 20%; (6.5) 4 - 100 mmHg; (49) 0.5 - 14kPa; (6.5)	Yes
$etCO_2$ low (MP)	0.5 - 20%; (4) 4 - 100 mmHg; (30) 0.5 - 14kPa (4)	Yes
CPAP high (MP)	Adult: 0 - 55 cmH_2O; (10) Infant: 0 - 55 cmH_2O; (10)	Yes
CPAP low (MP)	Adult: 0 - 47 cmH_2O; (10) Infant: 0 - 47 cmH_2O; (10)	Yes

a. HP = High priority alarm, MP = Medium priority alarm
b. If P_{aw} rises 6 cmH_20 above the set limit or if system pressure exceeds 117 ± 7 cmH_20, the safety valve opens.
c. Setting the alarm limit to 0 (zero) is equivalent to turning the alarm off.
d. If the alarm limit is set outside the measuring range, no alarm will be activated even if the limit is exceeded.

8 • Accessories

8.1 Servo Ultra Nebulizer

The Servo Ultra Nebulizer is intended for administering nebulizing drugs to patients requiring mechanical ventilation or positive pressure breathing assistance via an endotracheal tube or face mask/prongs.

The nebulizer operates continuously regardless of ventilation mode setting. No extra gas volume is added to the inspiratory minute volume and thus neither the ventilator settings nor the readings are affected.

Important: When using the Aeroneb Professional Nebulizer System, the accuracy of the Y Sensor measurement may be compromised. Therefore, you should remove the Y Sensor from the patient circuit when the Aeroneb Professional Nebulizer System is in use.

Important: Before administering any medication via the nebulizer, consult the manufacturer regarding the appropriateness of ultrasonic nebulization for that medication.

Important: If a nebulizer and the CO_2 Analyzer are in use simultaneously, the CO_2 reading may be affected.

Note: The Servo Ultra Nebulizer may be interrupted briefly due to overheating. It will automatically start again when the buffer water has cooled. During this short period of time no alarm is activated and the timer is not interrupted.

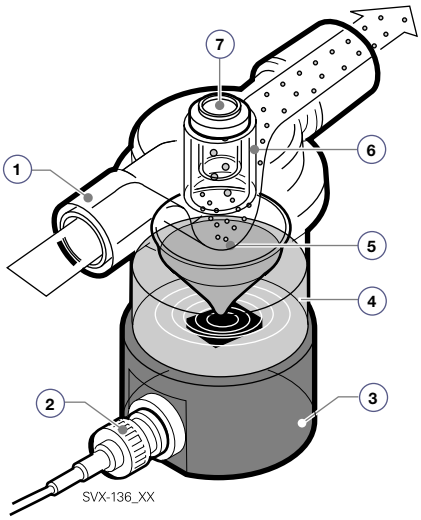
Note: The nebulizer module becomes disabled whenever the ventilator is running on battery power.

8.1.1 Nebulizer Use Guidelines

These guidelines are reminders for health care professionals who have already been trained to use the Servo Ultra Nebulizer:

- Disconnect the Servo Humidifier/HME during nebulization; otherwise the humidifier may become blocked.
- Turn off the heated humidifier during nebulization; otherwise the particle size may be affected.
- Do not use the nebulizer without buffer liquid (sterile water); otherwise the ultrasonic generator crystal may break.
- Do not use the nebulizer without a filter connected to the expiratory inlet of the ventilator.
- Before starting the nebulizer check that the medication cup is undamaged and firmly in place.
- During nebulization, frequently check the buffer liquid level. Keep the level between MIN and MAX when the nebulizer is operating.
- During nebulization, carefully monitor the airway pressure. Increased airway pressure could result from a clogged filter. Replace the filter if the expiratory resistance increases or after 24 hours of nebulizer use, whichever comes first.
- During nebulization, frequently check that moisture is being generated in the medication cup.

8.1.2 Nebulizer Components



1. Gas from ventilator
2. Cable from ventilator
3. Ultrasonic generator
4. Sterile buffer water
5. Medication mist produced in the medication cup

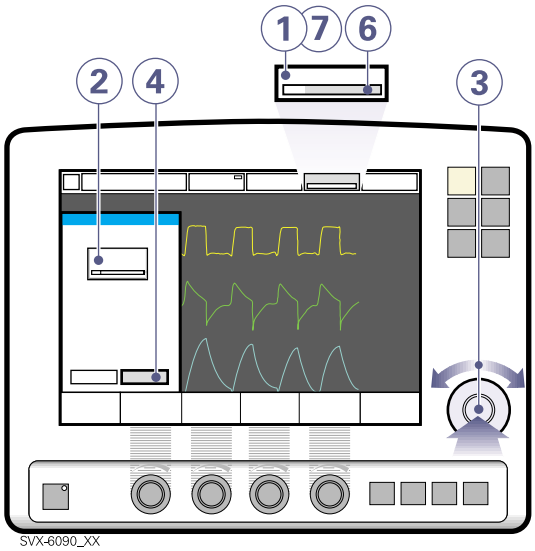
The 10 ml cup is disposable. It can be filled during nebulization through an injection membrane in the T-piece, or before mounting the T-piece. The medication mist is carried to the patient by the inspiratory flow.

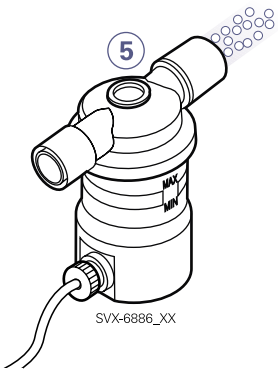
6. T-piece with mechanical particle separation system (baffles)

The system ensures a mass median diameter (MMD) of approximately 4.0 µm for droplets in the mist. Larger droplets are renebulized.

7. Injection membrane

8.1.3 Operation





To operate the nebulizer:

1. Press the *Nebulizer* touchpad.
2. Press the *Time* touchpad.
3. Set the time using the Main Rotary Dial.
4. Touch *Accept* to accept the time.
5. Check that medication mist is produced.
6. View the remaining nebulization time.
7. Press the *Nebulizer* touchpad to change the time or cancel nebulization.

8.2 X CO_2 Analyzer

When the CO_2 Analyzer is in use, the following data is displayed on the screen:

- CO_2 concentration vs. time (waveform)
- End Tidal CO_2 concentration ($etCO_2$)
- CO_2 minute elimination
- CO_2 tidal elimination

Note: Alarm limits for high and low $etCO_2$ can be individually set.

Important: If the upper alarm limit is set above the maximum measuring range, no alarm will be activated even if the upper limit is exceeded.

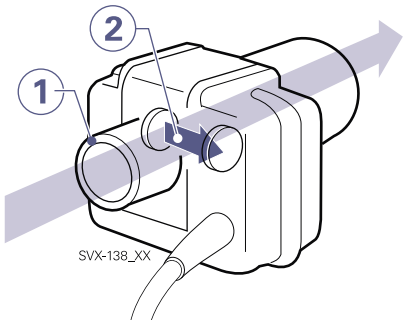
Important: If a nebulizer and CO_2 Analyzer are in use simultaneously, the CO_2 reading may be affected.

8.2.1 CO_2 Analyzer Use Guidelines

These guidelines are reminders for health care professionals who have already been trained to use the CO_2 Analyzer:

- The capnostat sensor and airway adapter windows should be placed vertically to reduce the possibility of optical interference due to window contamination.
- Do not insert two CO_2 modules at the same time. The Servo-i Ventilator System can only handle one CO_2 module at a time.
- Use only a MAQUET airway adapter with the capnostat sensor.

8.2.2 CO_2 Analyzer Components



1. Gas flow through the airway adapter in the capnostat sensor.
2. The sensor uses a solid state and IR based optical system with no moveable parts. It measures the difference between a reference light beam and one filtered for CO_2 wave lengths.

8.2.3 CO_2 Analyzer Calibration

Before beginning the calibration procedure make sure the capnostat sensor is warm. Values displayed during warm-up have reduced accuracy. If calibration is needed, a message will appear.

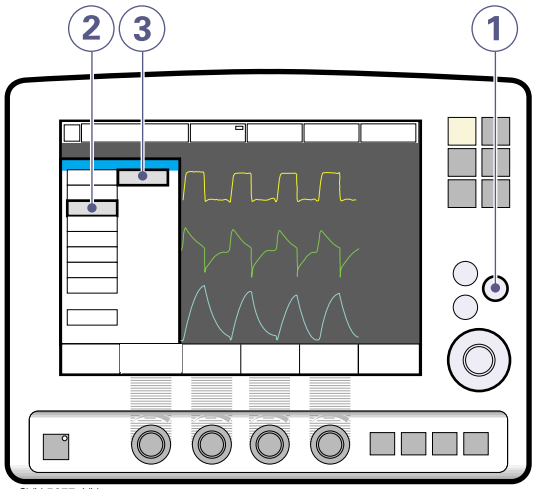
There are two calibration options: cell zero and verification (see later in this section).

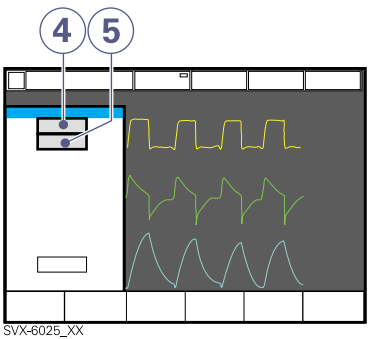
To calibrate the CO_2 Analyzer:

1. Press the fixed key *Menu*.
2. Press the *Options* touchpad.
3. Press the *CO_2 calibration* touchpad.
4. Press the *Cell zero* touchpad if the capnostat sensor has been shifted.
5. Press the *Verification* touchpad to perform a calibration including cell zeroing, verification against reference cell, and adapter zeroing.

Important: Verification calibration is recommended. Always perform a verification when the airway adapter is altered, a faulty capnostat sensor is suspected, or the system requests calibration.

Procedure Diagram: CO_2 Analyzer Calibration

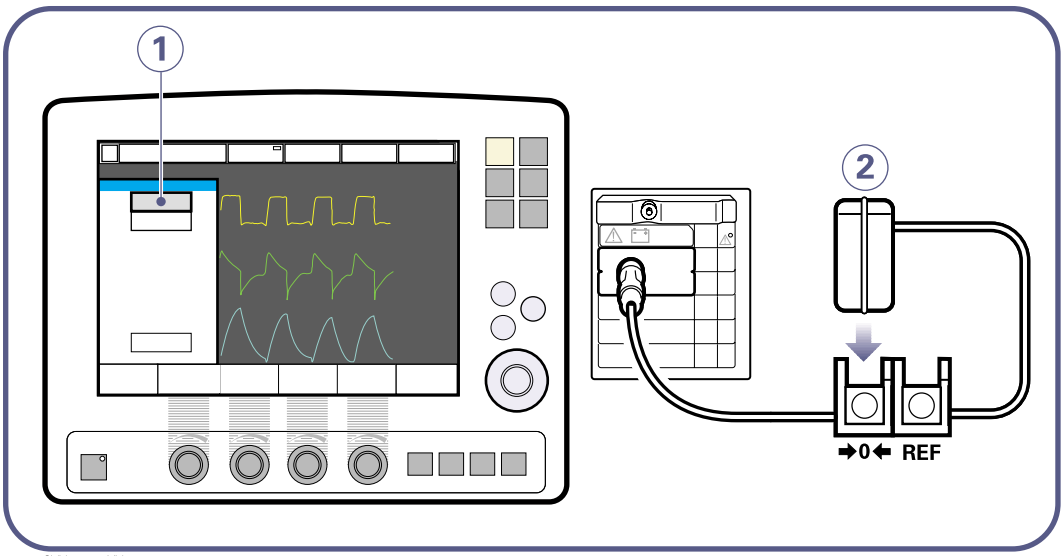




Notes:

- The *etCO_2 concentration low* alarm can be permanently silenced (Audio off) when the message *Silence alarm permanently?* is shown.
- During calibration no CO_2 waveforms or measured CO_2 values will be displayed.
- During zero calibration the adapter must contain room air only.

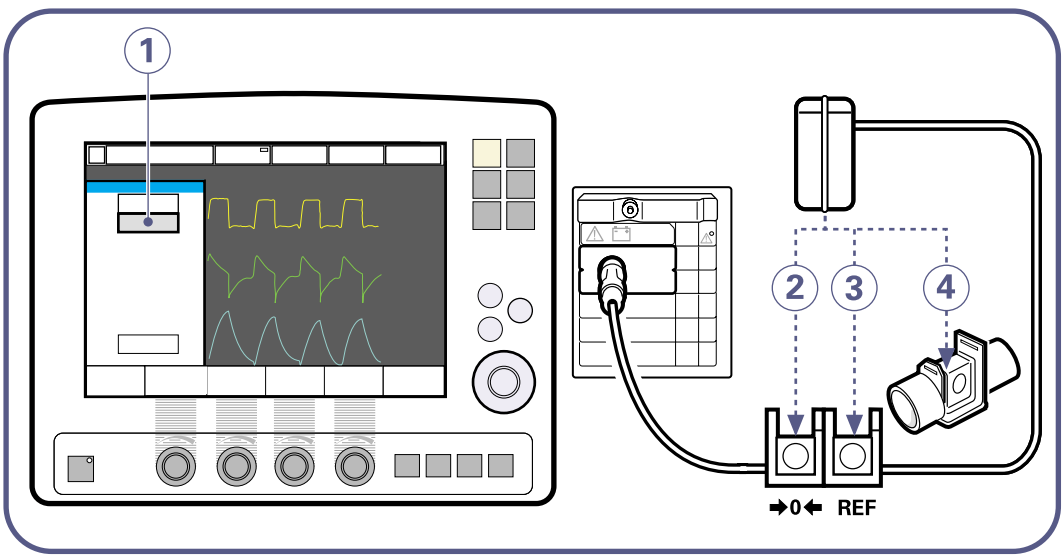
8.2.3.1 Cell Zero Calibration



SVX-5078_XX

1. Press the *Cell zero* touchpad; wait for on-screen instructions.
2. Place the capnostat sensor on the zero cell.

8.2.3.3 Verification Calibration



SVX-5079_EN

1. Press the *Verification* touchpad; wait for on-screen instructions.
2. Place the capnostat sensor on the zero cell; wait for on-screen instructions.
3. Place the capnostat sensor on the reference cell; wait for on-screen instructions.
4. Place the capnostat sensor on an unconnected airway adapter, containing room air.

8.3 Y Sensor

The Y Sensor is a fixed-orifice, differential pressure sensor. It allows the pressure and flow to be measured close to the patient's airway. The Y Sensor can be used in all ventilation modes.

Important: When using the Aeroneb Professional Nebulizer System, the accuracy of the Y Sensor measurement may be compromised. Therefore, you should remove the Y Sensor from the patient circuit when the Aeroneb Professional Nebulizer System is in use.

Note: To guarantee that waveforms and metrics are always displayed on the screen, the internal pressure and flow sensors are at all times active as backup. Their readings are compared with the Y Sensor measurement. The Y Sensor is disabled if there is a significant deviation or malfunction.

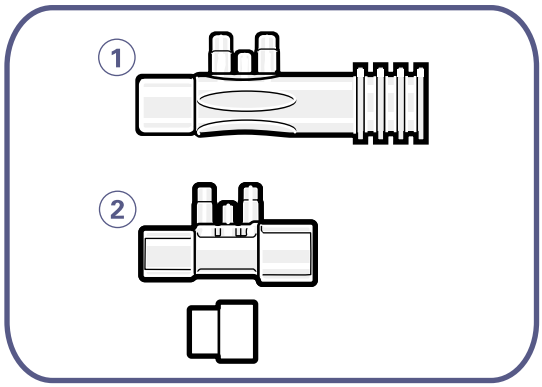
Note: A Pre-Use Check or a Patient Circuit Test is required to prior to using the Y Sensor.

8.3.1 Y Sensor Use Guidelines

These guidelines are reminders for health care professionals who have already been trained to use the Y Sensor.

- The Y Sensor is intended for single-patient use only.
- Do not insert two Y Sensor modules at the same time. The Servo-i Ventilator System can handle only one Y Sensor module at a time.
- Do not apply tension to the Y Sensor tubing.
- Make sure there are no kinks in the Y Sensor tubing.
- If the Y Sensor is not connected to the module, do not connect to the patient circuit as this may cause leakage.
- Frequently check for condensed water or other fluids in the Y Sensor. Fluids in the Y Sensor can cause immediate loss of accuracy or long-term drift.
- Place an HME or tube between the Y Sensor (adult version) and the test lung to avoid inaccurate measurements caused by high resistance in the test lung.

8.3.2 Y Sensor Components



SVX-9049

The two versions of the disposable, single-use Y Sensor —Adult (1) and Infant (2)—are shown in the figure above. The Infant sensor includes an adaptor for use with the neonate CO_2 adapter.

9 • System Messages

9.1 Introduction

This chapter lists and describes alarm, pre-use check, CO_2 Analyzer calibration, and technical messages. The lists also provide suggested actions in response to the messages.

Note: Most technical errors require the attention of a service technician.

WARNING! Always disconnect the ventilator when performing operations that increase risk to the patient, such as replacing the O_2 cell.

Caution: Do not lift the expiratory cassette when the ventilator is operating; instead, you may do this in Standby mode.

9.2 High Priority Alarms

Alarm Message	Possible causes	Remedies
Apnea	Preset or default alarm limit exceeded. Time between two consecutive inspiratory efforts exceeds the set alarm limit.	Check patient and breathing system. Check ventilator settings.
Backup ventilation	An apnea has caused the ventilator to switch from support mode to backup ventilation mode.	Check patient. Select ventilator mode. Check ventilator settings. Contact a service technician.
Check tubing	Problems with patient tubing or expiratory pressure transducer. Disconnected pressure transducer (expiratory or inspiratory). Blocked pressure transducer (expiratory or inspiratory). Water in expiratory limb of ventilator. Wet or clogged bacteria filter. Excessive leakage.	Refer to service. Remove water from tubing and check humidifier settings, *e.g.*, relative humidity. Check heater wires in humidifier (if present). Check connections of tubing and expiratory cassette.
Expiratory cassette disconnected	The expiratory cassette is disconnected or not connected properly.	Connect the expiratory cassette. Replace the expiratory cassette. Perform a Pre-Use Check if a new expiratory cassette is inserted.
Expiratory Minute Volume: High	Preset or default alarm limit exceeded. Increased patient activity. Ventilator self-triggering (autocycling). Improper alarm limit setting.	Check patient and breathing system. Check trigger sensitivity setting. Check alarm limit settings.
Expiratory Minute Volume: Low Also see note at the end of this table.	Preset or default alarm limit exceeded. **Note:** This alarm also works as a patient disconnect alarm. Low spontaneous patient breathing activity. Leakage around the cuff. Leakage in the patient breathing system. Improper alarm setting.	Check patient. Check cuff pressure. Check patient breathing system (perform leakage test if necessary). Check pause time and graphics to verify. Consider increased ventilatory support for the patient.
Gas supply pressures: Low	Air and O_2 supply is below 2.0 kPa x 100. Both air and O_2 gas supply disconnected.	Check the gas connections.

Alarm Message	Possible causes	Remedies
High continuous pressure	Constant high airway pressure for more than 15 seconds (PEEP + 15 cmH_2O).	Check patient and breathing system. Check ventilator settings. Contact a service technician.
Leakage out of range	Leakage too high. The mask / prongs may not be adjusted properly for the patient or may be the wrong size.	Check patient and breathing system. Check mask / prongs size and patient fit.
Limited battery capacity	Less than 10 minutes left of battery operating time.	Insert a new battery module or connect to AC power.
Low battery voltage	Battery voltage too low. Cannot guarantee continued ventilator operation.	If possible, connect to AC power supply. Replace and discard all batteries if this message appears even when batteries are fully charged.
Nebulizer hardware error	Technical problem with nebulizer hardware. Temperature too high.	Change the nebulizer. Contact a service technician.
No battery capacity	Less than 3 minutes left of battery operation.	Connect to AC power. Insert charged battery modules.
No patient effort detected	The time between two consecutive inspiratory efforts has exceeded 45 seconds for adults or 15 seconds for infants.	Check patient and breathing system. Check ventilator settings.
O_2 cell / sensor failure	O_2 cell / sensor missing or disconnected.	Check O_2 cell / sensor and connection. **Note:** If O_2 sensor is being used, make sure O_2 sensor software is installed.
O_2 concentration: High	Measured O_2 concentration exceeds the set value by more than 6 Vol.%. Gas supply or air line disconnected. No supply from wall outlet. The air gas module is disconnected. If no gas is available, then both expiratory and safety valves will open.	Check air supply. Perform a Pre-Use Check. Perform O_2 cell adaptation.

Alarm Message	Possible causes	Remedies
O_2 concentration: Low	Measured O_2 concentration is below the set value by more than 6 Vol.% or concentration is below 18 Vol.% which is independent of operator settings. Gas delivered in O_2 supply line is not O_2. O_2 sensor faulty or exhausted. O_2 cell uncalibrated. O_2/oxygen gas module faulty.	Check O_2 supply line. Perform a Pre-Use Check. Perform O_2 cell adaptation.
Paw high **Caution:** If airway pressure rises 6 cmH_2O above set upper pressure limit, the safety valve opens. The safety valve also opens if system pressure exceeds 117± 7 cmH_2O.	Airway pressure exceeds preset Upper Pressure Limit. Kinked or blocked tubing. Mucus or secretion plug in endotracheal tube or in airways. Patient coughing or fighting ventilator. Inspiratory flow rate too high. Improper alarm setting. Blocked expiratory filter.	Check patient and breathing system. Check ventilator settings and alarm limits.
Restart ventilator!	Software error.	Restart the ventilator and perform a Pre-Use Check. Contact a service technician.
Safety valve test failed	During Pre-Use Check the system found problems with the opening pressure for the safety valve.	Contact a service technician.
Settings lost; Restart ventilator	Software error, memory corrupt.	Restart the ventilator and perform a Pre-Use Check. Check ventilator settings.
Technical error in Expiratory cassette	Technical problem with the expiratory cassette.	Perform a Pre-Use Check. Change the expiratory cassette and perform a Pre-Use Check. Contact a service technician.
Technical error: Restart ventilator	Ventilator settings lost.	Restart the ventilator, perform a Pre-Use Check and check all settings. Contact a service technician.
Time in waiting position exceeds 2 min.	Time in waiting position is exceeded. Patient is not connected to the ventilator or leakage is excessive.	Check patient and breathing system.

Note: *Expiratory Minute Volume: Low*

Considerable leakage may occur around the endotracheal tube if it is uncuffed. The combination of small tidal volumes, leakage around the tube and activated compliance compensation may trigger the *Low Expiratory Minute Volume* alarm, due to a very low expiratory flow passing from the patient through the expiratory channel. By observing the difference between the Vti and Vte values presented on the screen, a leakage can be detected and its extent easily controlled. The first time an unacceptably large leakage occurs around the tube, correct this problem to avoid triggering this alarm. If leakage persists, adjust the alarm limit to its lowest level (10 ml) if this is clinically appropriate. Finally, if the leakage still has not been remedied, deactivate the compliance compensation to avoid triggering the alarm. If the compliance compensation is deactivated from Pressure Control, Pressure Support, or SIMV (Pressure Control) ventilation modes, then no further settings need to be adjusted. However, if volume-related modes are used, the set volumes must be adjusted.

9.3 Medium Priority Alarms

Alarm message	Possible causes	Remedies
Air supply pressure: High	Air supply pressure above 6.5 kPa x 100. Air supply pressure at gas inlet is too high.	Check the gas supply lines. Perform a Pre-Use Check. Contact a service technician.
Air supply pressure: Low	Air supply pressure below 2.0 kPa x 100. Air supply pressure at gas inlet is too low. Gas supply line disconnected. **Note:** This alarm can be permanently silenced (Audio off) when activated.	Check and connect gas supply lines. Perform a Pre-Use Check.
Alarm output connection error	Technical problems (hardware or software) with the external alarm function.	Contact a service technician.
Battery mode! Nebulizer switched off	Ventilator is running on batteries and the Servo Ultra Nebulizer is disabled to reduce power consumption.	Connect to AC power to use the Servo Ultra Nebulize. Check the connection to AC power.
Battery operation	AC power interrupted.	Check the connection to AC power.
Check alarm limits	The persistent memory has corrupt contents.	Check the alarm limits.
Check CO_2 airway adapter	The data, reference channel, or both are out of range. Usually occurs if the airway adapter is removed from the capnostat, there is optical blockage on the windows of the airway adapter, or the adapter type was changed and verification was not performed.	Make sure that the adapter is completely inserted. Clean airway adapter if necessary. Open the CO_2 Calibration Window and perform Verification.
Check default alarm limits	Problems in internal memory for default alarm limits.	Check default alarm limits. Contact a service technician.
Check Y Sensor	Y Sensor is not connected to the patient breathing system or Y Sensor is not working properly.	Check sensor connection to patient breathing system. Change the Y Sensor.
CO_2 module error	Hardware error in the CO_2 Analyzer module.	Unplug and reinsert the module. Change the module. Contact a service technician.
CO_2 module unplugged	CO_2 Analyzer module is not properly inserted.	Insert the CO_2 Analyzer module.
CO_2 sensor disconnected	CO_2 capnostat sensor is not attached.	Connect the sensor to the CO_2 Analyzer module.

Alarm message	Possible causes	Remedies
CO_2 sensor error	Hardware error in CO_2 capnostat sensor. The values in the capnostat memory failed the internal test.	Unplug and reinsert the capnostat sensor. Calibrate the capnostat sensor. Change the capnostat sensor. Contact a service technician.
CO_2 sensor temperature too high	Possible hardware error. The capnostat sensor temperature is higher than 50°C.	Make sure the capnostat sensor is not exposed to extreme heat (heat lamp, incubator etc.). Replace the capnostat sensor.
CO_2 sensor temperature too low	The capnostat sensor does not reach operating temperature.	Change capnostat sensor and/or module. Contact a service technician.
CPAP High/Low	Preset or default alarm exceeded.	Check patient and breathing system. Check mask/ prongs size and patient fit. Check alarm settings.
etCO_2 high	Hypoventilation. Leakage with high bias flow. CO_2 sensor, Y-piece, HME.	Check patient circuit. Check ventilator settings.
etCO_2 low	Hyperventilation. Leakage with high bias flow. CO_2 sensor, Y-piece, HME.	Check patient circuit. Check ventilator settings.
Exp. cassette exchanged	Expiratory cassette has been exchanged during operation. Pre-Use Check not performed after exchange.	Perform a Pre-Use Check.
Inspiratory flow overrange	Combination of settings exceeds the allowable inspiration flow range.	Change ventilator settings. Increase the gas inlet pressure.
Internal temperature: High	Temperature inside the ventilator is too high.	Check fan operation. Check the operating temperature.
Nebulizer disconnected	The nebulizer is disconnected during nebulization. Technical problem with connection cable.	Connect the nebulizer. Change the connection cable.
Nebulizer hardware error	Technical problem with nebulizer hardware. Temperature too high. Not enough buffer liquid. Technical problem with connection cable.	Restart the nebulizer. Check buffer liquid level. Change the nebulizer. Change connection cable. Contact a service technician.
Nebulizer inhibited due to overheating	Temperature too high.	Turn off the nebulizer and restart when cool.

Alarm message	Possible causes	Remedies
O_2 supply pressure: High	O_2 supply pressure above 6.5 kPa x 100. O_2 supply pressure at gas inlet is too high.	Check the gas supply lines. Perform a Pre-Use Check. Contact a service technician.
O_2 supply pressure: Low	O_2 supply pressure below 2.0 kPa x 100 or above 6.5 kPa x 100. O_2 supply pressure at gas inlet is too low. Gas supply line disconnected. **Note:** This alarm can be permanently silenced (Audio off) when activated.	Check and connect gas supply lines. Perform a Pre-Use Check.
Panel disconnected	No communication between user interface and patient unit.	Check control cable. Contact a service technician.
PEEP High	The measured end expiratory pressure is above the preset or default alarm limit for three consecutive breaths.	Check patient breathing system. Check patient connection (cuff pressure/tracheal tube size). Perform a Pre-Use Check. Check ventilator settings. Check alarm settings.
PEEP Low	The measured end expiratory pressure is below the preset or default alarm limit for three consecutive breaths. **Note:** Setting the alarm to zero turns the alarm off. Leakage in patient breathing system. Leakage at patient connection (cuff, tracheal tube).	Check patient breathing system. Check patient connection (cuff pressure/tracheal tube size). Perform a Pre-Use Check. Check alarm settings.
Regulation pressure limited	It is not possible to reach the Set volume in PRVC and VS due to restrictions imposed by the set upper pressure limit. Set high pressure alarm limit; this limits the regulatory pressure used in PRVC or VS.	Check ventilator settings.
Remove one CO_2 module	Two CO_2 Analyzer modules are connected at the same time.	Remove one of the CO_2 Analyzer modules.
Respiratory Rate: High	Respiratory frequency too high. Auto triggering.	Attend to the patient. Check the trigger setting.
Respiratory Rate: Low	Respiratory frequency too low. Trigger sensitivity setting incorrect. Large tidal volume.	Attend to the patient. Check trigger setting. Check inspiratory cycle-off setting.

Alarm message	Possible causes	Remedies
VT inspiratory overrange	Setting causing larger volume than allowed for the selected category. Limited adjustment of excessive tidal volume.	Check the adjustment for the inspiratory tidal volume.
Y Sensor mismatch	Y Sensor does not match the selected patient category	Check patient category setting. Check Y Sensor.
Y Sensor Module disconnected	Y Sensor module is not properly inserted.	Insert the Y Sensor module.
Remove one Y Sensor Module	Two Y Sensor modules are connected at the same time.	Remove one of the Y Sensor modules.
Y Sensor Module error	Hardware error in the Y Sensor measuring module.	Unplug and reinsert the module. Change the module. Contact a service technician.
Y Sensor Module temp high	Possible hardware error. The Y Sensor module temperature is higher than 60°C.	Make sure the Y Sensor module is not exposed to extreme heat. Change the module. Contact a service technician.
Y Sensor measuring error	Derivation between Y Sensor measuring and internal measurements, Y Sensor measuring has been disabled.	Check patient and patient circuit. Change the Y Sensor.
Y Sensor disconnected	Y Sensor is not attached.	Connect the sensor to the Y Sensor module.

9.4 Low Priority Alarms

Alarm message	Possible causes	Remedies
Touch screen or knob press time exceeded	Screen or knob has been pressed for more than one minute. Screen or knob hardware time out.	Check screen and knobs. Contact a service technician.

9.5 Pre-Use Check Messages: General

Message	Cause	Remedies
Cancelled	The test was cancelled by the user.	You should always perform a Pre-Use Check before connecting the ventilator to a patient.
Failed	The test did not pass.	Check all connections and the expiratory cassette. Perform a Pre-Use Check again. Contact a service technician.
Not completed	The test was not completed. The test case passed with some reservations. This message appears when: • the battery option is installed and the battery capacity is less than 10 minutes; or • the test could not be completed due to a missing gas.	The ventilator may still be used (limited). If you supply missing gas, you must perform another Pre-Use Check.
Passed	The test case has passed, and the device is working according to the test specifications.	None required.
Running	A test is in process. The message flashes during the test.	None required.

9.6 Pre-Use Check Messages: Specific

Message	Description	Remedies, if test fails
Alarm state test	Verifying that no Technical Error Alarms are active.	Refer to Service.
Barometer test	Checking barometric pressure measured by the internal barometer.	Check the barometric pressure value in the Status Window.
Battery switch test	If battery modules are connected, checks the ability to toggle between AC power and backup power when AC power is lost and regained.	Check that the total remaining time for the connected battery modules are >10 min. If not, replace the discharged battery with a charged battery and repeat the test.
Flow transducer test	Checks the inspiratory flow transducers. Calibrates and checks the expiratory flow transducer.	Check that the connected gas supply pressure (Air and O_2) is within the specified range. Check that the cassette is correctly seated in the cassette compartment.
Gas supply pressure test	Checks that the gas supply pressures (air and O_2) measured by the internal gas supply pressure transducers are within the specified range.	Check that the connected gas supply pressure (air and O_2) is within the specified range.
Internal leakage test	Checks for internal leakage, with test tube connected using the inspiratory and expiratory pressure transducers. Allowed leakage: 10ml/min at 80 cmH_2O. Message *Leakage* or *Excessive leakage* may appear.	Check that the test tube is correctly connected. Check all connections for the expiratory cassette and inspiratory section. Make sure the expiratory cassette and the inspiratory channel are clean and dry. Contact a service technician.
Internal test	Audio test and other internal tests (memories, safety-related hardware, etc.).	Make sure the patient unit front cover and the user interface rear cover are correctly mounted; otherwise, the audio test may fail.
O_2 cell / sensor test	Calibrates and checks the O_2 cell/ sensor at 21% O_2 and 100% O_2. Checks if the O_2 cell is worn out. **Note:** As different gas mixtures are used during this test, calibration and check of O_2 cell/sensor will not be performed if one gas is missing.	Check that the connected gas supply pressure (air and O_2) is within the specified range. Replace the O_2 cell. Replace gas modules (air and/or O_2).

Message	Description	Remedies, if test fails
Patient circuit leakage test	Checks the patient circuit leakage, with patient tubing connected using the inspiratory and expiratory pressure transducers. Allowed leakage: 80 ml/min at 50 cmH_2O. Allows the system to calculate a compensation for circuit compliance if the leakage requirements are met.	If the internal leakage test has passed, the leakage is located in the patient circuit. Check for leakage or replace the patient circuit.
Y Sensor test	Checks the pressure and flow measurement of the Y Sensor.	Check Y module and Y Sensor. Change Y Sensor and/or Y module.
Pressure transducer test	Calibrates and checks the inspiratory and expiratory pressure transducers.	If the Internal leakage test passed (see above): Check/replace inspiratory or expiratory pressure transducer. Check that there is no excess water in the expiratory cassette.
Safety valve test	Checks and adjusts the opening pressure for the safety valve to 117 ± 3 cm H_2O.	Check the inspiratory section: Ensure the safety valve membrane is correctly seated in the inspiratory pipe. Ensure the inspiratory pipe is correctly mounted in inspiratory section. Ensure the safety valve closes properly when the Pre-Use Check is started (a distinct clicking sound from the valve indicates proper closing).

9.7 X CO_2 Analyzer: Calibration Error Messages

Message	Description	Remedies
Adapter zero: Failed	An error was detected during the verification calibration (adapter zero). The airway adapter is occluded or CO_2 gas is present in the adapter. The calibration was cancelled and old cell zero parameters were not restored.	Perform a verification calibration. Hardware problem: contact a service technician.
CO_2 cell zero failed	An error was found during cell zero calibration. The calibration was cancelled and old cell zero parameters were not restored.	Perform a cell zero calibration. Hardware problem: contact a service technician.
Verification against Reference cell: Failed	The capnostat sensor is faulty or there is an optical blockage of the capnostat sensor windows.	Clean the capnostat sensor windows. Replace the capnostat sensor.

9.8 Technical Error Messages

Error code number	Causes	Remedies
xxxx (General)	Technical problem, identified by the error code xxxx.	Restart the ventilator and perform a Pre-Use Check. Shut down ventilator and contact a service technician.
1 - 6, 29, 10001	Power failure.	Contact a service technician.
7, 10-11	Expiratory / inspiratory channel failures.	Contact a service technician.
12, 16	Connection failures.	Contact a service technician.
25, 43	Communication failure.	Contact a service technician.
27	Test of backup sound device failed.	Restart the ventilator and perform a Pre-Use Check. Shut down ventilator and contact a service technician.
28, 20004	Alarm sound level too low.	Check that the loudspeaker outlet is not obstructed. Restart the ventilator and perform a Pre-Use Check. Shut down ventilator and contact a service technician.
38-39	Barometer failures.	Contact a service technician.
8-9, 33-35, 41	Timeout failures.	Contact a service technician.
46	Internal failure, alarm output circuitry.	Contact a service technician.
48	Timeout failures.	Contact a service technician.
49	Timeout failures.	Contact a service technician.
51	Technical problem with Y Sensor module.	Contact a service technician.
20002	Backlight broken.	Contact a service technician.
20003	Button stuck.	Check user interface buttons. Contact a service technician.
40001	Exp. flow meter failure.	Contact a service technician.
22, 24, 40, 42, 44, 45, 50, 10002-10003, 20001	Other failure.	Contact a service technician.

10 • Specifications

10.1 System

10.1.1 General

This device complies with requirements of Medical Device Directive 93/42/EEC.

Standards

EN IEC 60 601-1 (Class 1, Type B)

IEC 60601-2-12

EN 794-1

Electromagnetic compatibility (EMC)

According IEC 60601-1-2, 2nd edition (2001)

Immunity

Extended test to 30V/m

The EMC declaration: *Information to the Responsible Organization* is available from MAQUET.

Patient Range (kg)

Adult weight: 10 - 250

Infant weight: 0.5 - 30

NIV (PC + PS) Infant weight: 3 - 30

NIV Nasal CPAP Infant weight: 0.5 - 10

10.1.2 Operating Conditions

Operating Temperature range: +10 to +40°C

Relative humidity: 15 to 95% noncondensing

Atmospheric pressure: 60 to 1060hPa

Low est pressure in patient circuit: 400 cmH2O

Impact

Peak acceleration: 15 g

Pulse duration: 6 ms

Number of impacts:1000

10.1.3 Nonoperating conditions

Storage temperature: 25 to +60°C (-13 to 140°F)

Storage relative humidity: < 95%.

Storage atmospheric pressure: 470 — 1060 hPa

10.1.4 Power supply

Power supply, automatic range selection

100-120V ±10%, 220-240 V ±10%, AC 50-60Hz

Battery backup

2– 6 battery modules rechargeable 12 V, 3.5 Ah each. Recharge time approximately 3 h/battery. Battery backup time approximately 3 h, when using 6 batteries.

External 12V DC

12.0V - 15.0V DC, 10A

Caution: When external +12 V DC is used, at least one installed Battery module is required to ensure proper operation.

Max power consumption

At 110-120V: 2A, 190VA, 140W.

At 220- 240V: 1A, 190VA, 140W.

10.2 Ventilator

10.2.1 General

Dimensions (mm)
User Interface: 355 W x 53 D x 295 H

Patient Unit: 300 W x 205 D x 415 H

Weight, approximate (kg)
Total: 20

User interface: 5

Patient Unit: 15

Triggering Method
Flow and pressure

10.2.2 Gas Supply

Concentration Standards
Supplied gases must be free of water, oil, and particles.

Air: H_2O < 7 g/m^3, Oil < 0.5 mg/m^3

Oxygen: H_2O < 20 mg/m^3

Inlet gas pressure
2-6.5 kPa x 100 (29 – 94 PSI)

Connection standards available
AGA, DISS, NIST, or French.

10.2.3 Patient System Connectors

Conical fittings (mm)
Male 22 and female 15, in accordance with ISO 5356-1.

Gas exhaust port (mm)
Male 30 cone.

10.2.4 User Interface

Attaches to the mobile cart, a table, railing, or 15-30 mm diameter pipe.

10.3 Standard Condition Specification

Error ranges in this document assume the following standard conditions and the worst case, *i.e.* all errors are summarized positive. Statistically 95% of all values will be within 2/3 of the given error.

- Ambient pressure: 101.3 kPa
- Room temperature: 20 °C
- Dry gases in patient system
- Inlet pressure: 4.3 kPa x 100
- Pre-use check performed on a warmed up ventilator
- Default settings unless otherwise specified

10.4 Inspiratory Channel

Pressure drop
Maximum: 3 cmH_2O at a flow of 1 liter/s

Internal compressible factor
Maximum: 0.1 ml/cmH_2O

Gas delivery system
Microprocessor controlled valves

Gas delivery device
Flow range (±5% or ± 0.1 ml/s):

Adult: 0-3.3 l/s
Infant: 0-0.55 l/s

Maximum pressure setting: (±5% or ± 1 cmH_2O[1])

80/120 cmH_2O (Infant/Adult)

NIV Max leakage compensation level
Adult: 50 liters/min

Infant: 15 liters/min

Infant Nasal CPAP: 10 liters/min

O_2 concentration
Setting range: 21 - 100% ± 3% O_2

Inspiratory Minute Volume
Adult Setting range: 0.5 - 60 l/min ± 6%[2]

Infant Setting range: 0.3 - 20 l/min ± 6%[3]

Inspiratory Tidal Volume
Adult Setting range: 100 - 2000/4000 ml ± 7%[4]

Infant Setting range: 5 - 350 ml ± 6%[5]

1. at RR ≤ 100 b/min
2. at 2.5-60 l/min and set I:E<1:1
3. at 1-20 l/min and set I:E<1:1
4. at 400-4000 ml and set I:E<1:1
5. at 20-350 ml and set I:E<1:1

10.5 Expiratory channel

Pressure Drop
Maximum: 3 cmH_2O at a flow of 1 liter/s

Internal Compressible Factor
Maximum: 0.1 ml/cmH_2O

PEEP Regulation
Microprocessor controlled valve

PEEP Setting Range:
0 - 50 cmH_2O ± 5% or ± 1 cmH_2O[1]

Expiratory Flow Measurements
Flow range: 0 - 3.2 liters/s ±5% or ± 2.5 ml/s

Rise time (flow of 0.05 - 3.21 liters/s): < 12 ms for 10 - 90% response ±5% or ± 2.5 ml/s

10.6 Monitoring

Expiratory Minute Volume
Adult Range: 0 - 60 liters/min

± 8% or ± 0.15 liters/min[2], NIV: ± 10%[3]

Infant Range: 0 - 20 liters/min

± 8% or ± 0.15 l/min[4], NIV: ± 10%[5], NIV Nasal CPAP: ± 25% or ± 0.15 liters/min[6]

Expiratory Tidal Volume
Adult Range: 0 - 2000/4000 ml ± 8% or ± 18 ml[7]

Infant Range: 0 - 350 ml ± 8% or ± 2 ml[8]

O_2 Concentration
Range: 0 - 100% ± 5% of read value

Airway Pressure
Range: -40 - 160 cmH_2O ±5% or ± 1 cmH_2O

Supply Pressure
Range: 0 - 7 bar ± 5% of read value

10.7 Alarms

10.7.1 Allowed Alarm Settings

Airway Pressure (upper)
Adult: 16 - 120 cmH_2O

Infant: 16 - 90 cmH_2O

High Continuous Pressure (> 15 sec)
Set PEEP level+15 cmH_2O

O_2 Concentration
Set value±6vol% or ≤ 18 vol.%

Expired Minute Volume (Upper alarm limit)
Adult: 0.5 – 60 liters/min

Infant: 0.01 – 30 liters/min

Expired Minute Volume (Lower alarm limit)
Adult: 0.5 – 40 liters/min

Infant: 0.01 – 20 liters/min

Apnea
Adult: 15 - 45 s

Infant: 5 - 45 s[9]

Gas Supply
< 2.0 kPa x 100 or > 6.5 kPa x 100.

Respiratory Frequency
1 – 160 b/min.

High End Expiratory Pressure
0 - 55 cmH_2O

Low End Expiratory Pressure
0 - 47 cmH_2O[10]

End-Tidal CO_2 (upper and lower limit[11])
0.5-20%, 4-100 mmHg, 0.5-14 kPa

CPAP (Upper alarm limit)
Adult: 0-55 cmH_2O

Infant: 0-55 cmH_2O

CPAP (Lower alarm limit)
Adult: 0-47 cmH_2O

Infant: 0-47 cmH_2O

1. at RR ≤ 60 b/min
2. at RR < 100 b/min
3. at constant leakage fraction <30%
4. at RR < 100 b/min
5. at constant leakage fraction <30%
6. at constant leakage fraction <30%
7. at Expiration time < 4 s and RR <100 b/min
8. at Expiration time < 1 s and RR <100 b/min
9. The apnea alarm can be turned off in Nasal CPAP.
10. **Note:** Setting the alarm to 0 (zero) is equal to alarm off.
11. In NIV low limit can be set to 0 (zero).

10.7.2 Autoset Alarm Limits

High Airway Pressure:
Mean peak pressure +10 cmH2O or at least 35 cmH2O.

Expiratory Minute Volume (upper)
+ 50%

Expiratory Minute Volume (lower)
- 50%

Respiratory Frequency (upper)
+ 40%

Respiratory Frequency (lower)
- 40%

Mean End Expiratory Pressure (high)
+5 cmH_2O

Mean End Expiratory Pressure (low)
-3 cmH_2O.

$etCO_2$ Concentration (upper)
+ 25%

$etCO_2$ Concentration (lower)
- 25%

10.7.3 Alarms Miscellaneous

Audio Pause (Alarm silence/reset)
Two-minute silence and reset of latched alarms.

10.8 Ventilation modes

10.8.1 Controlled Ventilation

Pressure Control (PC)
Pressure controlled ventilation.

Volume Control (VC)
Volume controlled ventilation.

Pressure Regulated Volume Control (PRVC)
Pressure regulated volume controlled ventilation.

NIV Pressure Control
Noninvasive pressure controlled ventilation.

10.8.2 Supported ventilation

Volume Support (VS)
Volume supported ventilation.

Pressure Support (PS)/CPAP
Pressure supported ventilation / Continuous positive airway pressure ventilation.

NIV Pressure Support
Noninvasive pressure supported ventilation.

Nasal CPAP
Nasal continuous positive airway pressure ventilation.

10.8.3 Combined ventilation

SIMV (VC) + PS
Synchronized intermittent mandatory ventilation based on volume controlled ventilation with pressure support.

SIMV (PC) + PS
Synchronized intermittent mandatory ventilation based on pressure controlled ventilation with pressure support.

SIMV (PRVC) + PS
Synchronized intermittent mandatory ventilation based on pressure regulated volume controlled ventilation with pressure support.

Bi-Vent
Pressure controlled ventilation that allows the patient the opportunity of unrestricted spontaneous breathing.

Automode

Control mode		Support mode
VC	<---------- ---------->	VS
PC	<---------- ---------->	PS
PRVC	<---------- ---------->	VS

In Servo-i flow measurements all preset and indicated volumes are referenced to ambient pressure at +21˚C (AP21).

10.9 Trend Function

Peak Airway Pressure	Ppeak
Pause Airway Pressure	Pplat
Mean Airway Pressure	Pmean
End Expiratory Pressure	PEEP
Continuous Positive Airway Pressure	CPAP
Spontaneous breaths per minute	RRspont
Breathing frequency	RR
Spontaneous Exp. Minute Volume	MVe sp
Inspired Minute Volume	MVi
Expired Minute Volume	MVe
Leakage fraction (%)	Leakage
Inspired Tidal Volume	VTi
Expired Tidal Volume	VTe
End Expiratory Flow	$\dot{V}_{ee}$
Measured Oxygen Concentration	O_2
CO_2 End Tidal Concentration	etCO_2
CO_2 Minute Elimination	$\dot{V}_{CO_2}$
CO_2 Tidal Elimination	$VTCO_2$
Dynamic Characteristics	Cdyn
Static Compliance	Cstatic
Elastance	E
Inspiratory Resistance	Ri
Expiratory Resistance	Re
Work of Breathing ventilator	WOB v
Work of Breathing patient	WOB p
P0.1	P0.1
Shallow Breathing Index (SBI)	SBI

10.10 X Open Lung Tool Trend

EIP

PEEP

VT_i

VT_e

C dyn i

$VTCO_2$ (X CO_2 Analyzer)

10.11 Log function

Event Log

Alarms

Ventilator settings

Apnea periods

Immediate functions

Service Log

Technical alarms

Test results

Preventive maintenance

Service report history

Configuration log

10.12 Immediate functions

Oxygen Breaths
100% for 1 minute.

Start Breath
Initiation of 1 breath in all modes.

(In SIMV mode initiation of one mandatory breath).

Pause Hold
Inspiratory or expiratory.

10.13 Communication/ Interface

Serial Port
RS-232C-isolated. For data communication via the Communication Interface Emulator (CIE).

✗Alarm Output Connection Option
Isolated 4-pole modular connector for communication of high and medium priority alarms. The alarm output connection option is a non-guaranteed alarm in accordance with IEC60601-1-8. Max 40 V DC, Max 500 mA, Max 20 W.

Data Transfer via Ventilation Record Card
File format is Unicode (big endian). Required software is Microsoft Excel 2000 with Visual Basic for applications.

Service
- Preventive maintenance must be performed by authorized personnel at least once every year as long as the unit is not operated for more than 5000 hours per year. The *Status* menu on the user interface shows the current operating time.
- Battery modules must be replaced every 3 years.
- Original parts from MAQUET must be used.
- Service repair must be performed by MAQUET-authorized personnel only.
- Service mode should only be used without a patient connected to the ventilator.

10.14 ✗Servo Ultra Nebulizer

Patient Unit
Weight, approximate (g):

125

Dimensions (mm):

60 W x 108 L x 105 H

Nebulizer T-Piece Connections
Inlet/outlet:

22/15 mm outside/inside diameter
22 mm inside diameter, ISO standard

Infant patient tubing, nipple connectors:

22/10 mm outside diameter
15/10 mm outside diameter

Internal Volume (ml)
60

Ultrasonic Generator Frequency (MHz)
2.4

Particle Size, approximate (water, µm)
4.0, mass median diameter (MMD) measured distally in endotracheal tube 8 mm inside diameter.

Output from nebulizer (water)
Minimum water flux:

0.1 ml/min at gas flow 0.1l/s

0.3 ml/min at gas flow 0.5l/s

0.5 ml/min at gas flow 1.0l/s.

Buffer Liquid
Sterile water

Maximum Medication Temperature
55° C (131° F)

Volume, medication cup (Maximum, ml)
10

Noise level (Maximum, dBA)
50, measured at 0.3 m distance

Connection Cable Length (m)
2.0

Note: For information about the stand-alone Aeroneb Professional Nebulizer System, refer to accompanying documentation.

10.15 X CO_2 Analyzer

General
Standard compliance: EN864, ISO9918.

Classification: Class I equipment
(According to IEC 60 601-1/EN 60 601-1. Type BF.)

Size (mm)
CO_2 Analyzer module: 154 x 90 x 43

Sensor: 32.0 x 42.4 x 21.6

Weight (g)
CO_2 Analyzer module: 450

Sensor: 18

Airway adapter: 10

Connectors and Cables
CO_2 Analyzer module:15-pole D-sub female connector

Sensor 20-pole: 2.4 m cable

Power source
CO_2 Analyzer module supply voltage: powered from the Servo-i

Power consumption: ≤ 8 W at 12V, during warm up;
≤ 6.5 W at 12V, during normal operation

Sensor: powered from the CO_2 Analyzer module.

Performance
Measuring method: Mainstream, dual-wavelength, nondispersive infrared.

Stability (within 8-hour period):

0 to 100 mmHg ± 2mmHg
0 to 13.3 kPa ± 0.3 kPa
0 to 13.2% ±0.3%
(at a barometric pressure of 1013hPa).

Measuring range:

0 to 100 mmHg CO_2 partial pressure
0 to 13.3 kPa CO_2 partial pressure
0 to 13.2% CO_2 volume

(at a barometric pressure of 1013hPa).

Accuracy
0 to 40 mmHg ± 2mmHg
41 to 70 mmHg ± 5% of reading
71 to 100 mmHg ± 8% of reading

0 to 5.3 kPa ± 0.3 kPa
5.4 to 9.3 kPa ± 5% of reading
9.4 to 13.3 kPa ± 8% of reading

0 to 5.3% ± 0.3%
5.4 to 9.2% ± 5% of reading
9.3 to 13.2% ± 8% of reading

Measurement Conditions
CO_2 minute elimination and CO_2 tidal elimination measurements are referenced to standard temperature and pressure (STP).

Standard gas mixture of CO_2, balance saturated air at 33° C, barometric pressure 1013 hPa, gas flow rate 2 l/mm, halogenated hydrocarbons <5%.

Step response time
<25 ms (10 to 90% step response)

Warm-up time
30 s to initial CO_2 indication

maximum 5 minutes to full specification.

Oxygen concentration compensation
Automatic. Values supplied from the Servo-i Ventilator System.

Barometric pressure compensation
Automatic. Values supplied from the Servo-i Ventilator System.

Digitizing Rate (Hz)
87

Airway adapter dead space
Adult <5 cm^3
Infant <0.5 cm^3

10.16 ✕Y Sensor Measuring

Size (mm)
Y Sensor Module: 154 x 90 x 43
Y sensor adult Length: 84
Y sensor infant Length: 51

Weight (g)
Y Sensor Module: 400
Y sensor adult: 10.5
Y sensor infant: 7.5

Sensor Material
Makrolon polycarbonate

Tubing
2.0 m Medical grade PVC

Power Source
Y Sensor Module supply voltage: powered from Servo-i, < 5 W at 12 V (normal operation)

Y Sensor Measuring Performance
Measuring method: Fixed orifice, differential pressure

Parameters
Airway pressure
Airway flow
Inspiratory Volume
Expiratory Volume

Measuring Range
Adult: 2 to 180 liters/min
Infant: 0.125 to 40 liters/min

Airway Adapter Dead Space
Adult: < 9.0 ml
Infant: < 0.45 ml

10.17 Accessories

✕Mobile Cart

Weight (kg)
20

Dimensions (mm)
542 W x 622 L x 1010 H

✕Drawer Kit

Weight (kg)
4.5

Dimensions (mm)
300 W x 210 L x 240 H

✕Holder

Weight (kg)
3.5

Dimensions (mm)
159 W x 247 L x 352 H

✕Shelf Base

Weight (kg)
1.2

Dimensions (mm)
159 W x 205 L x 29 H

✕Gas Cylinder Restrainer

Maximum load
Two 5-liter bottles.

✕IV Pole

Maximum Load (total, kg)
6

✕Gas Trolley

Maximum load
Two 10-kg bottles

✕Compressor Mini

Dimensions (mm)
430 W x 330 D x 250 H

Weight (approximate, kg/lbs)
26/70

Power supply
115 V AC, 60 Hz; 220 –240 V AC, 50 Hz

Compressor capacity
Continuous flow at normal atmospheric pressure (approximately 1013 hPa) 30 l/min (expanded to ambient air pressure) at 3.5 kPa x 100 (bar)/50 psi.

10.18 Breathing Parameters: Default Values & Allowed Settings (Standard Configuration)

Parameter	Factory set default				Setting range			
	Infant	Adult	Universal		Infant	Adult	Universal	
			Infant	Adult			Infant	Adult
Automode ON/OFF	OFF	OFF	OFF	OFF	ON/OFF	ON/OFF	ON/OFF	ON/OFF
Automode trigger timeout (s)	3	7	3	7	3 - 7	7 - 12	3 - 7	7 - 12
Backup pressure above PEEP	10	20	10	20	5-(80-PEEP)	5-(120-PEEP)	5-(80-PEEP)	5-(120-PEEP)
Backup Ti (s)	0.5	1.0	0.5	1.0	0.3-1	0.5-2	0.3-1	0.5-2
Bias flow (l/min)	0.5	2	0.5	2	-	-	-	-
Breath cycle time, SIMV (s)	1	4	1	4	0.5 - 15	1 - 15	0.5 - 15	1 - 15
CMV frequency (b/min)	30	15	30	15	4 - 150	4 - 100	4 - 150	4 - 150
Compensate for compliance	OFF	OFF	OFF	OFF	ON/OFF	ON/OFF	ON/OFF	ON/OFF
CPAP (cmH_2O) in NIV Nasal CPAP	5	-	5	-	2-20	-	2-20	-
Flow trig sensitivity level (fraction of bias flow)	50%	50%	50%	50%	0-100%	0-100%	0-100%	0-100%
I:E ratio	1:2	1:2	1:2	1:2	1:10-4:1	1:10-4:1	1:10-4:1	1:10-4:1
Inspiratory cycle-off (% of peak flow)	30	30	30	30	1 - 70	1 - 70	1 - 70	1 - 70
Inspiratory cycle-off (% of peak flow) in NIV	30	50	30	50	10-70	10-70	10-70	10-70
Inspiratory rise time (%)	5	5	5	5	0 - 20	0 - 20	0 - 20	0 - 20
Inspiratory rise time (s)	0.15	0.15	0.15	0.15	0 - 0.2	0 - 0.4	0 - 0.2	0 - 0.4
Inspiratory rise time (s) in NIV	0.15	0.2	0.15	0.2	0 - 0.2	0 - 0.4	0 - 0.2	0 - 0.4
Maximum inspiratory flow (l/s)	0.56	3.3	0.56	3.3	-	-	-	-
Maximum permitted absolute pressure (cmH_2O)	80	120	80	120	-	-	-	-
Minute Volume (l/min)	-	7.5	2.4	7.5	-	0.5-60	0.3-20	0.5-60

Parameter	Factory set default				Setting range			
	Infant	Adult	Universal		Infant	Adult	Universal	
			Infant	Adult			Infant	Adult
Mode (in NIV)	PS	PS	PS	PS	-	-	-	-
Mode (Invasive ventilation)	PC	VC	PC	VC	-	-	-	-
Nebulizer	OFF	OFF	OFF	OFF	ON/OFF	ON/OFF	ON/OFF	ON/OFF
Nebulizer time (min)	10	10	10	10	5 - 30	5 - 30	5 - 30	5 - 30
NIV Rate (b/min)	4	4	4	4	4-40	4-20	4-40	4-20
O_2 concentration (%)	40	40	40	40	21 - 100	21 - 100	21 - 100	21 - 100
PEEP (cmH_2O)	5	5	5	5	0 - 50	0 - 50	0 - 50	0 - 50
PEEP in NIV (cmH_2O)	5	5	5	5	2-20	2-20	2-20	2-20
Phigh (cmH_2O)	15	15	15	15	(PEEP+1) - 50	(PEEP+1) - 50	(PEEP+1) - 50	(PEEP+1) - 50
Press trig sensitivity level (cmH_2O)	-	-	-	-	-20 - 0	-20 - 0	-20 - 0	-20 - 0
Pressure level above PEEP (cmH_2O)	20	20	20	20	0 - (80 - PEEP)	0 - (120 - PEEP)	0 - (80 - PEEP)	0 - (120 - PEEP)
Pressure level above PEEP in NIV (cmH_2O)	5	5	5	5	0-(32-PEEP)	0-(32-PEEP)	0-(32-PEEP)	0-(32-PEEP)
PS above PEEP (cmH_2O)	0	0	0	0	0-(80-PEEP)	0-(120-PEEP)	0-(80-PEEP)	0-(120-PEEP)
PS above Phigh (cmH_2O)	0	0	0	0	0-(80-P_{High})	0-(120-P_{High})	0-(80-P_{High})	0-(120-P_{High}
SIMV frequency (b/min)	20	5	20	5	1 - 60	1 - 60	1 - 60	1 - 60
Thigh (s)	1	2	1	2	0.2 - 10	0.2 - 10	0.2 - 10	0.2 - 10
Ti (s)	0.5	0.9	0.5	0.9	0.1-5	0.1-5	0.1-5	0.1-5
Tidal Volume (ml)	-	500	80	500	-	100-2000	5 - 350	100-4000
Tpause (%)	-	10	10	10	-	0 - 30	0 - 30	0 - 30
Tpause (s)	-	0.4	0.2	0.4	-	0-1.5	0 - 1.5	0-1.5
TPEEP (s)	1	2	1	2	0.2 - 10	0.2 - 10	0.2 - 10	0.2 - 10
Weight (kg)	3	50	3	50	0.5 - 30	10- 250	0.5 - 30	10- 250

10.19 Alarm Limits: Default Settings & Allowed Ranges

Alarm limits	Factory set default				Setting range			
	Infant	Adult	Universal		Infant	Adult	Universal	
			Infant	Adult			Infant	Adult
Airway pressure, upper limit (cmH_2O)	40	40	40	40	16 - 90	16-120	16 - 90	16-120
Airway pressure, upper limit (cmH_2O) in NIV	20	20	20	20	16 - 60	16-60	16 - 60	16 - 60
Apnea, time till alarm (s)	10	20	10	20	5 - 45	15 - 45	5 - 45	15 - 45
CPAP high limit (cmH_2O)	10	10	10	10	0 - 55	0 - 55	0 - 55	0 - 55
CPAP lower limit (cmH_2O) **Note:** Setting the alarm to zero turns off the alarm.	10	10	10	10	0 - 47	0 - 47	0 - 47	0 - 47
End expiratory pressure, high limit (cmH_2O)	10	10	10	10	0 - 55	0 - 55	0 - 55	0 - 55
End expiratory pressure, lower limit (cmH_2O) **Note:** Setting the alarm to zero turns off the alarm.	10	10	10	10	0 - 47	0 - 47	0 - 47	0 - 47
$etCO_2$ lower limit:								
%	4.0	4.0	4.0	4.0	0.5-20	0.5-20	0.5-20	0.5-20
mmHg	30	30	30	30	4-100	4-100	4-100	4-100
kPa	4.0	4.0	4.0	4.0	0.5-14	0.5-14	0.5-14	0.5-14
$etCO_2$ lower limit in NIV: **Note:** In NIV low limit can be set to 0 (zero).								
%	4.0	4.0	4.0	4.0	0 - 20	0 - 20	0 - 20	0 - 20
mmHg	30	30	30	30	0 - 100	0 - 100	0 - 100	0 - 100
kPa	4.0	4.0	4.0	4.0	0 - 14	0 - 14	0 - 14	0 - 14
$etCO_2$ upper limit: **Note:** In NIV low limit can be set to zero.								
%	6.5	6.5	6.5	6.5	0.5-20	0.5-20	0.5-20	0.5-20
mmHg	49	49	49	49	4-100	4-100	4-100	4-100
kPa	6.5	6.5	6.5	6.5	0.5-14	0.5-14	0.5-14	0.5-14
Expired minute volume, lower limit (l/min)	2.0	5.0	2.0	5.0	0.01-20.0	0.5 - 40.0	0.01-20.0	0.5 - 40.0
Expired minute volume, upper limit (l/min)	5.0	40.0	5.0	40.0	0.01-30.0	0.5 - 60.0	0.01 - 30.0	0.5 - 60.0

Alarm limits	Factory set default				Setting range			
	Infant	Adult	Universal		Infant	Adult	Universal	
			Infant	Adult			Infant	Adult
Respiratory frequency, lower limit (b/min)	20	5	20	5	1 - 160	1 - 160	1 - 160	1 - 160
Respiratory frequency, upper limit (b/min)	50	30	50	30	1 - 160	1 - 160	1 - 160	1 - 160

Default values are set:

- during power up
- when admitting a new patient
- when changing X type of ventilation or
- when changing X patient category.

Always make sure relevant values are set.

11 • Definitions

b/min—Breaths per minute

Bias flow—The continuous flow during the expiratory phase

Breath cycle time—Total cycle time per mandatory breath in SIMV (inspiratory + pause + expiratory). Set in seconds.

Cdyn—Dynamic characteristics

CMV—Controlled Mechanical Ventilation

CPAP—Continuous Positive Airway Pressure

Cstatic—Static compliance, respiratory system

E—Elastance

etCO_2—End tidal carbon dioxide concentration

Expiratory hold—Manual closure of inspiration and expiration valves after expiration (max. 30 seconds). Measures Total PEEP.

Flow sensitivity level—The flow that the patient must inhale to open the ventilator for, and start, an inspiration (fraction of the bias flow).The trigger functionality is set for either pressure or flow sensitivity.

HME—Heat and moisture exchanger

I:E—Inspiration to Expiration ratio (only during controlled ventilation)

Inspiratory hold—Manual closure of inspiration and expiration valves after inspiration (max. 30 seconds). Measures plateau pressure.

Inspiratory cycle-off—Fraction of maximum flow at which inspiration should switch to expiration (%)

Inspiratory rise time—Time to full inspiratory flow or pressure at the start of each breath, as a percentage or in seconds of the breath cycle time (% or s)

Leakage—Leakage during inspiration (%)

Minute Volume—Volume per minute or target volume (l)

MVe—expiratory Minute Volume

MVe sp—Spontaneous expiratory minute volume

MVe sp / MVe—The ratio of spontaneous expired minute volume to total expired minute volume (only applicable in Bi-Vent)

MVi—inspiratory Minute Volume

O_2: Oxygen concentration in vol.%

O_2 breaths—100% oxygen for one minute.

Option—Optional, add-on functionality or accessory

NIV—Noninvasive Ventilation

NIV Rate—Rate of controlled mandatory breaths in NIV in absence of spontaneous breathing (b/min)

P—Pressure

P0.1—Indicator for respiratory drive

Pause time—Time for no flow or pressure delivery (%)

PC—Pressure Control

PEEP—Positive end expiratory pressure (cmH_2O)

Paw—Airway pressure

Ppeak—Maximum inspiratory pressure

Phigh—High pressure level

Pmean—Mean airway pressure

P_{plat}—Pressure during end-inspiratory pause

PRVC—Pressure-regulated volume control

PS—Pressure support

PS above Phigh—Inspiratory pressure support level for breaths triggered during the T_{High} period in Bi-Vent (cmH_2O)

PS above PEEP—Inspiratory pressure support level for breaths triggered during the T_{PEEP} period in Bi-Vent (cmH_2O)

Re—expiratory resistance

RH—Relative humidity

Respiratory Rate—Rate of controlled mandatory breaths or used for calculating target volume (b/min)

Ri—inspiratory resistance

RR—Respiratory rate

Service card—Field service software card

SIMV—Synchronized Intermittent Mandatory Ventilation

SIMV rate—Rate of controlled mandatory breaths (b/min)

Start breath—Manually triggered set breath

T—Time

Tc—Time constant

Ti—Inspiration time

Ti/Ttot—Duty cycle or ratio of inspiration time to total breathing cycle time (only during spontaneous breathing)

Tidal Volume—Volume per breath or target volume (ml)

Thigh—Time at Phigh level in Bi-Vent (s)

TPEEP—Time at *PEEP* level in Bi-Vent (s)

$\dot{V}$—Flow

$\dot{V}$**CO$_2$**—CO_2 Minute elimination

$\dot{V}_{ee}$—End expiratory flow

$\dot{V}$**leak**—Leakage flow (l/min)

Ventilation record card—Documentation card

VTCO$_2$—CO_2 tidal elimination

Va—Alveolar ventilation

VC—Volume Control

VDaw—Airway dead space

VS—Volume Support

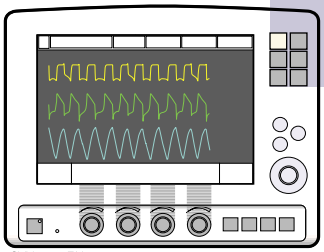
VTA—Alveolar Tidal Volume

VTe —Expiratory Tidal Volume

VTi—Inspiratory Tidal Volume

Appendix • User Interface

A.1 Fixed Keys



SVX-580_EN

Audio off / Audio pause (Silence or pre-silence alarms)

Alarm Profile

Alarm profile setup.

Possible selections:

- Pressure (upper)
- Minute Volume (Lower and upper)
- Respiratory Rate (Lower and Upper)
- End Expiratory Pressure (Lower)
- Alarm sound level (20-100%)
- End Tidal CO_2 (Lower and Upper)

Note. In NIV the alarm sound can be permanently silenced (Audio off).

By pressing the autoset in controlled modes of ventilation the alarm limits are automatically set for:

- Pressure
- Volume
- Resp. Rate
- PEEP

Note. Autoset is not possible in NIV.

In spontaneous modes an alarm setting for apnea time is available.

Save

The Save key can be used either to:
- copy screen or
- save one recording (10 s before and 10 s after pressing the key).

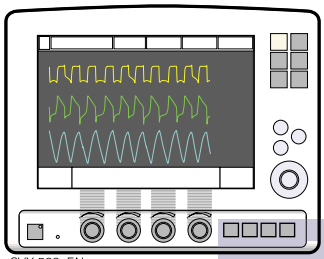
Trends

The trend graph appears when the *Trend* fixed key is pressed. Data can be recorded over a period of time up to 24 hours, the time resolution is displayed in the trend graph.

i

Function is not implemented

A.2 Special function keys



SVX-583_EN

Start breaths

The ventilator will initiate a new breath cycle according to the current ventilator settings.

O_2-breaths

This function allows 100 % oxygen to be given for 1 minute.
After this time the oxygen concentration will return to the pre-set value.
The oxygen breaths can be interrupted by repressing the *O_2 breaths* fixed key during the 1 minute interval.

Note. If O2 Breaths is activated during the pre- or post-oxygenation phase in Suction Support the procedure will be discontinued.

Exp. hold

Expiratory hold is activated by manually pressing the fixed key. The maximum time is 30 seconds.The inspiratory and expiratory valves close after expiration.
This function can provide an exact measurement of the end expiratory lung pressure. It can be used for static compliance measurement and to determine the total PEEP.

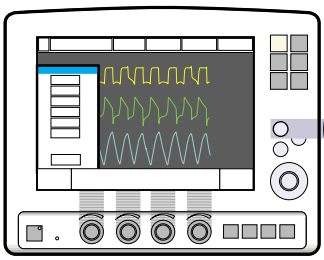
Note. Expiratory hold is not available in Nasal CPAP.

Insp. hold

Inspiratory hold is activated by manually pressing the fixed key. The maximum time is 30 seconds.The inspiratory and expiratory valves close after inspiration.
This function can provide an exact measurement of the end inspiratory lung pressure.It can be used during x-ray or to determine Plateau pressure, or static compliance calculation.

Note. Inspiratory hold is not available in Nasal CPAP.

A.3 Quick Access Key



SVX-581_EN

Suction Support

This function allows the user to disconnect the patient from the ventilator and turning off the alarms (for apnea, minute volume, frequency alarm, check tubing, EtCO2, low PEEP) during suction support.

Note. Suction Support is not available when NIV or O2 Breaths is activated.

Loops

Loops are graphs that show two measured values: one measured value (x-axis) against another measured value (y-axis). Loops are updated breath by breath.

Two loops are available:

- volume-pressure
- flow-volume

Note. A reference loop can be saved by the user.

Scales

Waveform scaling.

- Pressure scale
- Flow scale
- Volume scale
- CO_2 scale

These three scales are by default set to automatic scaling.
The sweep speed, mm/s, can be set to 6, 10 or 20 mm/s (default).

Waveform configuration

Possibility to increase the space viewing the waveform curves. This in turns means that more detailed information can be gained.

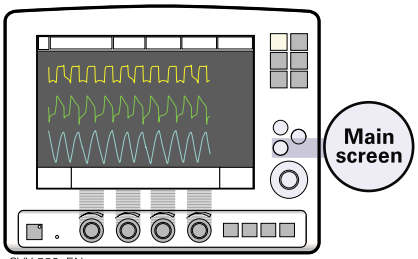
Open Lung Tool

The Open Lung Tool assists in alveolar recruitment procedures. The screen gives information about End inspiratory pressure (EIP) and PEEP, inspiratory and expiratory Tidal Volume as well as Dynamic Compliance (Cdyn i).

Note. Open Lung Tool is not available in NIV

Open Lung Tool scales

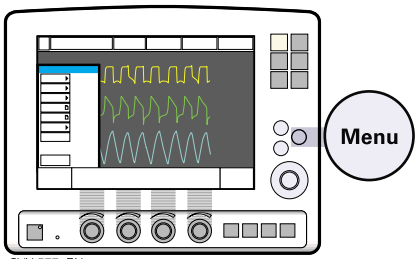
A.4 Main Screen Key



SVX-582_EN

Main screen → The *Main screen* fixed key will return you to the Main screen, cancelling current work, from wherever you are in the Menu/dialog windows.

A.5 Menu Key (in Standby Mode)



SVX-577_EN

Alarm

- **Profile** → **Alarm profile setup**

  Possible selections:
  - Pressure (upper)
  - Minute Volume (lower and upper)
  - Respiratory Rate (lower and upper)
  - End Expiratory Pressure (lower)
  - Alarm sound level (20-100%)
  - End Tidal CO2 (lower and upper)

  By pressing the autoset in controlled modes of ventilation the alarm limits are automatically set for:
  - Pressure
  - Volume
  - Resp.Rate
  - PEEP

  In spontaneous modes an alarm setting for apnea time is available.

  Note. In NIV the alarm sound can be permanently silenced (Audio off).

  Note. Autoset is not possible in NIV.

- History → This shows alarms that have been activated. The alarms are listed in chronological order.
- 🔕 → Audio off / Audio pause (Silence or pre-silence alarms)

Review → Review trends, recorded waveforms, event log or configuration.

Options → CO_2 Calibration

Compliance comp. → The calculation of the circuit Compliance value is performed during Pre-use check. The calculated value is displayed in the window. To activate or to deactivate select the appropriate soft key.

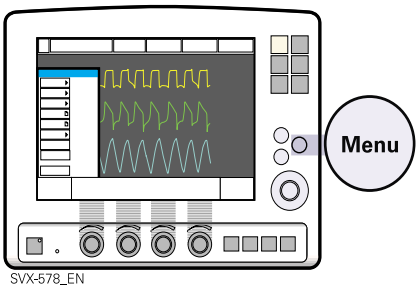
Copy data

- Copy data → Copy data (event log, recordings, trends, OLT data, Start-up configuration) to PC Card.
- Copy screen → Copy screen to PC Card.

Biomed → For more information, refer to heading "Biomed in standby mode" in this chapter.

Panel lock → Locks all user input functions on the User Interface. Press "Main screen" fixed key to unlock.

A.6 Menu Key (During Ventilation)



SVX-578_EN

Alarm

Profile

Alarm profile setup

Possible selections:
- Pressure (upper)
- Minute Volume (lower and upper)
- Respiratory Rate (lower and upper)
- End Expiratory Pressure (lower)
- Alarm sound level (20-100%)
- End Tidal CO2 (lower and upper)

By pressing the autoset in controlled modes of ventilation the alarm limits are automatically set for:
- Pressure
- Volume
- Resp.Rate
- PEEP

In spontaneous modes an alarm setting for apnea time is available.

Note. In NIV the alarm sound can be permanently silenced (Audio off).

Note. Autoset is not possible in NIV.

History

This shows alarms that have benn activated.
The alarms are listed in chronological order.

Audio off / Audio pause (Silence or pre-silence alarms)

Review

Trends
Recorded waveforms
Event log
View configuration

Review trends, recorded waveforms, event log or configuration.

Options

CO_2 Calibration

Compliance comp.

The calculation of the circuit Compliance value is performed during Pre-use check.
The calculated value is displayed in the window.To activate or to deactivate select the appropriate soft key.

Copy

Copy data

Copy data (event log, recordings, trends, OLT data, Start-up configuration) to PC-card

Copy screen

Copy screen to PC-card.

Biomed

O_2 cell adaptation

Measured O_2 concentration will be adapted in relation to set value.

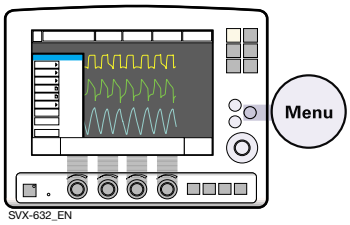
Panel lock

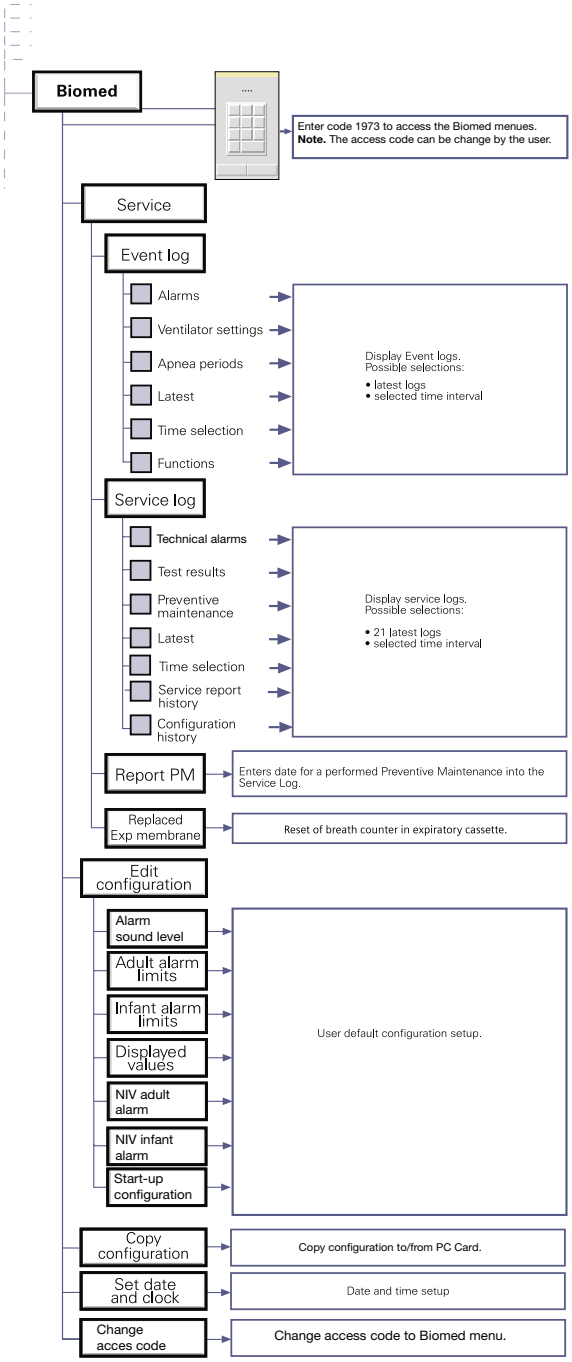
Locks all user input functions on the User Interface.
Press "Main screen" fixed key to unlock.

Change category

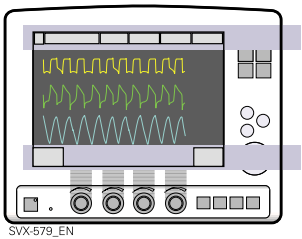
Available only in Servo-i Universal.
Switches between Adult and Infant patient category.

A.7 Biomed Menu (Standby Mode)





A.8 Screen Touch Pads


SVX-579_EN

Mode Xxxxx

When you press the soft key for a selected ventilation mode a window appears with the valid settings for this mode.The window has an accept soft key and a cancel soft key. When the accept soft key is pressed the ventilator starts to ventilate with your new settings. If the cancel soft key is pressed this window will disappear and the ventilator will continue to ventilate with the original settings. To support the clinician in adjusting settings some values, derived from settings, are shown in the upper right field of the set ventilation mode window e.g. inspiration time in seconds, calculated inspiratory flow.

Automode

The soft key Automode selects the Automode function When the patient is breathing spontaneously
- The green indicator is lit
- The ventilation mode text goes from grey to black

Admit patient

When the Admit patient function is activated the clinician can enter or amend patient details:
- patient name
- identity number
- date of birth
- date of admission
- height
- weight

Nebulizer

The Nebulizer function turns the nebulizer on or off. It is possible to set the duration of nebulization to between 5 and 30 minutes. The default time is 10 minutes.

During nebulization the time remaining is displayed in the nebulizer touch pad.

The nebulizer is automatically disabled during battery operation.

Status

General

O_2cell/sensor

Exp. cassette

Batteries

CO_2 Module

Y Sensor Measuring

Installed options

Pre-use check

In the *Status* function you have an icon displaying which power source is currently active i.e. Mains, Ext. 12V, or battery. When one or more batteries are in use, an information is also displayed showing the remaining time in minutes.When the *Status* soft key is activated a window appears displaying the status of:
- General system information
- Status of O_2cell/sensor
- Status of Expiratory cassette
- Status of batteries
- Status of CO_2 module (if available)
- Status ofY Sensor module (if available)
- Installed options
- Status of Pre-use check

Additional settings

Press the soft key Additional settings to see the settings available for the current mode.

Vital parameters are set using the Direct Access Knobs.

I:E / Insp. times

The bar below the numeric value is a graphical representation of the chosen value and gives information about the parameter ranges.
- the bar is white if your setting is within what is generally considered safe ranges
- the bar turns yellow if your setting is slightly beyond what is generally considered safe ranges
- the bar turns red if your setting is significantly beyond what is generally considered safe ranges

Trigger

The trigger sensitivity bar is colored based on the setting:
- the bar is green for a normal setting for flow triggering
- the bar is red when there is a risk of self-triggering
- the bar is white when the pressure triggering is selected.

Pressure support/ Backup ventilation

Depending on set ventilation mode this pad will be visible

NIV Backup

This pad is only visible during NIV Pressure Support mode.

Additional values

This is an area of the screen which shows measured/calculated values in numerics.

Three pages with values are available. By pressing Additional values it is possible to scroll between pages.

Note. In NIV only one page is available.