Service Manual

HAMILTON-C1

624338/02 | 2014-09-30
including maintenance, repairs, and tests

CE 0197

HAMILTON MEDICAL
Intelligent Ventilation since 1983

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Hamilton Medical AG will make available on request, component parts lists, descriptions, calibration instructions, or other information that will assist the user's appropriately trained personnel to repair those parts of the equipment designated by Hamilton Medical AG to be repairable.

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2 Conventions

2.1 Notes, Cautions and Warnings

WARNING	A warning alerts the user to the possibility of injury, death, or other serious adverse reactions associated with the use or misuse of the device.
CAUTION	A CAUTION alerts the user to the possibility of a problem with the device associated with its use or misuse, such as device malfunction, device failure, damage to the device, or damage to other property.
Note	A NOTE emphasizes information of particular importance.

2.2 *Typographic Conventions*

Tab. 1 Typographic Conventions

<table>
<tr><th>Effect</th><th>Example</th><th>Function</th></tr>
<tr><td>Bold</td><td>Configuration</td><td>Marks text quoted directly from the ventilator screen.</td></tr>
<tr><td rowspan="3">Italic</td><td>Ventilator Operator’s Manual</td><td>Marks the names of other documents.</td></tr>
<tr><td>Upgrade paths, on page</td><td>Marks text that is a quotation from within the manual. In this example, it is part of a cross-reference.</td></tr>
<tr><td>Tank</td><td>Marks a term that is in the glossary.</td></tr>
<tr><td>Bold</td><td>TRIGGER</td><td>Marks text that is quoted directly from:
– The ventilator case
– A touch key
– A printed circuit board</td></tr>
<tr><td>Bold, italic</td><td>Select only the first column.</td><td>Emphasizes important text.</td></tr>
<tr><td>Number sequence</td><td>1. Step one in a sequence
2. Step two in a sequence</td><td>Organizes the performance of actions into steps.</td></tr>
<tr><td>Letter sequence</td><td>A Identifies part A
B Identifies part B</td><td>Used in photos and illustrations to identify the topic being discussed and relates to specific text.</td></tr>
<tr><td>Blue text Chapter 2.2</td><td></td><td>If you are using a PDF file to view this, you can hyperlink to the glossary by clicking on these items.</td></tr>
</table>

2.3 Expressions

Tab. 2 Expressions

Expression	Example	Explanation
Activate	Activate **LED ON/OFF**.	Using the P+T knob, you must first select the **LED ON/OFF** button on the ventilator's screen, and then press theP+T knob.The button on the screen changes its appearance, so that it looks "pressed". It now performs its function (turning the LED ON in this case). Sometimes you are told to "activate and set" a field. In this case you first activate the field, and then turn the P+T knob to set a value.
Deactivate	Deactivate **LED ON/OFF**.	With **LED ON/OFF** still selected and activated, you must press the P+T knob again.The button on the screen changes its appearance, so that it looks "unpressed". It stops performing its function (turning the LED OFF in this case).
Select	Select **LED ON/OFF**.	Touch the touchscreen to select the LED ON/OFF button.
De-select	De-select **LED ON/OFF**.	Touch the touchscreen to deselect the LED ON/OFF button.
Pressure	Patient pressure is 80 mbar.	Pressure refers to the amount of pressure above ambient pressure. If the patient pressure (Ppat) is 80 mbar, it means the pressure is 80 mbar above the ambient (room) pressure.
Software version	0.6.0	The ventilator contains a memory device that holds software identified by a version number.
Update	This kit or software enables an update to an existing function.	An update is an improvement to an existing function. An update normally involves only software. A software update is indicated by an increment of the last digit of the three digit software version number (e.g. 1.2.1 to 1.2.2).
Upgrade	This kit or software enables an upgrade to implement a new function.	An upgrade is the addition of new functions to a device. There are three ways to perform an upgrade: – Add a hardware item that offers additional functions. – Upgrade to a higher software revision. Depending on how important the software upgrade is, it is either marked by an increment on the first or on the second digit (e.g. 1.2.0 to 1.3.0 or 1.2.0 to 2.0.0) – Upgrade to a higher type of software.
*	With this kit, you can update or upgrade from software version.	Unless otherwise stated, a syntax variable ("wild card") indicates the use of any alpha-numeric character.

2.4 Foreword

WARNING	– To prevent possible patient injury, disconnect the patient from the ventilator before you start service or maintenance. – Service the HAMILTON-C1 only as described in this manual, using only parts approved or supplied by HAMILTON MEDICAL AG. Incorrect parts, components or assemblies could result in patient injury. See available spare parts starting in chapter Chapter 13.1. – For incorrectly used parts HAMILTON MEDICAL AG will not honour any warranty.

The HAMILTON-C1 Service Manual is for:

Engineers who have successfully completed a HAMILTON MEDICAL AG service training course for the HAMILTON-C1.

Training courses are held regularly in Bonaduz, Switzerland, at HAMILTON MEDICAL AG's headquarters, and at other locations throughout the world. For more information, visit the partner section of the HAMILTON MEDICAL AG website (http://www.hamilton-medical.com).

Note	If you have questions about testing or any part of this manual, contact HAMILTON MEDICAL AG (techsupport@hamilton-medical.ch).

The HAMILTON-C1 Service Manual contains:

The architecture and components of the HAMILTON-C1.

In addition, information on testing, troubleshooting and repairing the HAMILTON-C1. Appendices.

The HAMILTON-C1 Service Manual does not contain:

Information about operating the HAMILTON-C1. See the HAMILTON-C1 Operator's Manual for operating instructions.

The HAMILTON-C1 Service Manual Structure:

Tab. 3 HAMILTON-C1 Service Manual Structure

Section	Function	Your resonsibility
HAMILTON-C1 Overview starts Chapter 3.1	This section explains the theory behind the HAMILTON-C1.	**You should fully understand this section.**
Pneumatics: Overview and Theory of Operation starts Chapter 4.1	This section explains each component and the gas flows, flow measurements, and pressure measurements in the pneumatic circuits.	**You should be able to name and explain the functions of all the major components.**
Electronics: Component Functions starts Chapter 5.1	This section explains the basic functions of the printed circuit boards, Printed circuit boards are not repaired in the field.	**You should be able to identify all circuit boards, and know where they are positioned in the HAMIN-C1.**
Lithium Ion Battery starts Chapter 6.1	This section explains the use, care and maintenance of the Lithium Ion Battery Pack.	**You have to understand the safety concerns and hazards, and know how to perform charging and calibration of the Lithium Ion Battery Pack.**
Chapter 7.1 Preventive Maintenance and Testing Overview	This section gives a schedule for maintenance.	**You have to be familiar with the maintenance schedule for the HAMILTON-C1.**
Chapter 7.2 Hospital Preventive Maintenance	This section gives the Hospital Preventive Maintenance details.	**You should be able to perform this maintenance and assertain if this maintenance is being performed regularly.**
Chapter 7.3 Engineer Preventive Maintenance	This section gives maintenance details.	**You have to be able to perform all the tasks in this section.**

Section	Function	Your resonsibility
Electrical Safety Tests starts Chapter 8.1	This section lists further test's you must perform on the HAMILTON-C1 before you start the Service Software test's.	**You have to be able to use this section to test the HAMILTON-C1.**
Service Software starts Chapter 9.10	This section explains how you perform the test's that are built into the software of the HAMILTON-C1.	**You have to know how to perform all the appropriate test's.**
Technical faults starts Chapter 10.1.1	This section gives an overview of the alarm indications.	**You should know how to interpret technical faults to isolated faulty components.**
Components Removal/Assembly starts Chapter 11.1	This section explains how to remove and assemble each major component.	**You have to be able to use this section to make repairs.**
Maintenance Tools and Test Equipment starts Chapter 12.1	This appendix lists the equipment you require to work on the HAMILTON-C1.	Check this appendix to make sure you have the correct tools and test equipment.
Spare Parts starts Chapter 13.1	Information resource.	You only require this section when you must order spare parts.
Schematics starts Chapter 14.1	This section includes many of the schematics produced by HAMILTON MEDICAL AG for internal use.	You are sometimes directed to this section when reading in other parts of the manual.
Hardware revisions, features and compatibility starts Chapter 16.1	This section explains many of the expressions used in the manual.	You should know how to find information in this section.
Glossary starts Chapter 19.1	This section explains many of the expressions used in the manual.	You should know how to find information in this section.
Ventilator Test Report starts Chapter 17.1	Test Report pages for the Service Software section.	Complete the report when using the Service Software test's.
Software revisions, features and compatibility starts Chapter 15.1	This section explains many of the expressions used in the manual.	You should know how to find information in this section.

3 HAMILTON-C1 Overview

3.1 Front and right Side Components Overview

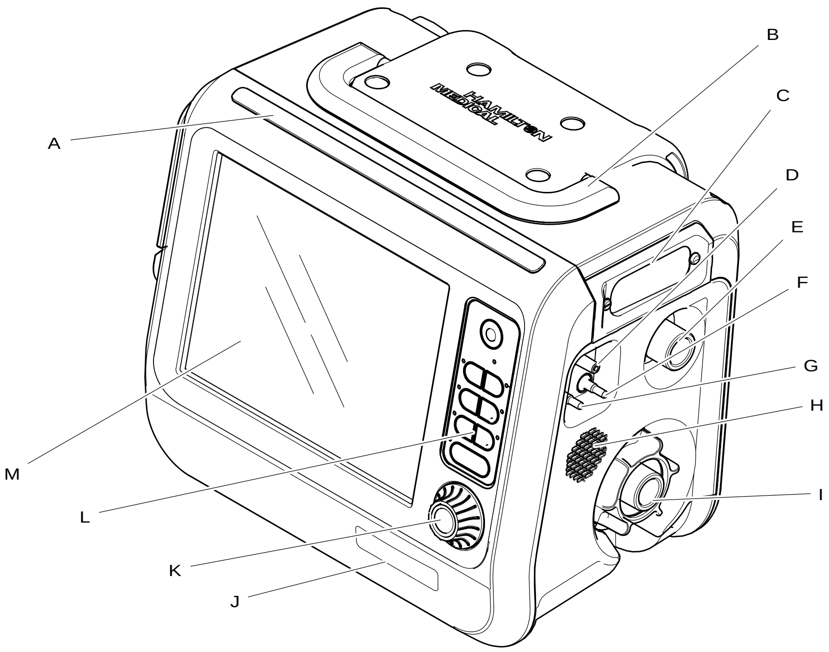


Fig. 1 Front and Right Side Components Overview

Legend:

A	Alarm lamp – Yellow - medium and low priority alarms – Red - high priority alarms and technical faults
B	Handle bar
C	Option slot
D	Nebulizer connection
E	Patient breathing circuit connector to the patient
F	Flow sensor connection, proximal side (blue tube)
G	Flow sensor connection, distal side (clear tube)
H	Loudspeaker (not shown)
I	Patient breathing circuit connector from the patient
J	Battery compartment
K	P+T (press and turn) knob
L	Front panel keys
M	8.4” TFT display with touchscreen and backlight

3.2 Rear and left Side Components Overview

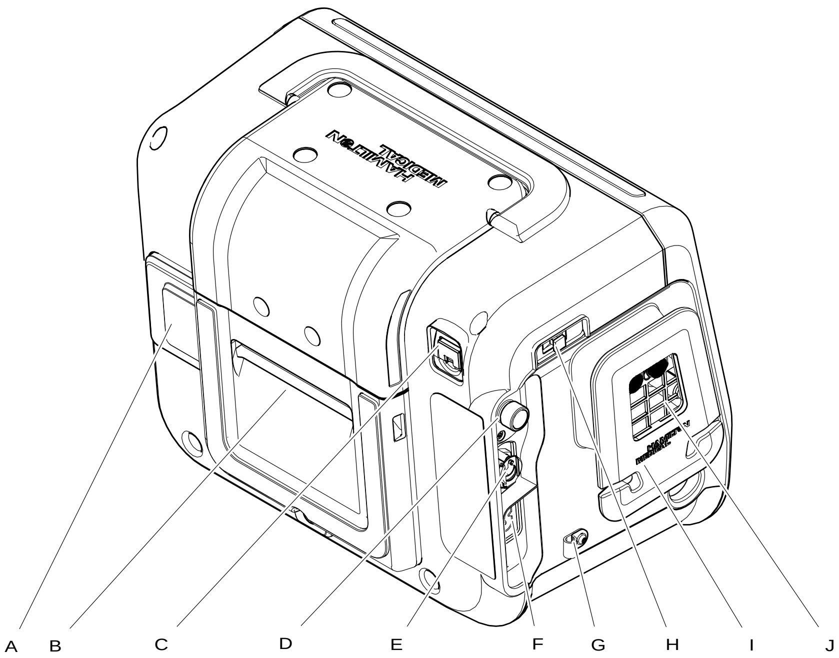


Fig. 2 Rear Components Overview

A	O2 cell (not shown)
B	HEPA pre filter (not shown)
C	Ethernet connection (for internal use only)
D	High pressure Oxygen (HPO) DISS or NIST connection
E	Low pressure Oxygen (LPO) connection
F	AC input
G	Retaining clip
H	USB connector. For software update, event log export,configuration setting export and import, and print screen.
I	Cable holder
J	Fan filter

WARNING	During transfer of a ventilated patient the USB port of the HAMILTON-C1 must be protected with the included cover. It is not allowed to use the USB port during transfer of a ventilated patient. In case of an uncovered USB port during transport it is not permitted to touch the USB port.

Note	The USB connector is intended for passive memory devices only.

3.3 Front Panel Internal Components Overview

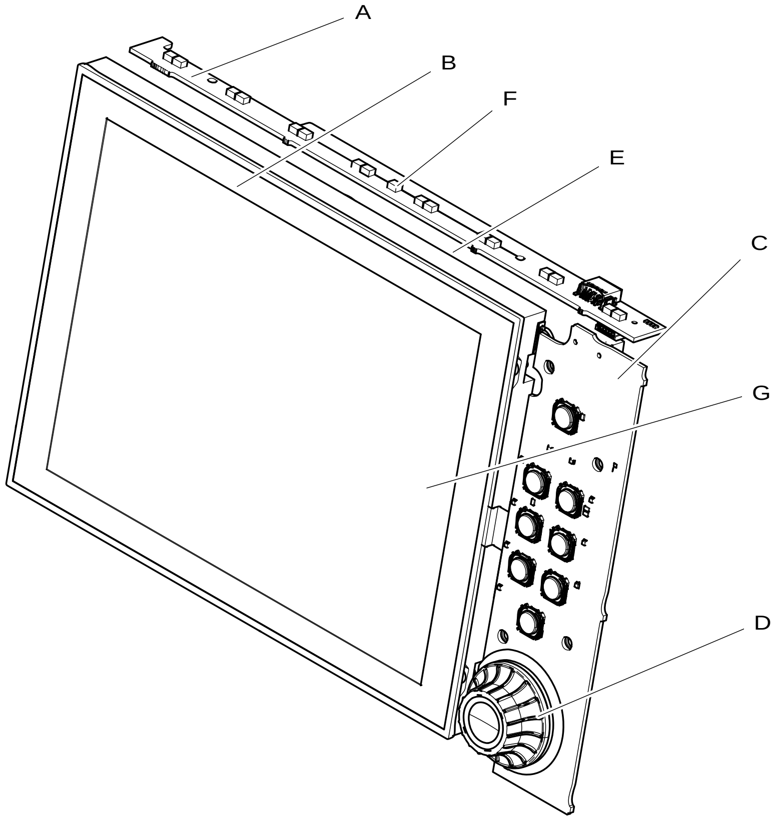


Fig. 3 Front Panel Internal Components Front Overview

A	Alarm lamp LED’s
B	Touchscreen
C	Front panel board
D	P+T (press and turn) knob with encoder
E	8.4” TFT display with backlight
F	LED for automatic brightness control and for backup alarming
G	Top sheet

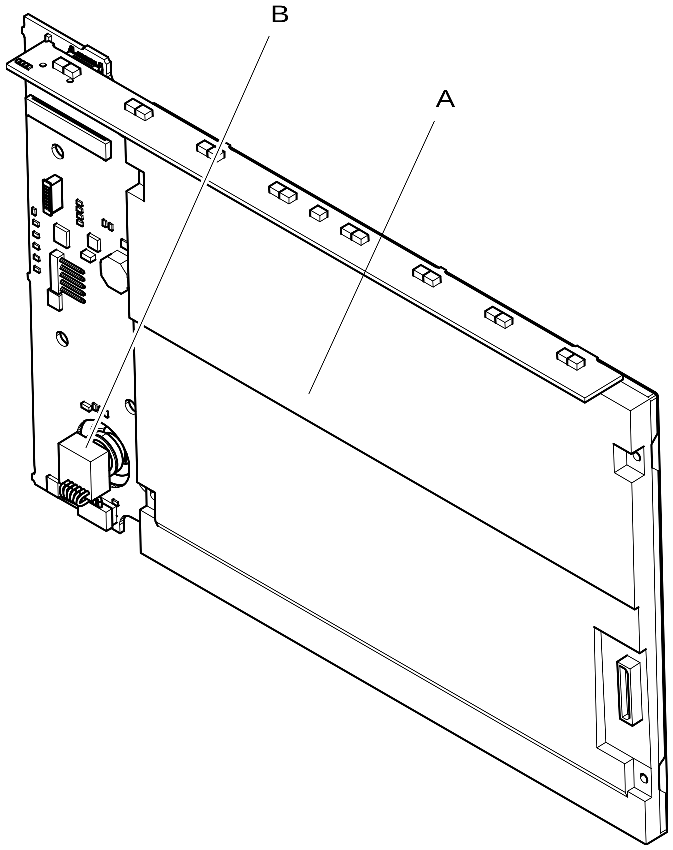


Fig. 4 Front Panel Internal Components Rear Overview

A	8.4" TFT LCD display with front panel and backlight
B	P+T encoder

3.4 Internal Components Overview

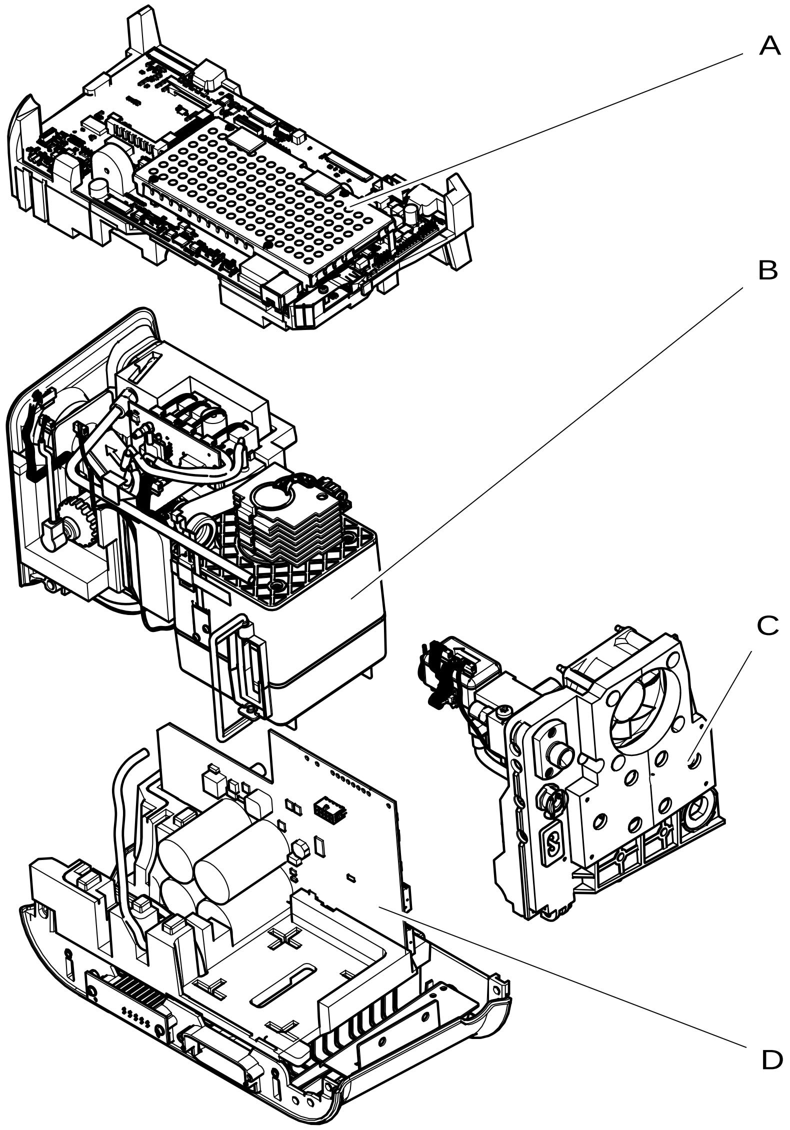


Fig. 5 Internal Components Overview

The ventilator is divided into 4 sections:

A	Top section
B	Middle section
C	Side section
D	Bottom section

3.5 Top Section

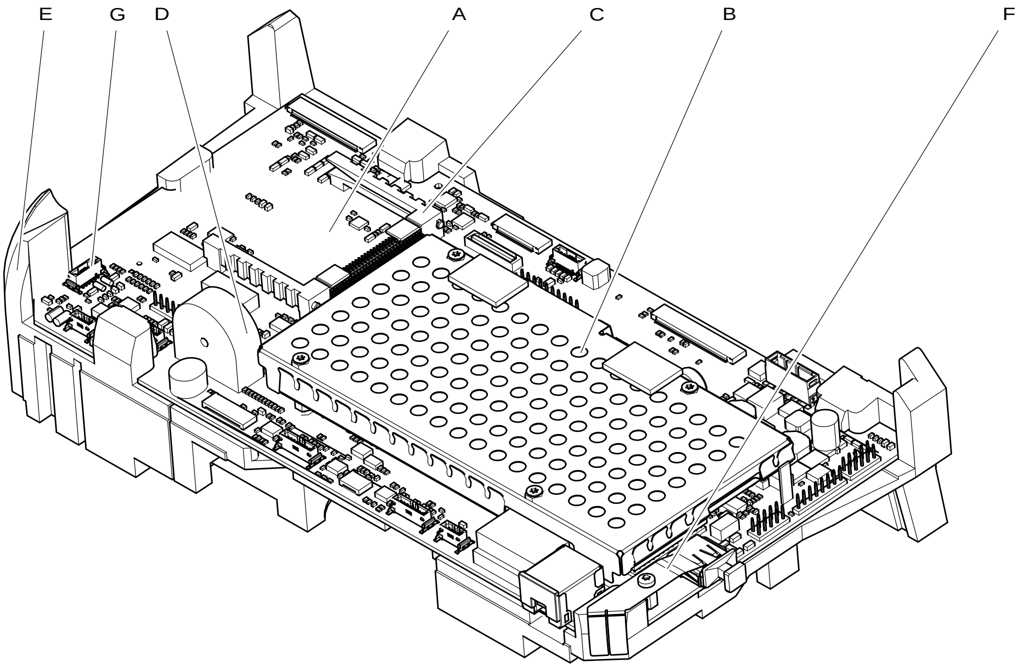


Fig. 6 Internal Components Top Section Front Overview

Legend:

A	Control board
B	ESM (embedded system module)
C	Options slot
D	Buzzer
E	Top foam
F	ESD ground protection spring

3.6 Middle Section

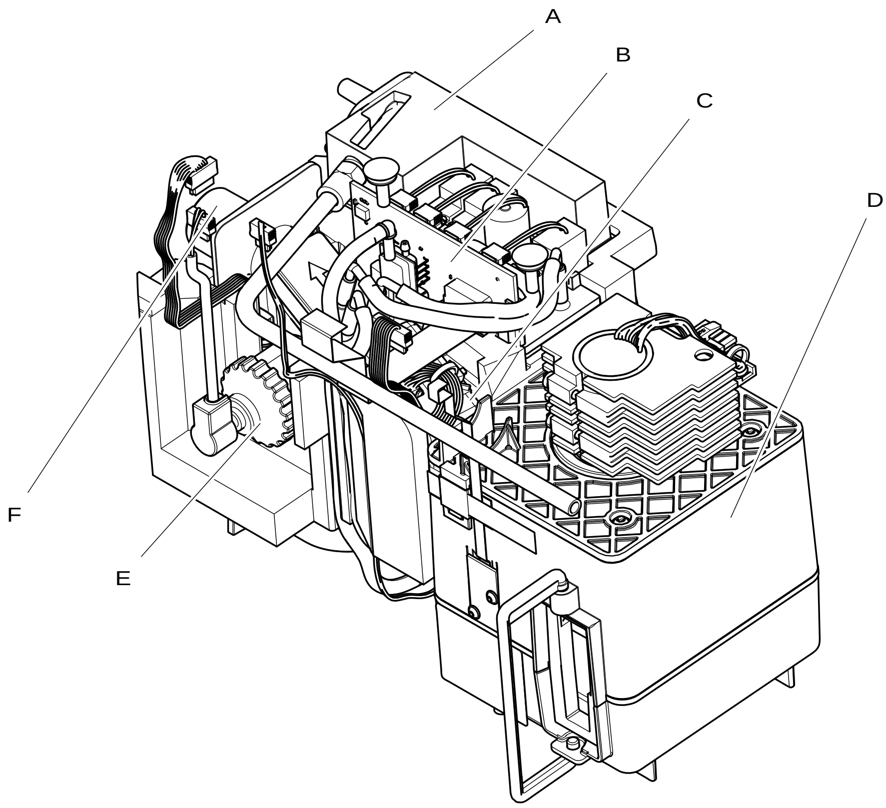


Fig. 7 Internal Components Middle Section Front Overview

Legend:

A	Pressure sensor assembly with rinse flow tank
B	Pressure sensor board (pressure sensor assembly)
C	Flow sensor Qvent
D	Blower module
E	O2 cell
F	Patient breathing circuit connection to the patient

3.7 Side Section

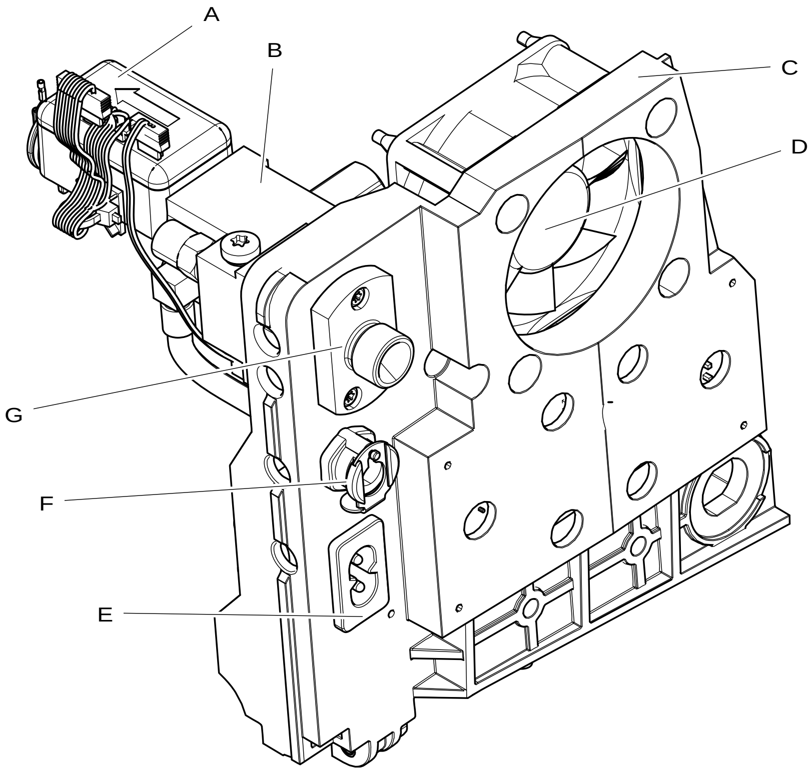


Fig. 8 Side Section

Legend:

A	Flow sensor QO2
B	O2 mixer assembly
C	Connection plate
D	Fan
E	AC Input
F	Low pressure Oxygen (LPO) input
G	High pressure Oxygen (HPO) input (DISS or NIST)

3.8 Bottom Section

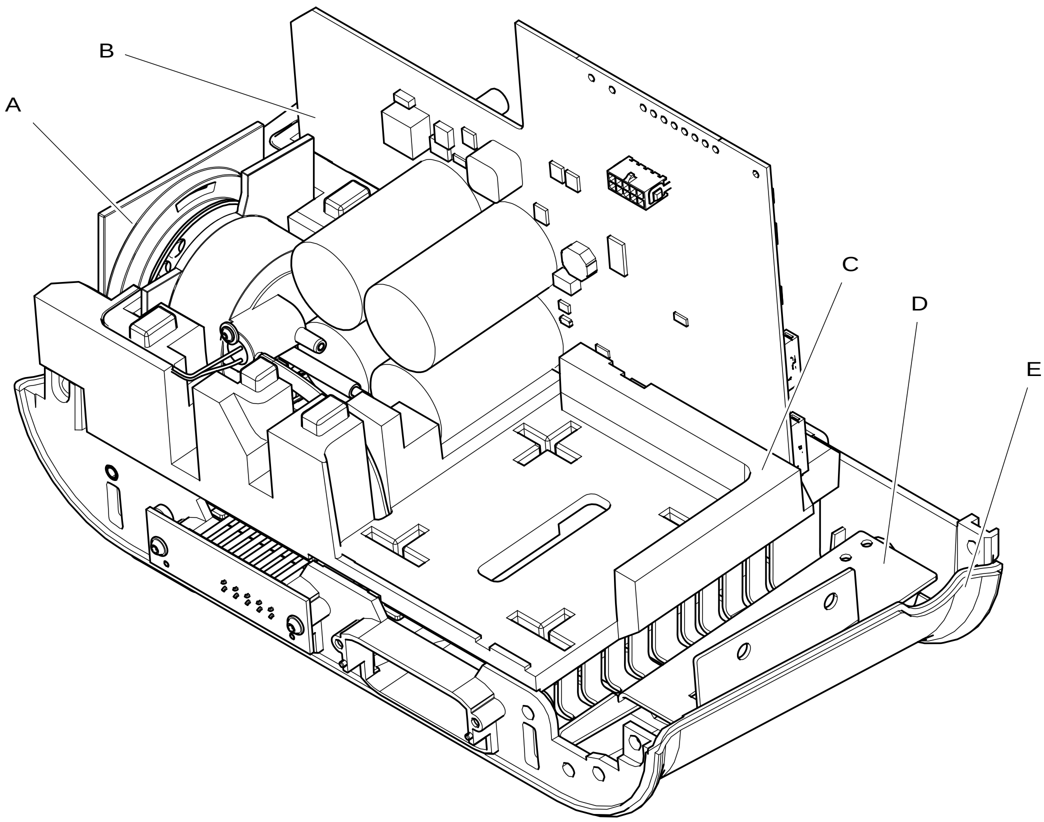


Fig. 9 Internal Components Bottom Section Overview

Legend:

A	Expiratory valve
B	Driver board
C	Bottom foam
D	Bottom housing
E	Bottom mounting plate

4 Pneumatics: Overview and Theory of Operation

4.1 Overview

WARNING	Service the HAMILTON-C1 only as described in this manual, using only parts approved or supplied by HAMILTON MEDICAL AG. Incorrect parts, components or assemblies could result in patient injury. See available spare parts starting in chapter Chapter 13.1.

Note	The figures in this section show exploded and transparent views of the HAMILTON-C1 components. The exploded diagrams may not always show components in their correct positions.

This section introduces all the major pneumatic components in the HAMILTON-C1. In addition, the gas flows and theory of operation are explained see pneumatic diagram Chapter 13.1.

4.2 Blower Assembly

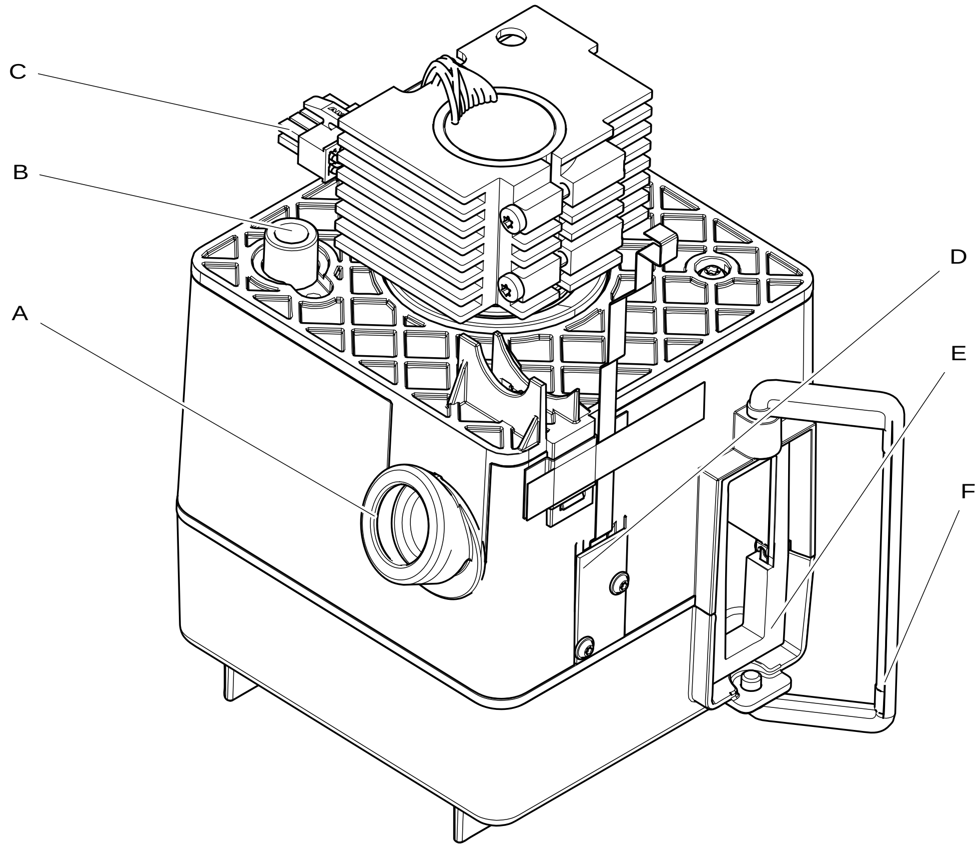


Fig. 10 Blower Assembly

The blower assembly supplies the air and oxygen mixture for patient inspiration.

A	Blower outlet (compressed air and oxygen mixture)
B	Oxygen inlet from O2 mixer assembly
C	Blower cable and connector
D	Filter pressure sensor board (Pfilter)
E	Air low pressure inlet / HEPA filter connector
F	Clamp for HEPA filter

4.3 Oxygen Mixer Block Assembly

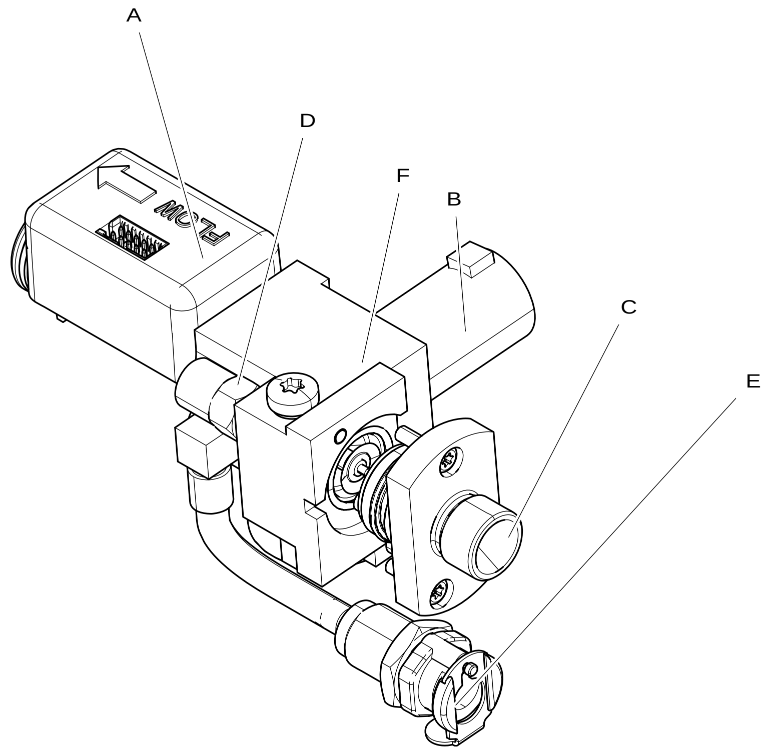


Fig. 11 O2 Mixer Block Assembly

The oxygen mixer block assembly controls the flow of oxygen into the blower assembly.

A	Flow sensor QO2
B	O2 Proportional valve
C	High pressure oxygen (HPO) DISS or NIST connection
D	Nebulizer tube connector
E	Low pressure oxygen (LPO) connection
F	O2 mixer block assembly

4.4 Check valve assembly

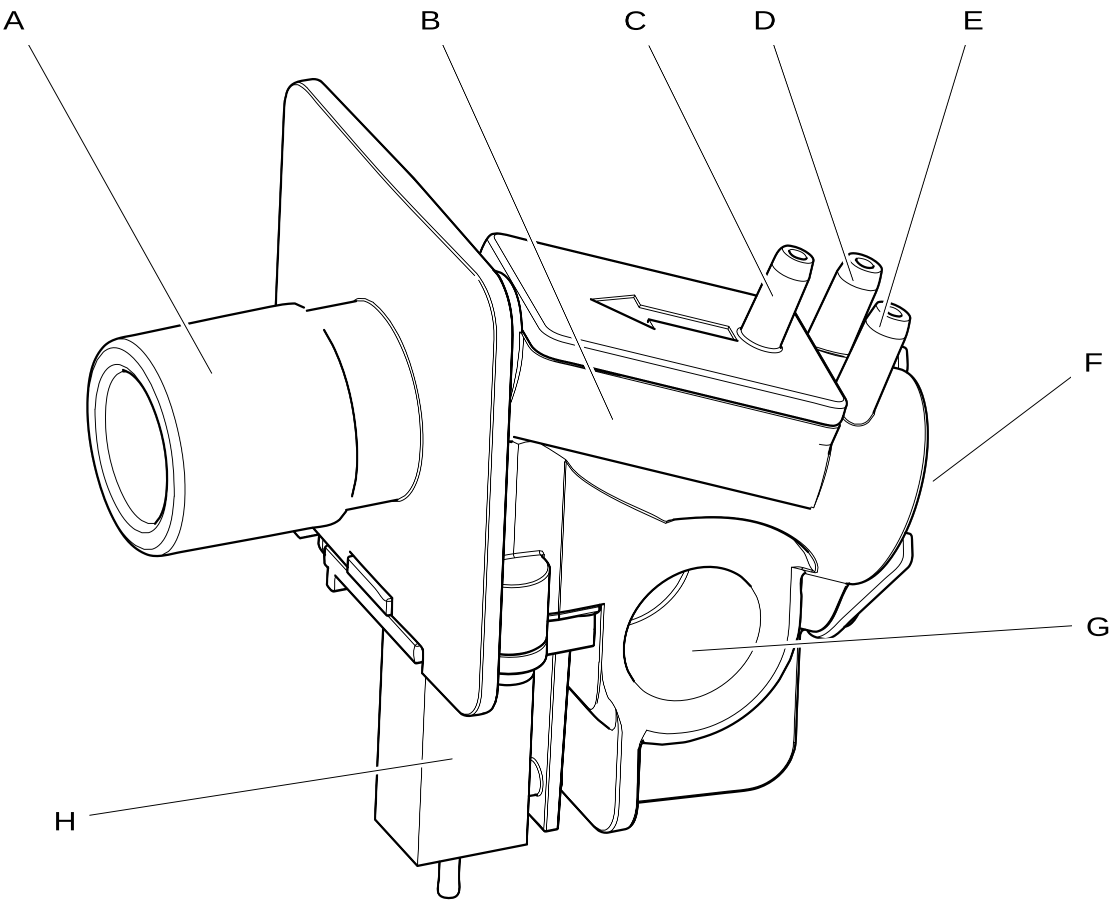


Fig. 12 Check valve assembly

The check valve assembly prevents to exhale through the inspiratory path.
The onstruction valve opens (release to room air) during situations where exhalation obstructed is present.

A	To patient port
B	Check valve (Flap not shown)
C	Tube connector to Pvent_Monitor sensor (Pressure sensor assembly) (HAMILTON-C1 ≥ SN6000)
D	Tube connector to Pvent_Control sensor (Pressure sensor assembly)
E	Tube connector to expiratory valve assembly
F	Connector to flow sensor AIR (Qvent)
G	Connection thread for O2 cell
H	Obstruction valve (HAMILTON-C1 ≥ SN6000)

4.5 Expiratory Valve

WARNING	Never attach a spirometer or any other device or tube to the exhaust port of the expiratory valve. This can cause the ventilator to lose control of PEEP/CPAP.

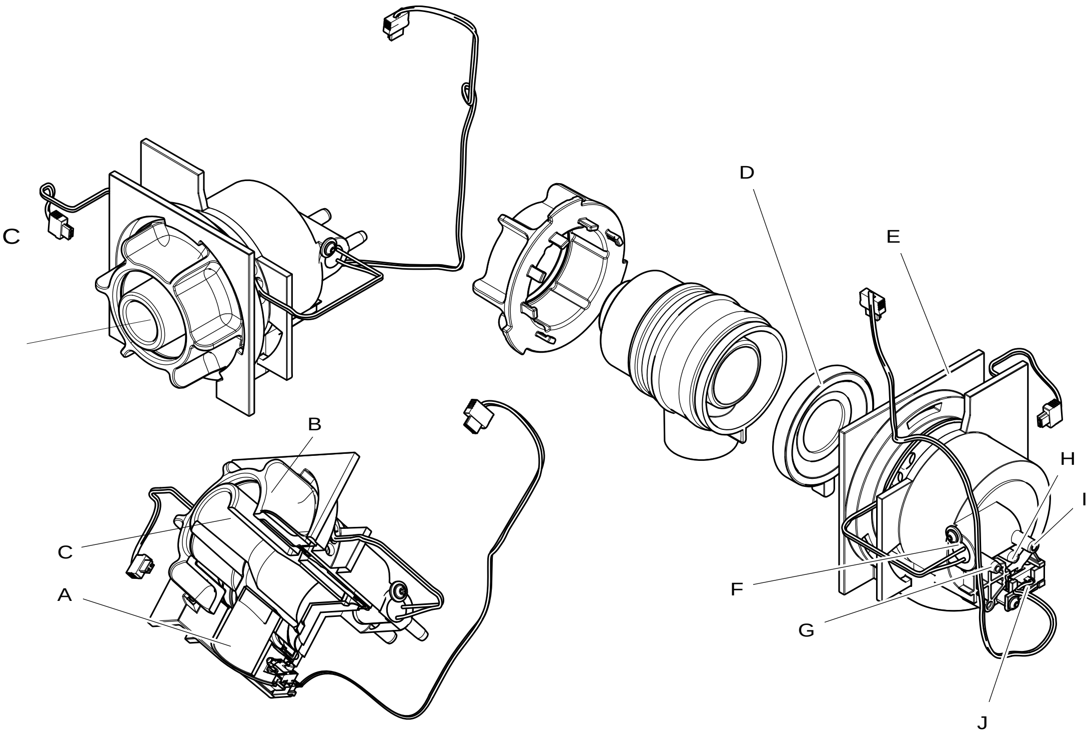


Fig.13 Expiratory Valve Overview

The expiratory valve enables gas to escape from the patient breathing circuit in a controlled manner, allowing the patient to exhale.

Legend:

A	Expiratory valve exhaust
B	Expiratory valve cover
C	Connection from the patient breathing circuit (expired gas from the patient), (see C)
D	Silicone membrane
E	Expiratory valve housing
F	Expiratory proportional valve
G	Expiratory valve bleed port (release to room air)
H	Tube connector to pressure sensor Pexpvalve (pressure sensor board)
I	Tube connector from inspiration path (check valve assembly)
J	Micro switch for neonatal expiratory valve cover detection

4.6 Patient Flow Sensor

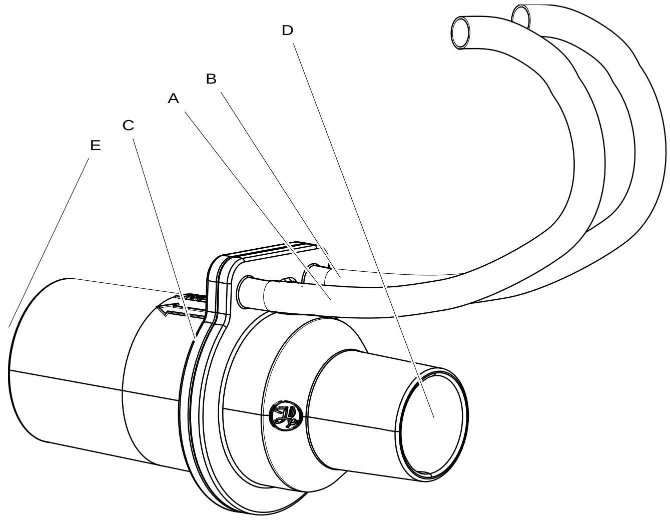


Fig. 14 Patient flow sensor

The HAMILTON-C1 accurately measures flow, volume, and pressure in the patient's airway with the HAMILTON MEDICAL flow sensor. This proximal flow sensor lets the HAMILTON-C1 sense even weak patient breathing efforts. Between its highly sensitive flow trigger and fast response time, the HAMILTON-C1 helps to minimize the patient's work of breathing.

The flow sensor contains a thin, diamond-shaped membrane within the outer housing and has a pressure port on either side. The membrane allows bidirectional flow through its variable orifice.

The area of the orifice changes depending on the flow rate. It opens progressively as the flow increases, creating a pressure drop across the orifice. The pressure difference is measured by a high-precision differential pressure sensor (Pflowsensor) located on the pressure sensor assembly inside the ventilator. The pressure difference varies with flow (relationship determined during flow sensor calibration), so the patient's flow is determined from the pressure drop. The HAMILTON-C1 calculates volume from the flow measurements. The flow sensor is highly accurate even in the presence of secretions, moisture, and nebulized medications. The HAMILTON-C1 continuously flushes the sensing tubes with mixed gases (rinse flow) to prevent blockage.

A	Blue tube - proximal side measured Pflow sensor pressure and Paw pressure
B	Clear tube - distal side measures Pflow sensor pressure
C	Variable orifice membrane
D	Two-way gas flow connection on the distal side of the patient flow sensor
E	Two-way gas flow connection on the proximal side of the patient flow sensor

Note	Ventilation is not totally dependent on the flow sensor. If the flow sensor malfunctions, patient ventilation continues. The ventilator has an internal flow measurement for inspiratory flow.

4.7 Gas Rinse Flow

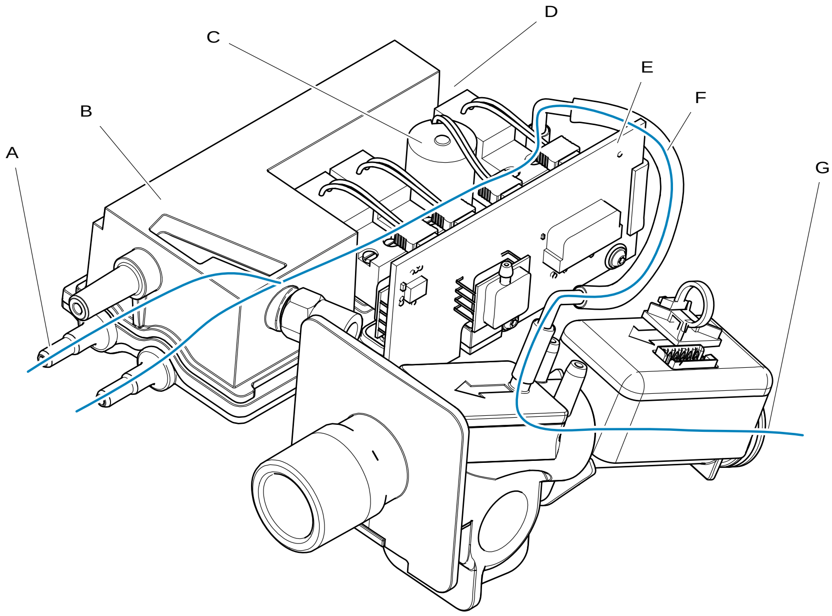


Fig. 15 Components that generate the Flow Sensor Rinse Flow

Legend:

A	Flow sensor connectors
B	Rinse flow tank
C	Rinse flow valve
D	Pressure sensor assembly
E	Pressure sensor board
F	Gas supply for the rinse flow tank
G	Gas from the blower assembly

The rinse flow is provided from the rinse flow tank. During every inspiration the rinse flow tank will be filled with air and oxygen from the blower. The rinse flow tank provides a continuous flow of gas during inspiration and expiratory through the flow sensor tubes to the flow sensor. The difference between the proximal and distal rinse flows is ±10%. The rinse flow prevents contamination of the ventilator, the flow sensor and its tubes, and cross-contamination when connecting new patients.

4.8 Oxygen Cell

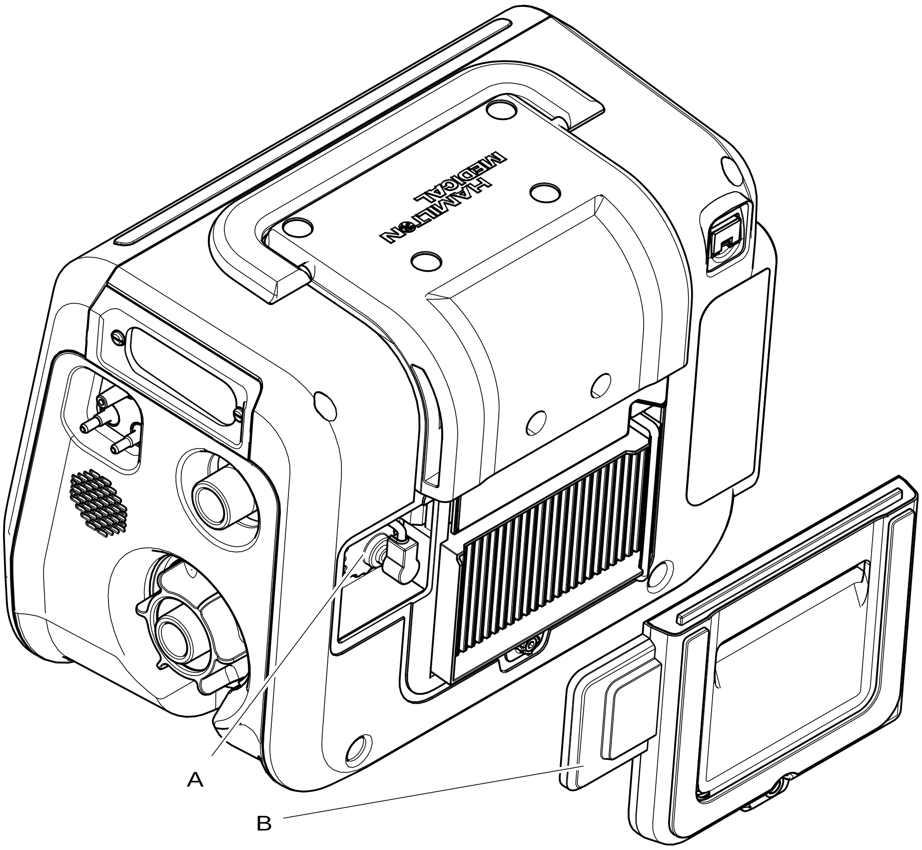


Fig. 16 Oxygen Cell

WARNING	The ventilator cannot be operated without O2 cell installed.

Note	HAMILTON MEDICAL AG O2 cells are available from HAMILTON MEDICAL AG only.

The O2 cell (A) is attached to the back left side of the ventilator behind the O2 cell cover (B). It is used to monitor the O2 concentration in the gases delivered to the patient. The O2 cell performs only a monitoring function, and can be disabled by the user, if required.

The HAMILTON MEDICAL AG O2 cell produces a voltage between 11 and 13mV at 21% O2 which changes with O2 concentration. Each unit comprises a teflon-bonded gold cathode and a lead anode, submerged in a liquid electrolyte solution. When oxygen diffuses through the flouropolymer membrane, the electrochemical reduction of O2 on the cathode and the corresponding oxidation of the anode generates an electrical current that is proportional to the concentration of O2.

4.9 Nebulizer Gas Flow

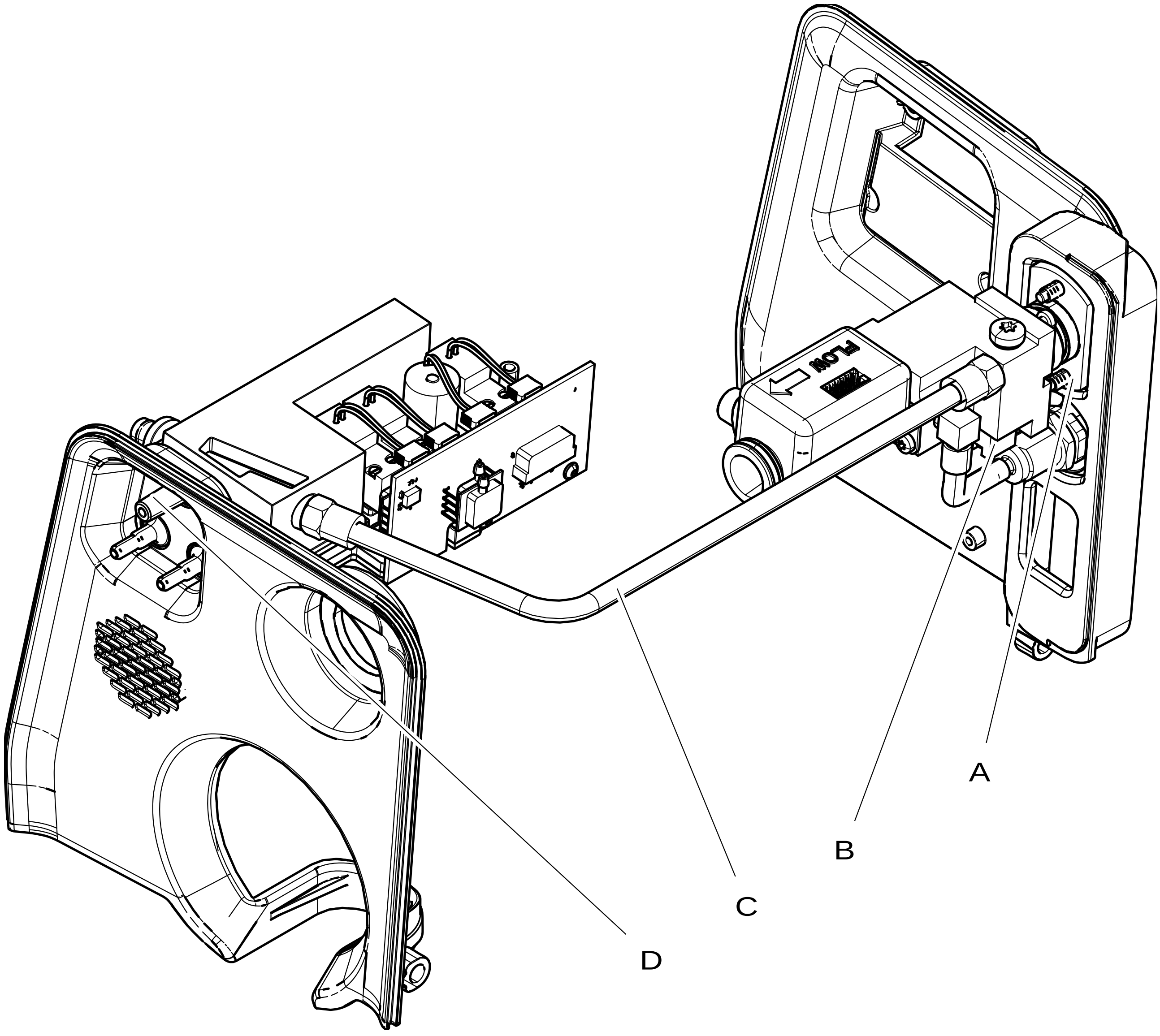


Fig. 17 Nebulizer Output Overview

The ventilator provides oxygen with sufficient pressure to drive the nebulizer jar. The oxygen flow is reduced to approximately 8 liters/minute by means of an internal flow restrictor in the oxygen mixer block assembly. A valve attached to the oxygen mixer block assembly switches the flow of oxygen to the nebulizer jar through the output connection at the front panel. The pneumatic nebulizer is disabled when low-pressure oxygen is used.

A	High-pressure-oxygen (HPO) inlet
B	Nebulizer valve
C	Tubing from oxygen mixer block assembly to the nebulizer front panel connection
D	Nebulizer front panel connection

4.10 Gas Supply and Delivery

The HAMILTON-C1 uses room air and low- or high-pressure oxygen.

Air enters through a fresh gas intake port and is compressed together with the oxygen by the blower.

Oxygen enters through a high- or low-pressure inlet.

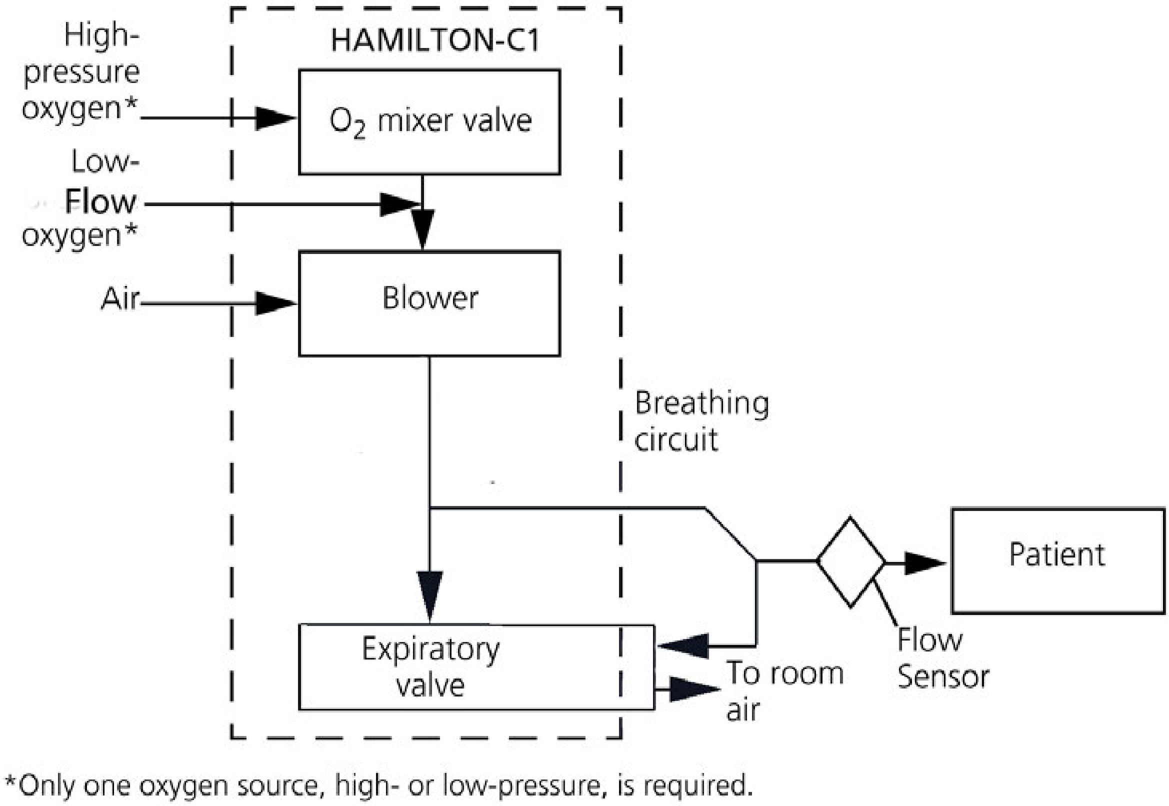


Fig. 18 Description of function

Within the ventilator, the gas enters the HAMILTON-C1's pneumatic system. If high-pressure oxygen is supplied, a mixer valve provides for the operator-set concentration. If low-pressure oxygen is supplied, the delivered oxygen concentration is determined by the flow of the source oxygen. Gas is supplied to the patient via the blower which acts as breath pattern generator. The microprocessor controls the speed of the blower and the duration to meet the user settings. The HAMILTON-C1 delivers gas to the patient through the inspiratory limb breathing circuit parts gas exhaled by the patient passes through the expiratory limb breathing circuit parts. Gas is vented through the expiratory valve cover such that no exhaled gas comes into contact with any internal components of the HAMILTON-C1. The operations of the blower and expiratory valve are coordinated to maintain system pressure levels.

Note	High-pressure-oxygen: Maximal Pressure 600kPa / Maximal Flow 200l/min Low-pressure-oxygen: Maximal Pressure 600kPa / Maximal Flow 15 l/min

4.10.1 Principal Gas Flow in the Ventilator

The following flow occurs in the “Principal Gas Flow”:

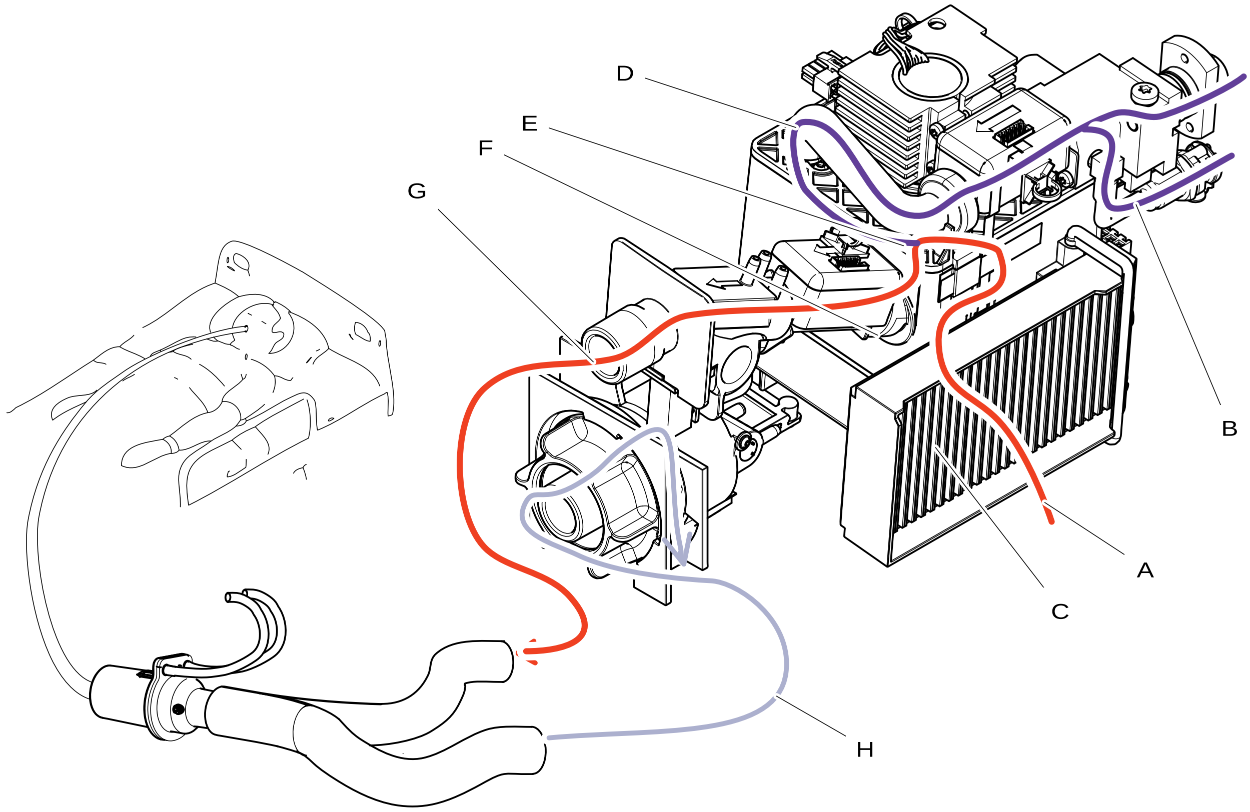


Fig. 19 Principal Gas Flow in the HAMILTON-C1

Legend:

A	Room air
B	High or low pressure oxygen supply
C	HEPA filter assembly
D	Air and oxygen mixed in the blower assembly
E	Air/oxygen mixture flows through the turbine blower
F	From the turbine blower to the inspiratory path
G	Air/oxygen mixture into the inspiratory path
H	Expired gas to the expiratory valve

4.10.2 Components for the Ambient State Gas Flow

In case a technical fault alarm is serious enough to possibly compromise safe ventilation, the ventilator enters the ambient state.

The inspiratory channel and expiratory valves are opened, letting the patient breathe room air unassisted. The ventilator needs to be switched off to exit the ambient state.

The one-way function of the expiratory valve makes sure the patient does not inhale his exhaled CO2 (rebreathing).

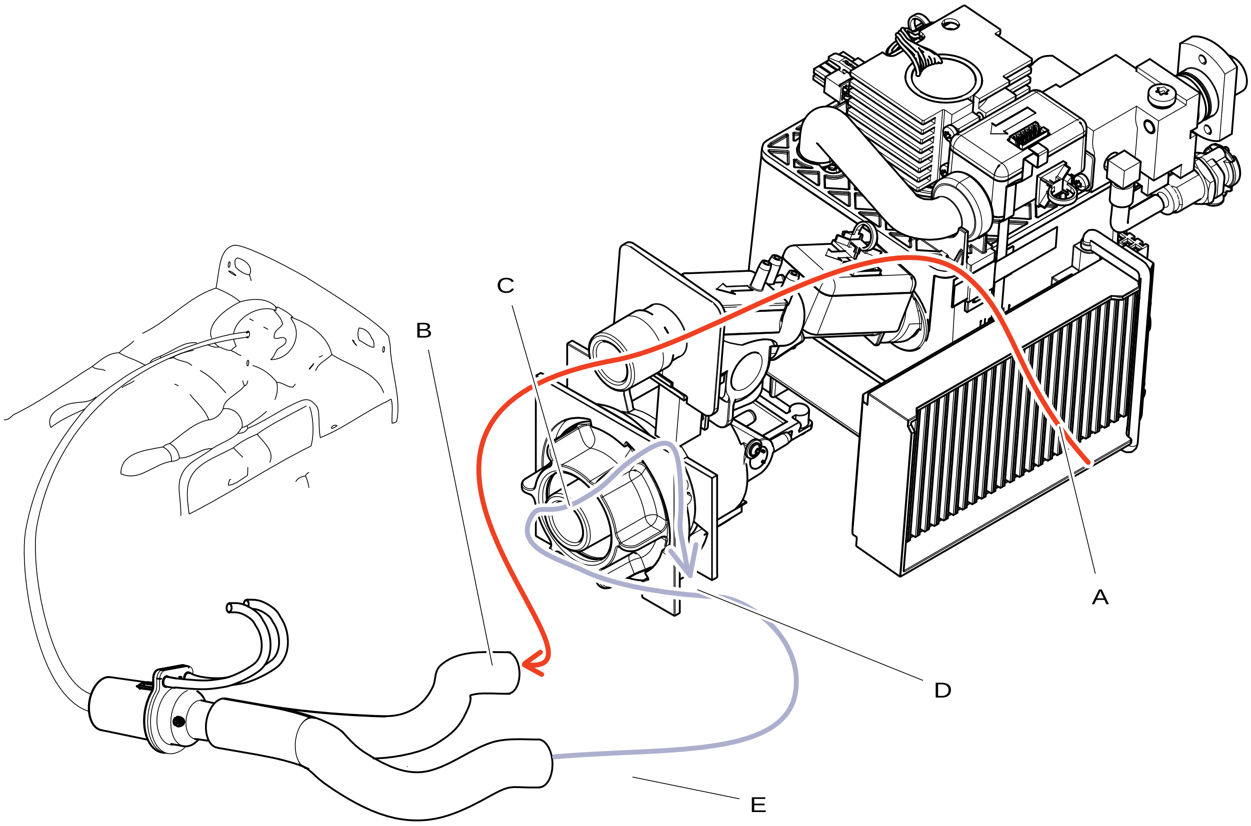


Fig. 20 Components for the Ambient State Gas Flow

A	Room air
B	Into patient breathing circuit
C	Expiratory valve
D	Expired gas to the room
E	From the patient breathing circuit

4.11 Ventilation Control Principle

The HAMILTON-C1 is a pressure-controlled ventilator. This means that the applied volume is controlled by a specific calculated pressure and not by a preset volume only. The ventilator does not contain a tank as space for the gases to mix. The required pressure is generated by a turbine, known as blower module, which turns with approximately > 30000 RPM during normal ventilation. This pressure source provides the required ventilation pressure, e.g. PEEP+Pcontrol= Pblower.

To get a certain pressure in the breathing circuit the pressure of the patient outlet is observed with a 1000-measurements-per-second interval, measured by the internal pressure sensor (Pvent_control). The results of this constant measurement are used to regulate the outlet pressure of the blower. The expiratory valve manages the outflow of the gas. It regulates a pressure to the membrane which has a direct effect on the gas in the breathing circuit (back pressure). The outlet of the breathing circuit never closes completely during ventilation, so the membrane is floating all the time.

4.11.1 Flow measurement

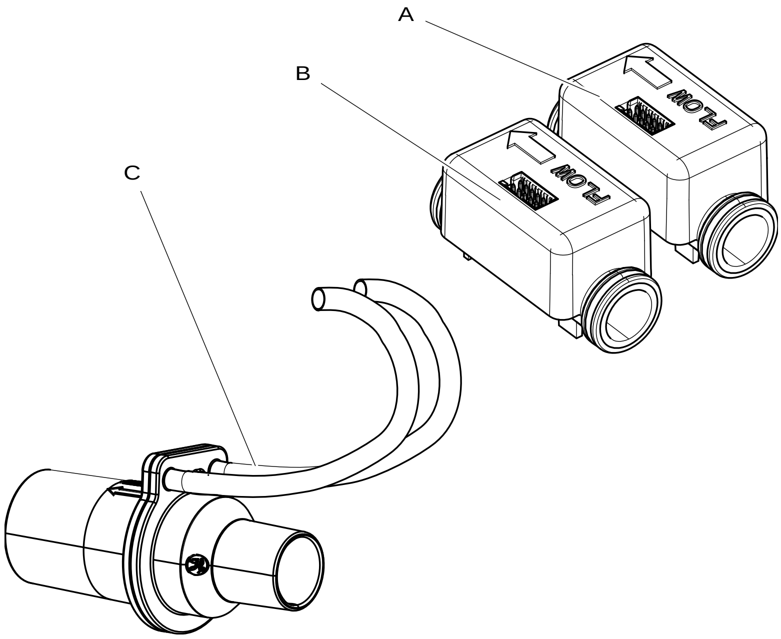


Fig. 21 flow sensor used for Flow Measurement Overview

flow sensors used for flow measurement are:

A	The internal flow sensor QO2 measures the flow of the oxygen into the blower assembly. Works with the internal flow sensor Qvent to control the air/oxygen mixture.
B	The internal flow sensor Qvent measures the flow of the air/oxygen mixture into the patient breathing circuit.
C	External patient flow sensor Chapter 4.6

4.11.2 Pressure Measurement and Control

The ventilator has five pressure sensors to apply, control and monitor the airway pressure and proximal flow.

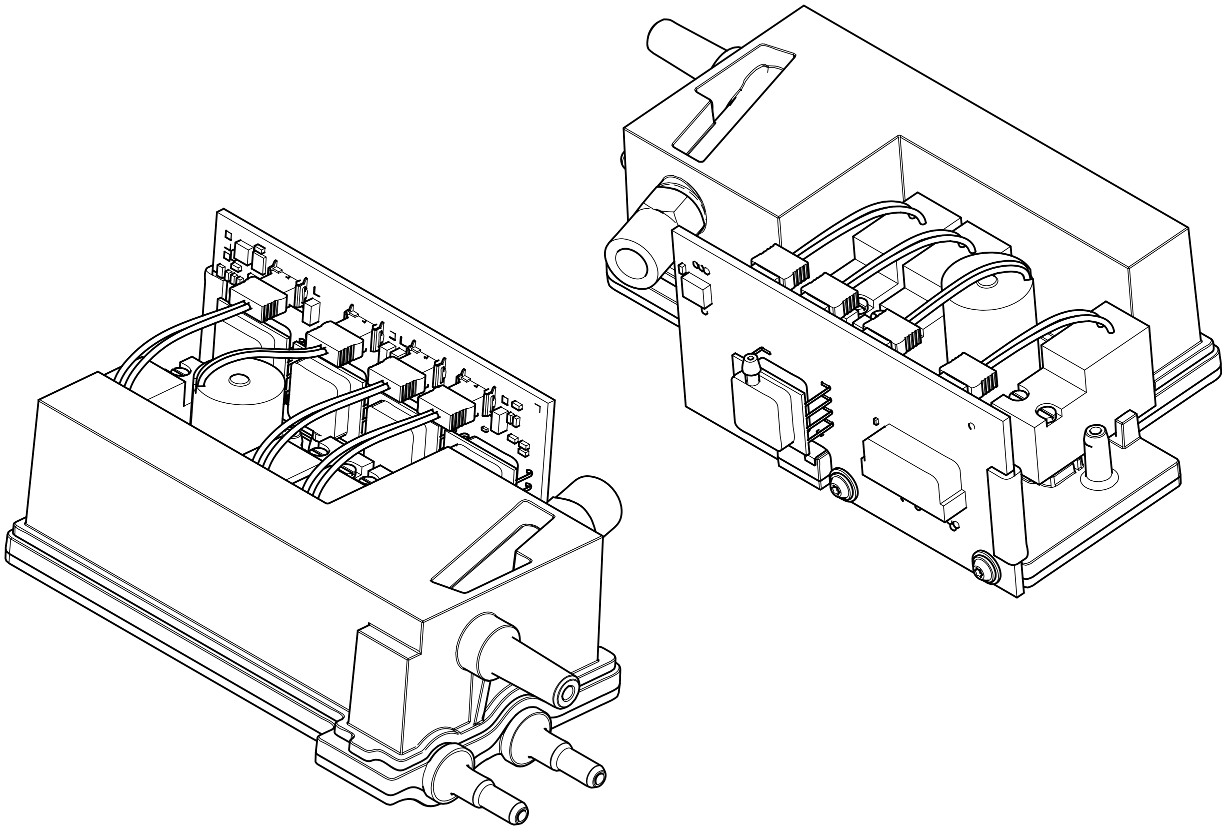


Fig. 22 Pressure Sensor Assembly

For sensor description see Chapter 5.2.4.

4.11.3 Flow Restrictors used for Flow Reduction

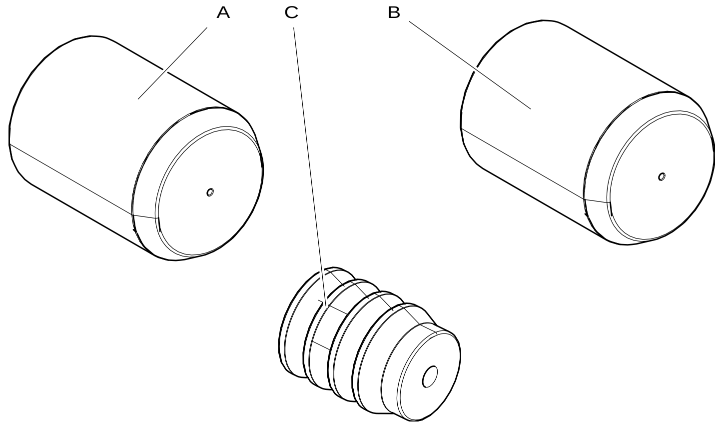


Fig. 23 Flow Restrictors

Flow restrictors with the purpose of reducing flow are:

A	A restrictive “Orifice” for the oxygen flow to the nebulizer valve.
B	Two precisely matched “Orifice” restrictors for the flow sensor rinse flow (only one showed).
C	Flow restrictor for the blower pressure to expiratory proportional valve.

5 Electronics: Component Functions Overview

5.1 Overview

WARNING	Service the ventilator only as described in this manual, using only parts approved or supplied by HAMILTON MEDICAL AG. Incorrectly repaired parts, components or assemblies could result in patient injury. See available spare parts in Spare Parts Chapter 13.1.

This section introduces the major electronic components in the ventilator. Where you require more information, cross-references direct you to other parts of this manual.

This section does not include a theory of operation, because engineers do not require a detailed knowledge of board-level electronics to service and maintain the ventilator. All electronic failures are dealt by replacing complete circuit boards. Any repairs at a lower level than the spare parts provided in Chapter 13.1.

Note	Always send defective printed circuit boards to HAMILTON MEDICAL AG with a completed returned goods ID tag (RGA). Refer to PN 699138 RGA procedure, available as download from www.hamilton-medical.com at the technical support section.

5.2 Electronic Components

5.2.1 Control Board

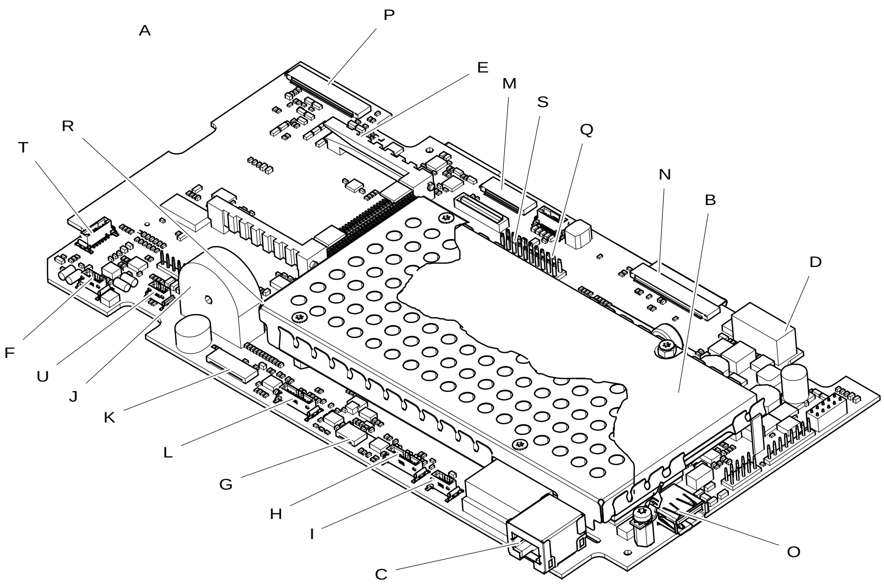


Fig. 24 Control Board

A **Control Board**

- Serves as the carrier board for the processor board and the connector board for all sensors
- The control board controls:
  - ON/OFF key
  - Hardkey and lamps
  - Touch panel
  - TFT display
  - Expiratory valve
  - Mixer valves
  - Nebulizer valve
  - Emergency status indicator
  - Option board
- Interfaces with the following boards:
  - Pressure sensor assembly
  - Filter pressure board
  - Driver board
  - Front panel board
- Sensor monitoring:
  - Instrument temperature
  - Pambient
  - Flow sensor QO2
  - Flow sensor Qvent

- Proximal flow sensor
- O2 cell

– Input voltage supplied from the power supply

– Output voltages created by switching regulators on the control board:

– 3.3VDC - Qvent flow sensor, O2 flow sensor, USB port, pressure sensors, P+T knob, ESM module, blower temperature sensor and HEPA filter temperature sensor, flow sensor , LED backlight and USB port

– 5VDC

B	**ESM Module** – Embedded system module
C	**Ethernet connection**
D	**Cable to driver board power**
E	**Option slot**
F	**Cable to O2 cell, 3,5mm Jack**
G	**FFC to filter pressure board**
H	**Cable to flow sensor O2**
I	**Nebulizer connection**
J	**Buzzer**
K	**FFC to pressure sensor board**
L	**Cable to flow sensor ventilation**
M	**FFC to display**
N	**FFC to driver board**
O	**USB connection**
P	**FFC to front panel board**
Q	**Voltage test points**
R	**Sensor voltage test points**
S	**Tesla spy (not in use)**
T	**Obstruction valve**
U	**Connector to micro switch (expiratory valve cover detection)**

Control board voltage testpoints:

For voltage ranges see Schematics "Voltage Distribution HAMILTON-C1", Chapter 14.1.

For sensor voltage range see Fig 26.

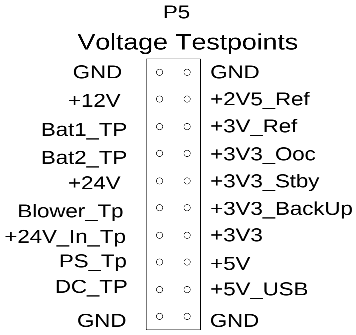


Fig. 25 Voltage Testpoints P5

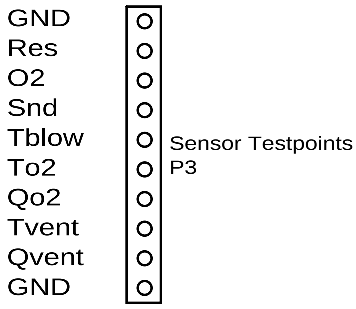


Fig. 26 Voltage Sensor Testpoints P3

Tab. 4 Sensor voltage range

Signal name	**Voltage level**	**Voltage range (standby / service software)**
O2	0.227; when O2 cell is disconnected and during offset calibration for ~1s.	0.223 - 0.231
Soundlevel	1.15 while loudspeaker and buzzer are inactive	1.11 - 1.19
Tblower	0.5 @ 20°C	+ 39mV/°C
TO2	1.25 @ 25°C	1.15 - 1.35
QO2	0.25	0.05 - 0.45
Tvent	1.25 @ 25°C	1.15 - 1.35
Qvent	0.25	0.05 - 0.45

5.2.2 Driver Board

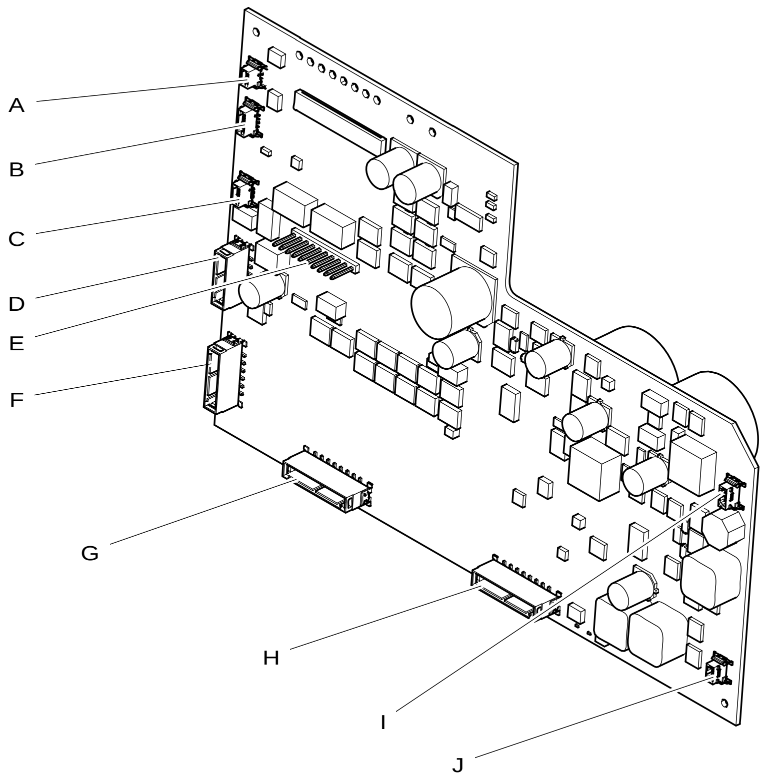


Fig. 27 Driver Board

Connections:

A	Not used
B	Fan
C	O2 valve
D	Power to control board
E	Voltage testpoint
F	Power supply
G	not used
H	Battery 1 power
I	Loudspeaker
J	Expiratory valve

Serves as the as the power management for the system, valves and peripheries.

Contains:

- Power path selector
- Battery management
- Endstage for the blower
- Endstage for the expiratory proportional valve
- Endstage for the O2 proportional valve
- Fan Control
- Loudspeaker

- Energy recovery logic

Interfaces with:

- Power supply
- Smart battery
- Control board
- Expiratory proportional valve
- O2 proportional valve
- Loudspeaker
- Fan

5.2.3 Power Supply Components Overview

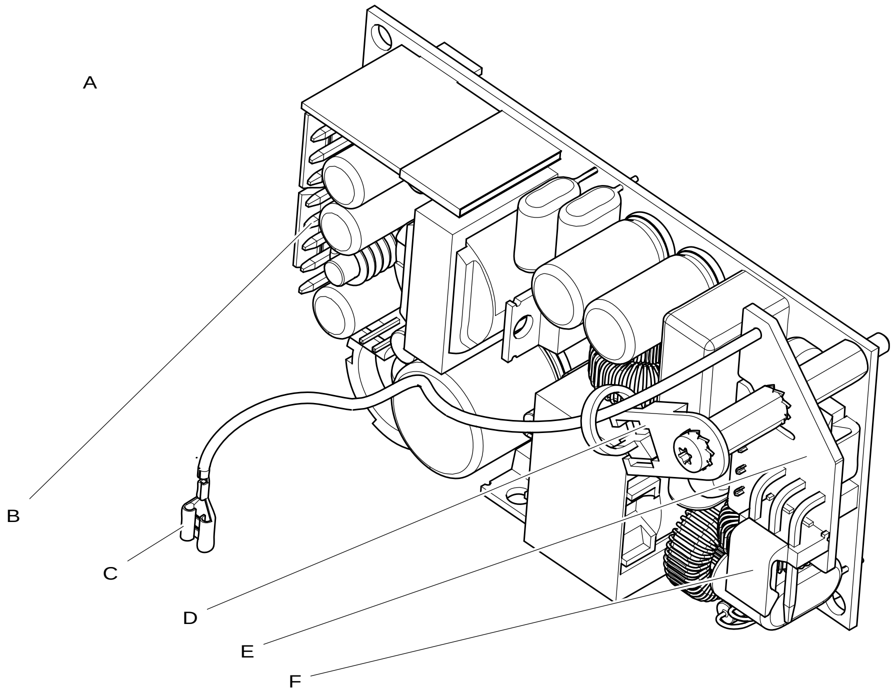


Fig. 28 Power Supply Overview

A	Power supply – Provides power conversion for the mains power
B	Power outlet connector – Cable for 24VDC supply from the power supply to the driver board P2 connector
C	Wire to ground (bottom mounting plate)Power outlet connector
D	Cable holder
E	Protection Board
F	Power inlet connector – Cable from AC power inlet

5.2.4 Pressure Sensor Assembly Components Overview

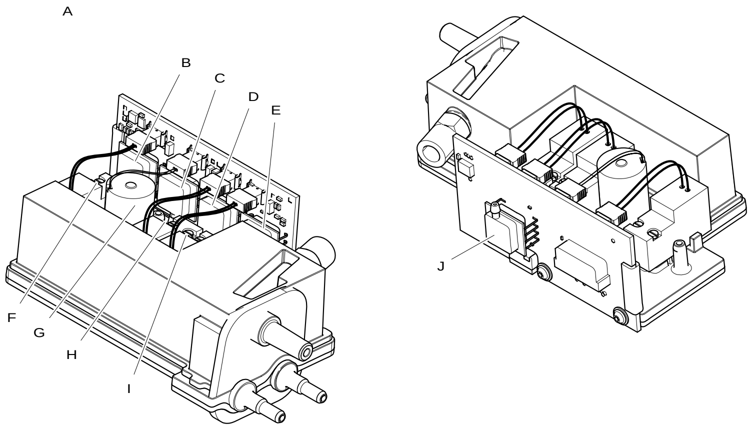


Fig. 29 Pressure Sensor Assembly Components Overview

A Pressure sensor assembly

- Provides components for pressure measurements.

B Pvent_monitor pressure sensor

- Pvent_monitor is used to calculate the monitoring values based on the internal ventilator pressure.

C Pvent_control pressure sensor

- Pvent_control is used to regulate the pressure by the control software.

D Pflowsensor pressure sensor

- A measurement of the pressure difference between the front and rear chambers of the flow sensor.

E Paw pressure sensor

- A measurement of the pressure in the patient breathing circuit as measured at the flow sensor, in the chamber attached to the blue (patient side) pressure-sensing tube.

F Pvent_monitor autozero valve

- Switches the Pvent_monitor to allow for offset re-calculation to compensate for sensor drift for Pvent_control and Pvent_monitor.

G Proximal autozero valve

- Switches the Pflowsensor and Paw pressure sensor to ambient air to allow for offset re-calculation to compensate for sensor drift.

H Distal autozero valve

- Switches the Pflowsensor pressure sensor to ambient air to allow for offset re-calculation to compensate for sensor drift.

I Rinse valve

- The rinse valve opens during inspiration in order to charge the rinse flow tank. The tank provides the rinse flow during expiratory.

J Pexpvalve pressure sensor

- Measures the pressure applied to the expiratory valve membrane, used for controlling.

5.2.5 Front Panel Electronics Components

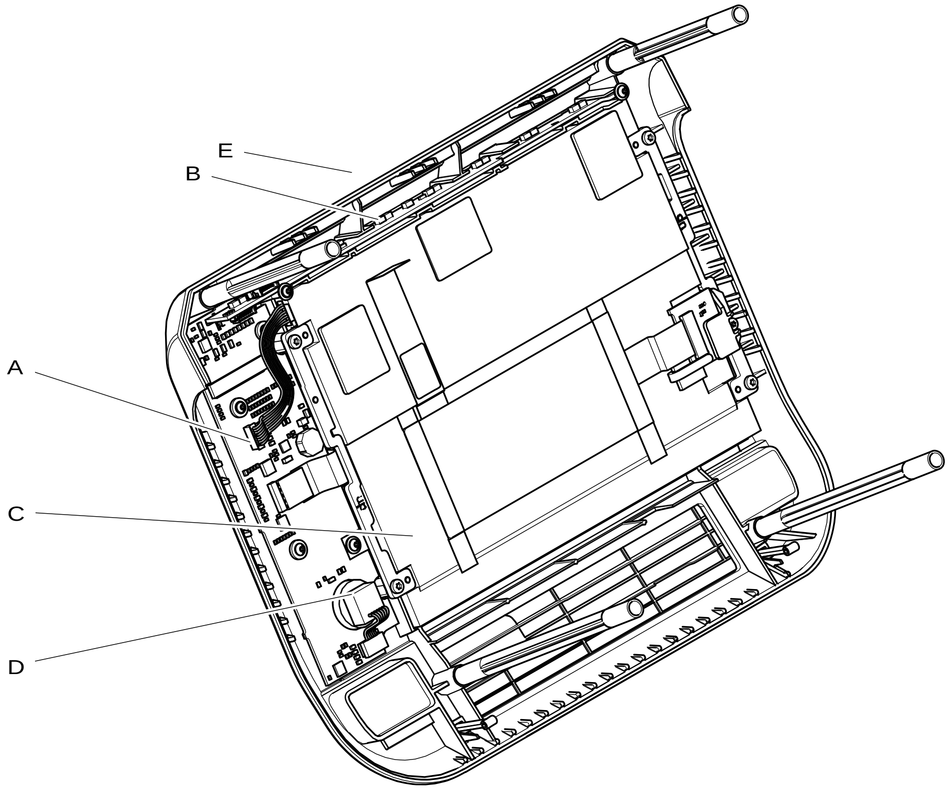


Fig. 30 Front Panel Electronics Components

A **Front Panel Board**

- Provides 7 hard keys for the operator with LED indicators
- Interfaces the P+T knob encoder
- LED colors available:
  - Red
  - Green
  - White

B **Alarm Lamp LEDs**

- Indicates alarm conditions:
  - Yellow – Medium and low priority alarms
  - Red – High priority alarms and technical faults

C **8.4" TFT LCD Display with Backlight**

- Graphical user interface (GUI)

D **P+T Knob Encoder**

- Provides additional controls for interaction with various screen functions
    - Switch activation when the P+T knob is pressed

E **Touchscreen (not shown)**

A resistive touchscreen panel is composed of several layers, the most important of which are two thin, electrically conductive layers separated by a narrow gap. When an object, such as a finger, presses down on a point on the panel's outer surface the two metallic layers become connected at that point: the panel then behaves as a pair of voltage dividers with connected outputs. This causes a change in the electrical current, which is registered as a touch event and sent to the controller for processing.

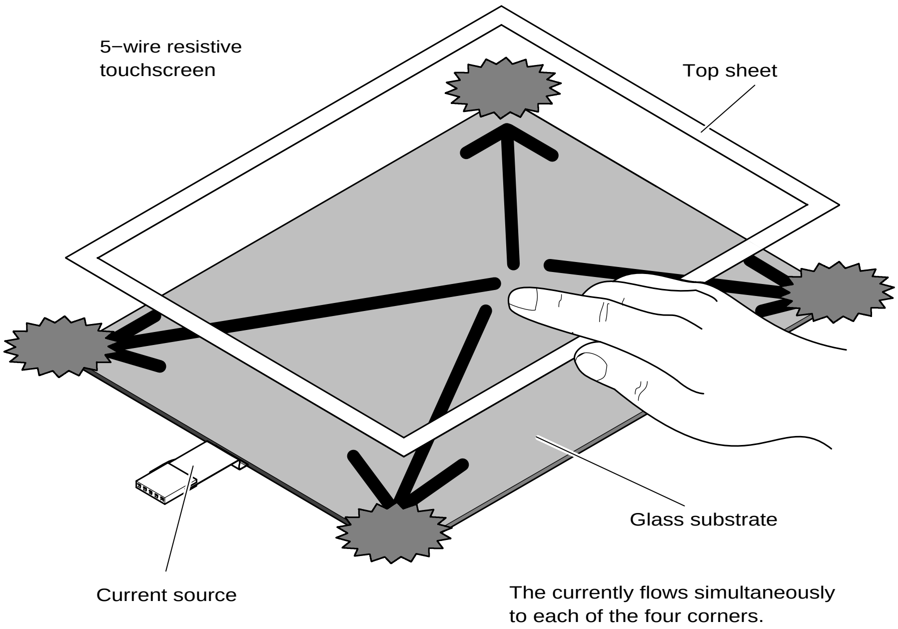


Fig. 31 Touchscreen Illustration

6 Lithium Ion Battery

6.1 Lithium Ion Battery Handling Precautions

Note	Before using lithium ion batteries for the first time, carefully study this section, including all Cautions and Warnings. Keep this section for future reference.

WARNING

1 Do not use the battery for a purpose other than those specified. Otherwise, its performance will be compromised and/or its service life will be shortened. Depending on the equipment in which the battery is used, excessively high current can flow through the battery, possibly damaging it and leading to acid leakage, overheating, smoke emission, bursting, and/or ignition.

2 Do not use the battery in combination with primary batteries (such as dry-cell batteries) or batteries of different capacities or brands. Otherwise, the battery can be overdischarged during use, or overcharged during recharging, abnormal chemical reactions may occur, possibly leading to acid leakage, overheating, smoke emission, bursting, and/or ignition.

3 Do not use or leave the battery near a heat source such as a fire or a heater (+80°C or higher). If the resin separator should be damaged owing to overheating, internal short-circuiting may occur to the battery, possibly leading to acid leakage, smoke emission, bursting and/or ignition.

4 Do not put the battery into a microwave oven or pressurized container. Rapid heating or disrupted sealing can lead to acid leakage, overheating, smoke emission, bursting and/or ignition.

5 Do not discard the battery into fire or heat it. Otherwise, its insulation can melt down, its gas release vent or safety features will be damaged and/or its electrolyte can ignite, possibly leading to acid leakage, overheating, smoke emission, bursting and/or ignition on it.

6 Do not immerse the battery in liquid, or allow it to get wet. Otherwise, the protective features in it can be damaged, it can be charged with extremely high current and voltage, abnormal chemical reactions may occur in it, possibly leading to acid leakage, smoke emission, bursting and/or ignition.

7 Do not pierce the battery with a nail or other sharp objects, strike it with a hammer, or step on it. Otherwise, the battery will become damaged and deformed, internal short-circuiting can occur, possibly leading to acid leakage, overheating, smoke emission, bursting and/or ignition.

8 Do not strike or throw the battery. The impact might cause leakage, overheating, smoke emission, bursting and/or ignition. Also, if the protective feature in it becomes damaged, it could become charged with an extremely high current and voltage, abnormal chemical reactions can occur, which can lead to acid leakage, overheating smoke emission, bursting and/or ignition.

9 Do not disassemble or modify the battery. The battery is equipped with built-in safety/protection features. Should these features be disabled, the battery can leak acid, overheat, emit smoke, burst and/or ignite.

10 If the battery leaks and the electrolyte gets into the eyes, do not rub them. Instead, rinse the eyes with clean running water and immediately seek medical attention. Otherwise, eye injury may result.

11 Do not use an apparently damaged or deformed battery. Otherwise, acid leakage, overheating, smoke emission, bursting and/or ignition of the battery may occur.

12 Consider consolidating these three into:Do not expose the battery to fire, flames, or excessive heat such as is generated by soldering, welding, radiators and so on. If the battery gives off a bad odor, melts, becomes discolored or deformed, leaks electrolyte fluid, appears in any way abnormal at any time, remove it from the equipment as the battery can leak acid (electrolyte fluid), emit smoke, burst,and/or ignite.

13 Do not reverse the positive (+) and negative (-) terminals. Otherwise, during recharging, the battery will be reverse-charged, abnormal chemical reactions then may occur, or excessively high current can flow during discharging, leading to acid leakage, overheating, smoke emission, bursting and/or ignition.

14 The positive (+) and negative (–) terminals are arranged in a particular orientation. Do not force the connection if you cannot easily connect the battery terminals to the battery charger or other equipment. Confirm that the terminals are correctly oriented. Reversing the terminals will result in reverse-charging, possibly leading to acid leakage, overheating, smoke emission, bursting and/or ignition.

15 Do not connect the positive (+) and negative (–) terminals with a metal object such as wire. Do not transport or store the battery together with metal objects such as necklaces, hair pins, etc. Otherwise, short-circuiting will occur, over-current will flow, causing the battery to leak acid, overheat, emit smoke, burst and/or ignite, or the metal object such as wire, necklace or hair pin can generate heat.

16 Do not connect the battery to an electrical outlet, vehicle cigarette lighter, etc. When subjected to large voltage, over-current can flow on the battery, possibly leading to acid leakage, overheating, smoke emission, bursting and/or ignition.

17 Do not recharge the battery near fire or above 45°C. Otherwise, hot temperatures can trigger its built-in protective features, inhibiting recharging, or can damage the built-in protective features, causing it to be charged with an extremely high current and voltage and, as a result, abnormal chemical reactions can occur in it, possibly leading to acid leakage, overheating, smoke emission, bursting and/or ignition.

18 To recharge the battery, use the battery charger specifically designed for the purpose and observe the recharging conditions, refer to Chapter 6.4. A recharging operation under non-conforming recharging conditions (higher temperature and larger voltage/current than specified, modified battery charger, etc.) can cause the battery to be overcharged, or charged with extremely high current, abnormal chemical reaction can occur in it, possibly leading to acid leakage, overheating, smoke emission, bursting and/or ignition.

19 If recharging operation fails to complete even when a specified recharging time has elapsed, immediately stop further recharging. Otherwise, acid leakage, overheating, smoke emission, bursting and/or ignition can occur.

CAUTION

1 If you find rust, a bad odor, overheating and/or other irregularities when using the battery for the first time, return it to HAMILTON MEDICAL AG.

2 If acid leaking from the battery comes into contact with your skin or clothing, immediately wash it away with running water. Otherwise, skin inflammation can occur.

3 The battery incorporates built-in safety devices. Do not use it in a location where static electricity (greater than the manufacturer's guarantee) may be present. Otherwise, the safety devices can be damaged, possibly leading to acid leakage, overheating, smoke emission, bursting and/or ignition.

4 Do not use or subject the battery to intense sun or above 65°C. Otherwise, acid leakage, overheating and/or smoke emission can occur. Also, its guaranteed performance will be lost and/or its service life will be shortened.

5 The guaranteed recharging temperature range is 0°C to +45°C. A recharging operation outside this temperature range can lead to acid leakage and/or overheating of the battery and may cause damage to it.

6 Store the battery in a location where children cannot reach it. Also, make sure that no child takes the battery out of the battery charger or equipment.

Fig. 32 Rechargeable Lithium Ion Battery

The battery can directly display the capacity information. The battery capacity is displayed as the relative state of charge (SOC). Each LED segment represents 25 percent of the full charge capacity. The LED pattern definition is given in the table below. The LED's illuminate for 4 seconds following switch activation. If the battery voltage is too low, there will be no LED indication.

Capacity	LED Indicators #				Note
	1	2	3	4	
At or below 10%					Blinks
10% - 25%					Lit for 4 seconds.
26% - 50%					Lit for 4 seconds.
51% - 75%					Lit for 4 seconds.
76% - 100%					Lit for 4 seconds.

Fig. 33 General Warnings and Cautions and Related Safety Data

6.2 *Rechargeable Lithium Ion Battery*

6.2.1 Overview

	The battery will not charge if the ambient temperature is above 43°C. Be aware, that ventilation stops if the internal battery are fully discharged and no external supply is available. Periodically check or replace the battery.

Note	- The use of the battery is mandatory. The battery is used as internal backup battery. - HAMILTON MEDICAL recommends that the ventilator's battery be fully charged before you ventilate a patient. Regularly monitor the battery charge level to ensure an adequate power supply. - The device generates alarms to alert you to low battery capacity. For details, see the Battery low alarm description on Operator's Manual. - The battery depletion rate may vary according to the age of the battery, ventilation mode, temperature, settings, etc.

The rechargeable lithium Ion batteries utilized in the HAMILTON-C1 are manufactured by Hy-Line.

6.2.1.1 Introduction

When the primary power source (AC Mains Power) fails, the ventilator automatically switches to backup battery operation with no interruption in ventilation. An alarm sounds to signal the switch over. You must silence the alarm to confirm notification of the power system change; this resets the alarm. The battery powers the ventilator until the primary power source is again adequate or until the battery is depleted.

As a further safeguard, the HAMILTON-C1 provides a low battery alarm. It also has a capacitor-driven backup buzzer that sounds continuously for at least 2 minutes when battery power is completely lost. The ventilator recharges the batteries whenever the ventilator is connected to AC, regardless of whether the ventilator is turned on.

Operating time:

Operating times are measured with a fully charged battery, the blower in use, without option board, and with the following settings: Mode = PCV+, Rate = 10 b/min, Pcontrol = 10 cmH2O, I:E = 1:4, PEEP = 5 cmH2O, Flow trigger = 5 l/min, FiO2 = 40%.

Approximate operating times under these conditions are as follows:

- Display brightness = 80%: 4 h
- Display brightness = 20%: 4.5 h

By default, display brightness on the device is set to 80%, an operating time of 4 h is typical.

This operating time applies to new, fully charged Li-ion batteries not exposed to extreme temperatures. The actual operating time depends on battery age and on how the battery is used and recharged. Recharge time: While ventilator is connected to primary power, it takes approximately 3.25 h to charge the battery fully. Storage: -20°C to 50°C, ≤ 95% relative humidity. Storage place should be free from vibration, dust, direct sunlight, moisture, and corrosive gases, and with a recommended temperature range < 21°C. Extended exposure to temperatures above 45°C could degrade battery performance and life.

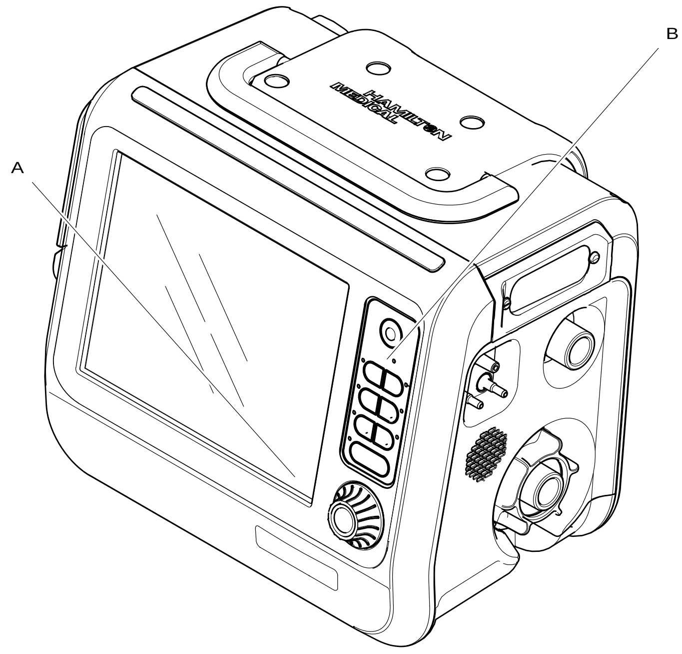


Fig. 34 Power Source Symbols and battery Charge Indicator

A **Battery charge indicator.** Lit to show the battery is fully charged, even if the ventilator is switched off. Flashes to show the battery is charging, even if the ventilator is turned off. Dark to show the battery is not being charged (over temperature) or a primary power source (AC) is missing.

B **Input power .** Shows all available power sources. The framed symbol indicates the current source (AC = main supply, 1 = battery 1). The green part of the battery symbol shows the level of battery charge, while the red shows the level of discharge.

6.3 Lithium Ion Battery Maintenance

6.3.1 Battery life expectancy:

- The lifetime of a battery is defined by its capacity loss. The capacity of a Li-Ion battery is lowered by the number of charge/discharge cycles and by aging e.g... an uncycled battery will lose capacity too. This capacity loss due to aging is about 5…10% per year for all Li-Ion batteries, depending on the temperature.

  Given normal storage usage, the user can expect the battery to deliver 75% or more of its initial capacity after 400 charge/discharge cycles or 3 years after date of manufacture.

- Hamilton Medical recommends replacing a battery when the capacity has been reduced to 80% of its designed capacity (5360mAh, PN 369108/04; 3600mAh, PN 369108/01-03).
- Cycle numbers (cy.) and full charge capacity (fc.) can be read in the technical state in the Service Software (SW ≥2.x.x).
- Batteries with a capacity loss of more than 25% will cause an error message ‘Battery replacement required’.

6.3.1.1 Storage hints:

- Always recharge the barreries before storing.

- Recharging is typically required every 6 months.
- Store below 25°C, best range within 5°C - 21°C.
- If the storage temperature exceeds 25°C then the shelf life may be reduced and provisions should be made to recharge the battery more frequently.
- Storage place should be free from vibration, dust, direct sunlight, moisture, and corrosive gases.

6.3.1.2 Maintenance hints:

- When the battery is used in a device, a calibration cycle on the Battery Charger PN 369104 is recommended once per year during preventive maintenance. Make sure you are using a charger with revision 07 or higher!
- Periodical use of the battery can extend the battery lifetime. Periodical use of the batteries can extend the battery life time and allows the battery a calibration cycle each time it is recharged. For more details see Chapter 6.8.
- When a ventilator is not in use, connect it to mains power for 1 hour every week. Make sure to disconnect it afterwards.

6.3.1.3 Warranty:

- Batteries are consumable parts. Therefore they are excluded from the standard warranty - excepting out-of-box failures!

6.3.1.4 Disposal:

- Regulations vary country by country. Dispose of the batteries in accordance with local regulations.

WARNING	When the battery reaches its end-of-life, the capacity is reduced and the battery becomes unreliable. The use of a ventilator with such batteries may cause wrong fuel gauge information leading to an unexpected ventilation stop when a power fail occurs!

6.4 Battery Charger / Calibrator

6.4.1 Battery Charger / Calibrator (PN 369104)

WARNING	Do not expose the charger or power supply to water or conductive liquids. The case is not waterproof. Do not open the charger or power supply case. There are no user serviceable parts inside. Do not cover the fan exhaust or obstruct the airflow, as this will cause overheating. Use only the manufacturer’s 24 V / 2.5 A power supply and observe terminal polarity. Place the charger in a cool spot, away from external heat sources.

CAUTION	During recalibration, the battery connector and base of the charger may become warm.

The battery charger / calibrator (PN 369104) is a standalone desktop battery charger with the added ability to recalibrate the fuel gauge on smart batteries.

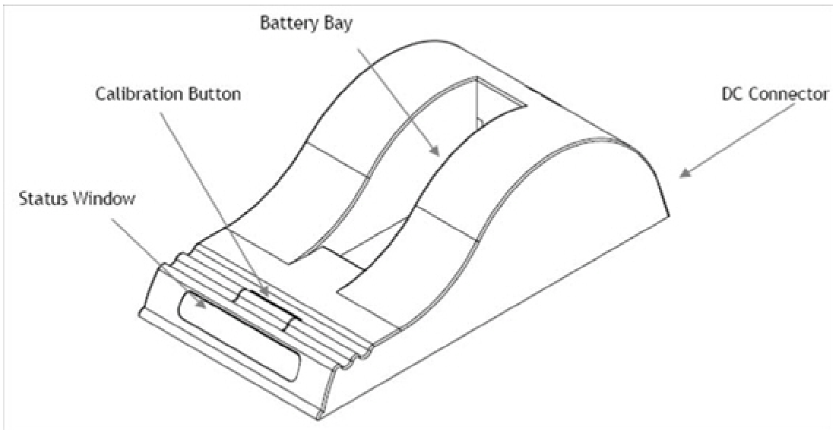


Fig. 35 Battery Charger / Calibrator

6.4.1.1 Package Contents

1 One desktop charger/calibrator (PN 369104),

2 Three plastic spacers to modify the battery recess to suit your battery size,

3 One 24V 2.5A AC:DC power supply, universal mains input,

Note	Chargers shipped with medical grade power supplies carry the suffix “M” – eg. CH5000AM.

4 Instruction manual

6.5 Battery Charger / Calibrator Installation

1 Place the charger unit on a flat, level surface away from sources of heat and moisture.
2 Plug the DC connector from the power supply into the back of the charger.
3 Connect the power supply to the AC mains supply using the supplied cable.

6.6 Battery Charging

1 Place the battery into the battery bay.
2 Make sure that the 5-way connector is fully seated.

Note	The charger will automatically begin to charge the battery. The LEDs in the status window will provide status information as detailed in the table.

Tab. 5 Charger LED Status Indicator Descriptions

LED Status	Status information
Green flashing	Charging
Green solid	Fully charged
Blue flashing	In calibration mode
Blue solid	Calibration complete
Red flashing	Fuel gauge calibration required
Red solid	Error

6.7 Battery Recharge Time

The times given below are for a full charge from 0% to 100% state of charge.

Tab. 6 Battery Charge Time

Battery chemistry	Part number / Revision	Typical recharge time
Li Ion	369108 / Rev. < 04	3 hours
Li Ion	369108 / Rev. 04	4.25 hours

6.8 Battery Calibration

6.8.1 Battery Recalibration

The battery calibration will be done automatically.

If the battery is in need of fuel gauge recalibration, the red LED will flash upon insertion of the battery into the battery charger. This indicator provides feedback to the user on the accuracy of the fuel gauge and avoids unnecessary battery calibration cycles.

The user has the option to calibrate the fuel gauge and charge the battery, or to only charge the battery. This option is given because a recalibration cycle is longer than a charge cycle.

To recalibrate the battery, press the calibrate button on the front of the charger.

Note	No action is required if only a recharge is required, as the charger will automatically begin to charge the battery.

The blue calibration LED will flash to indicate that the battery is undergoing the recalibration cycle. There may be a short delay before the calibration begins. During calibration the discharge resistors will heat up and the fan will operate to maintain temperature within acceptable limits.

At the end of this procedure the blue LED will stay constant indicating a fully charged, fully calibrated battery.

Note	The most common cause of calibration failure is overheating of the battery during discharge. Please keep the charger away from direct sunlight or heat sources.

6.8.1.1 Recalibration Time

The recalibration cycle begins by discharging any residual capacity. Then a calibration charge is delivered to the battery. This is followed by a calibration discharge. Finally the battery is given a regular charge. A calibration cycle will be faster if the battery is fully discharged to begin with. Recalibration time (Table 7) is governed by the battery voltage and capacity. Larger batteries, and lower voltage batteries will take longer to recalibrate.

Calibration is initiated each time the recalibration button is pressed, so it is not recommended to press the recalibration button part way through the recalibration cycle.

Tab. 7 Battery Recalibration Times

Battery chemistry	Battery model	Min. recalibration time	Max. recalibration time
Li Ion	369108	9 hours	15 hours

6.8.1.2 Recalibration Description

Impedance tracking fuel gauges retain accuracy longer than coulomb-counters can even self-recalibrate in use as long as there are periods of inactivity in the cycle so that the impedance measurement can be made more accurately.

If no periods of rest are present in the cycle then the Impedance tracking fuel gauge will accumulate the Max-Error at a rate of 1% every 20 cycles.

Impedance-Tracking fuel gauge recalibration is achieved by charging the battery, allowing it to rest, discharging it allowing it to rest again. This algorithm can only be performed on the external charger/calibrator CH5000 and takes about 9h to 15h.:

So recalibration is used to re-set the fuel gauge to match the actual capacity in the battery. In this way, even as the battery ages and things change, the accuracy and reliability of the fuel gauge can be retained throughout the life of the battery.

7 Preventive Maintenance and Testing

7.1 Overview

WARNING	– Device is potentially contaminated. – To prevent disease transmission, you must use personal protective equipment when handling contaminated bacterial filters, patient accessories or ventilator. Refer to the HAMILTON-C1 operator's manual for instructions on sterilizing patient system parts. – The device must be cleaned and disinfected to prevent the spread of infections and germs.
CAUTION	Make sure to observe the proper precautions for ESD (Electrostatic discharge) before handling any electronic components or before opening the HAMILTON-C1. For more information refer to Chapter 12.3. – You must complete a service training course for the HAMILTON-C1 with HAMILTON MEDICAL AG before undertaking the maintenance and testing procedures described in this manual.

1. Introduction

All preventive maintenance and testing must be performed:

- After replacing any component.
- Once a year or once every 5000 operating hours, whichever comes first.

To perform preventive maintenance, perform all the steps shown in Table 9.

2. Checking the Software Level

In general, HAMILTON MEDICAL AG recommends updating the HAMILTON-C1 to the latest Software available. See the HAMILTON MEDICAL AG partner website (http://www.hamilton-medical.com).

3. *Items Required for Preventive Maintenance and Testing*

Tab. 8 Items Required for Preventive Maintenance and Testing

Step	Items required, or possibly required
– Hospital Preventive Maintenance, refer to Chapter 7.2. – Engineer Preventive Maintenance, refer to Chapter 7.3.	– The HAMILTON-C1 Operator's Manual or local-language equivalent – HEPA Filter (PN 161236) – Filter set (each set has 5 dust air filter and 5 fan filter (PN 161275) – Blower module (MSP161170) – Lithium ion battery pack (PN 369108) – Battery charger / calibrator (PN369104) – HAMILTON-C1 O2 cell (PN 396200) – O2 Inlet filter kit (PN 160497) – Complete breathing circuit (Adult) (PN260086): – Test lung with ET-Tube (PN 151815) and adapter (PN 281420) – Filter inspiratory (PN 279204) **Note** For more details of parts refer to Chapter 13.1.
– Electrical Safety Tests, refer to Chapter 8.1 – Service Software, refer to Chapter 9.1.	– Test equipment for HAMILTON-C1; see HAMILTON MEDICAL AG website: Partner-net -> Technial support -> recommended spare part list -> Test equipment (complete) **Note** For more details of tools refer to Chapter 12.3

4. *Procedure*

Work methodically through the sections shown in Table 9.

Maintenance and testing is not complete until all steps are successfully performed.

Tab. 9 Overview of Preventive Maintenance and Testing

Step	Task	Where found	Time required
1.	Perform (or confirm it has been performed) the Hospital Preventive Maintenance.	Hospital Preventive Maintenance, refer to Chapter 7.2.	5-15 minutes
2.	Perform the Engineer Preventive Maintenance.	Engineer Preventive Maintenance, refer to Chapter 7.3.	10 minutes
3.	Perform parts replacements as necessary.	Components Removal/Assembly, refer to Chapter 11.1.	N/A
4.	Perform the Electrical Safety Tests.	Electrical Safety Tests, refer to Chapter 12.3.	10 minutes
5.	Perform the Service Software.	Service Software, refer to Chapter 9.1.	40 minutes
6.	Finish the testing by completing the tasks documented in the Tests, Calibrations and utilities section of the HAMILTON-C1 Operator's Manual.	The HAMILTON-C1 Operator's Manual or local-language equivalent.	10 minutes

If a part needs to be replaced go back to "Step 3" in Table 9.

7.2 Hospital Preventive Maintenance

Table 10 shows the maintenance tasks that hospital staff must perform. It is copied from the English version of the HAMILTON-C1 Operator's Manual.

Examine each HAMILTON-C1 for which you are responsible, and satisfy yourself that hospital staff are regularly performing these tasks. If necessary:

- Perform the tasks yourself.
- Train staff how to perform these tasks.

Tab. 10 Hospital Preventive Maintenance Schedule

Interval	Part/Accessory	Procedure
Between patients and according to hospital policy.	Breathing circuit (including mask, inspiratory filter, flow sensor, nebulizer jar, expiratory valve and membrane).	Replace with sterilized or new single use parts. Run the Tightness Test and the flow sensor calibration as shown in the HAMILTON-C1 Operator's Manual.
	Entire ventilator.	Run the pre-operational check as shown in the HAMILTON-C1 Operator's Manual.
Every 2 days or according to hospital policy	Breathing circuit.	Empty any water from breathing tubes or water traps. Inspect parts for damage. Replace as necessary.
Every month (or more often, if required).	Air intake dust filter and fan filter set (5 pieces) (rear panel).	Check for dust and lint. If needed, clean or replace as shown in the HAMILTON-C1 Operator's Manual.
Every 6 months (while the ventilator is in storage)	Battery	Recharge battery by plugging the ventilator into AC power for at least 4 hours.

7.3 *Engineer Preventive Maintenance*

WARNING	This section is not a stand-alone, independent part of the manual. Perform the tasks detailed here only as a part of, and as instructed, refer to Chapter 7.1 and Chapter 7.2.

Perform the Engineer Preventive Maintenance, according to the table below:

Interval	**Part/accessory**	**Procedure**
Yearly or every 5000 hours, whichever comes first, or as necessary	Ventilator	Carry out a visual inspection of the device: - All marks, symbols, and labels related to safety are complete and legible - The device is not damaged or dirty (nor are the cables)
	HEPA Filter	Replace as shown in the HAMILTON-C1 Operator's Manual.
	HPO inlet filter	Replace. See Chapter 11.33
	Calibrations and tests	Perform all calibrations and tests in the service software. Refer to Chapter 9.11
	General tests and checks	Perform all general tests and checks. Refer to Chapter 9.16
	Pre-Operational Checks:	Perform the Pre-Operational Checks as shown in the HAMILTON-C1 Operator's Manual, Section 3
	Oxygen Cell	Replace if depleted as shown in the HAMILTON-C1 Operator's Manual. O2 cell life specifications are approximate. The actual cell life depends on the operating environment. Operation at higher temperatures, higher Oxygen concentrations shorten cell life.
Replace battery when (whichever comes first): – PN 369108 Rev. 00-03 when capacity < 3600mAh – PN 369108 Rev. 04 when capacity < 5360mAh – Battery age > 3Y – Cycles > 400	Lithium ion battery	Replace the lithium ion battery. Also refer to Chapter 11.6
Typically after 8 years	Blower module	Replace the blower when blower timer has reached 100%. Refer to Chapter 16.3.4

8 Electrical Safety

8.1 Electrical Safety Overview

Electrical safety test's detailed in this section must be performed as part of, or as instructed by preventive maintenance and testing overview, refer to Chapter 7.1.

In addition, to comply with IEC 62353 the electrical safety test's must be performed after:

- the power supply board is replaced.
- the control board is replaced.
- the driver board is replaced.
- removing any ground contact from the ventilator.
- when performing preventive maintenance.
- any repair.
- installation.

8.1.1 Overview

HAMILTON MEDICAL AG performs a set of electrical safety test's, as specified in IEC 60601-1, on all the ventilator and compressor units that it manufactures. HAMILTON MEDICAL AG performs these test's automatically, using the RIGEL 288 or a device like Metron QA90.

As stated in the warning above, it is a legal necessity that, after performing the preventive maintencance, after a repair or after an adjustment described above, this test is performed.

8.2 Electrical Safety Tests - IEC 62353

8.2.1 Perform the Test

The electrical safety test's you must perform are explained in this section. If you have an automated safety testing device, such as the Metron Safety Analyzer or the RIGEL 288, used by HAMILTON MEDICAL, perform the automated test's in addition to the test's described in this section.

8.2.2 Device Type

Per the IEC 62353 standard for medical devices, the HAMILTON-C1 is a Class II, Type B device, or Type BF if the option board (PN161520/ PN 161636) for capnography and/or pulse oximetrie is installed.

8.2.3 Electrical Safety Tests - IEC 62353

The electrical safety test must be executed with suitable equipment, such as the RIGEL 288.

Because details of these automated electrical safety test's depend on the test equipment used, it is important to follow the test device instructions.

8.2.4 Specifications

Tab. 11 IEC 62353 Specifications for Class II Type B and BF Devices

Current in mA (RMS - Root Mean Square)	Type B	Type BF
Setup	Chapter 8.3	Chapter 8.4
Equipment leakage (direct method)	0.1 mA	0.1 mA
Patient leakage current (direct method) AC	-	5mA

All measured values must be documented using the measurement process and are considered reference values.

Should the measured values measured during the next maintenance cycle be within 90 to 100% of the permissible values, the reference values are to be used to evaluate the ventilators electrical safety.

8.3 Setup for Type B Device (option board CO2 / SPO2 not installed)

1 Connect the RIGEL 288 to the AC power supply.
2 Connect the RIGEL 288 and the HAMILTON-C1 to each other as shown below.
3 Turn on the HAMILTON-C1 (Standby mode) for the electrical safety test's.

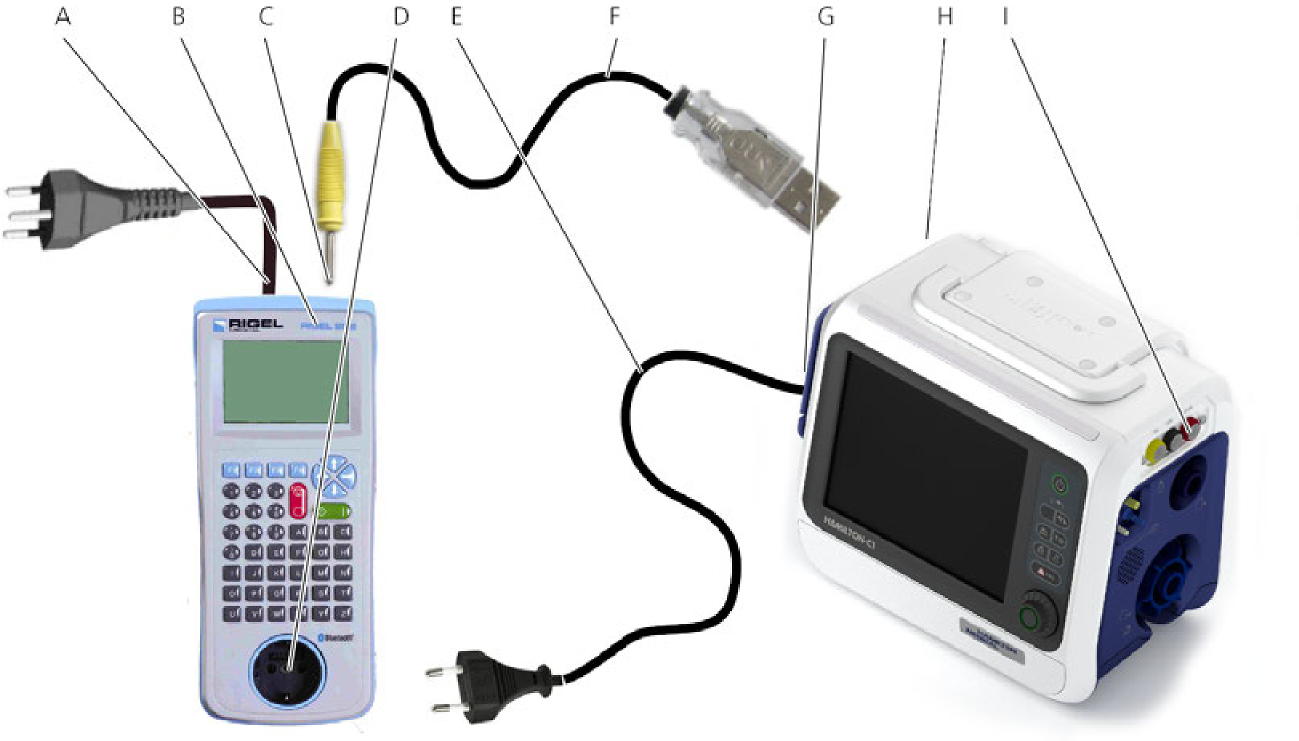


Fig. 36 Setup for Type BF Device (with installed option board for capnography)

Legend:

A)	AC power cable inlet (RIGEL 288)
B)	RIGEL 288 (handheld medical electrical safety tester)
C)	4 mm Earth bond probe socket (RIGEL 288)
D)	EUT socket (RIGEL 288)
E)	AC Power cord (HAMILTON-C1)
F)	Electrical safety test cable (PN 161618)
G)	AC Power plug (not visible)
H)	USB port (HAMILTON-C1)
I)	Option board slot (HAMILTON-C1)

8.4 Setup for Type BF Device (option board CO2 / SPO2 installed)

1 Connect the RIGEL 288 to the AC power supply.
2 Connect the RIGEL 288 and the HAMILTON-C1 to each other as shown below.
3 Turn on the HAMILTON-C1 (Standby mode) for the electrical safety test's.

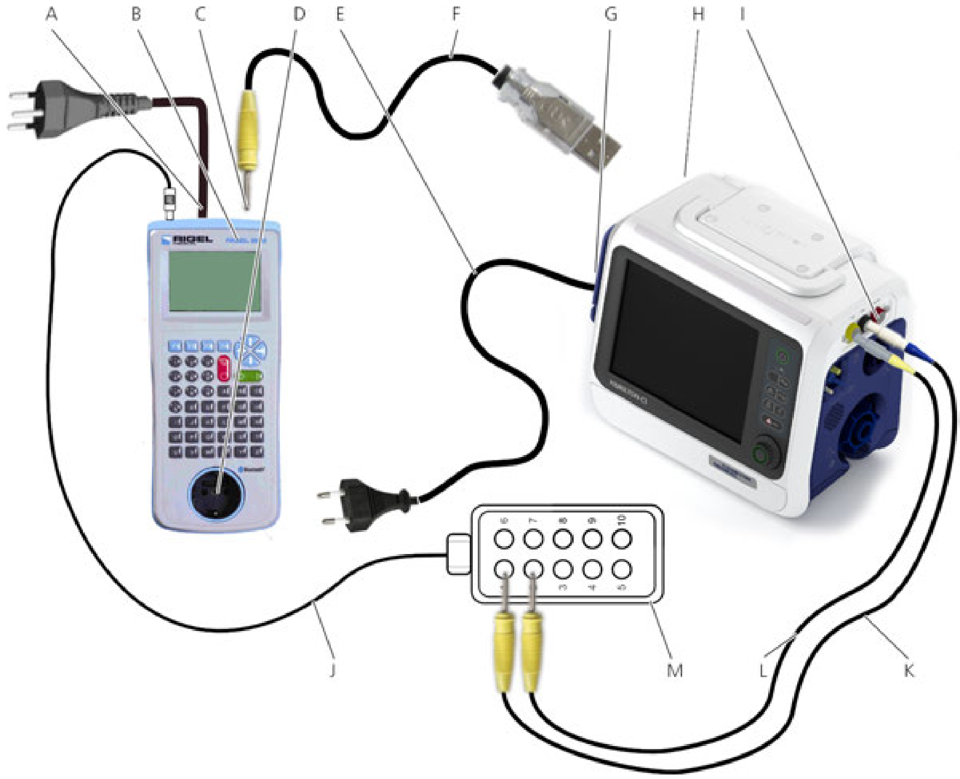


Fig. 37 Setup for Type BF Device (with installed option board for capnography)

Legend:

A)	AC power cable inlet (RIGEL 288)
B)	RIGEL 288 (handheld medical electrical safety tester)
C)	4 mm Earth bond probe socket (RIGEL 288)
D)	EUT socket (RIGEL 288)
E)	AC Power cord (HAMILTON-C1)
F)	Electrical safety test cable (PN 161618)
G)	AC power plug (HAMILTON-C1)
H)	USB port (HAMILTON-C1)
I	Communication board C1:
	-CO2, RS232, Nurse Call (PN 161520)
	-CO2, SPO2, RS232 (PN 161636)
J	Connector for AP-Box 331A700 (RIGEL 288)
K	Electrical safety test cable SPO2 option (PN 159681)
L	Electrical safety test cable CO2 option (PN 159171)
M	AP-Box 331A700 (RIGEL 288)

9 Service Software

9.1 Introduction

WARNING	– Read Section Preventive Maintenance and Testing Overview (Chapter 7.1), before performing any of the test's in this section. – If one of the test's indicates that you must replace a part, do so immediately and update the service entry (see Chapter 9.7.4Service Entry) and then repeat the complete series of test's. See contents in this section.

CAUTION	To prevent patient or ventilator contamination, always use a bacterial filter between the HAMILTON-C1 and the inspiratory limb of the patient breathing circuit. – For troubleshooting see knowledge base. – Record all results on the HAMILTON-C1 Test report Chapter 17.1. – Confirm that the technical state is updated and the device has been restarted after technical state modifications)see Chapter 9.7.4- Service Entry). Always use an adult breathing circuit, if a circuit is required during the test's.

Note	The HAMILTON-C1 needs a warm-up period. Make sure it was running for at least 20 minutes in the ventilation software.

This section describes each of the units comprising the HAMILTON-C1 Service Software.

Before starting, ensure that you are familiar with typographic conventions (Chapter 2.2) and expressions (Chapter 2.3).

The HAMILTON-C1 Test Report Form is the standard form to be used and must be completed each time the Service Software is performed. If there is not a suitable form, you can photocopy and use the form named HAMILTON-C1 Test Report Form (Chapter 17.1) at the back of this manual.

9.2 Functions of the Service Software

Units in the Service Software perform the following functions:

- Enables display information (concerning revisions and versions of the ventilator hardware and software)
- Enables checks on the ventilator hardware and software
- Enables calibration of the ventilator hardware
- Enables viewing and exporting of the Event Log and Service Log
- Enables software upgrades

9.3 Structure of the Service Software

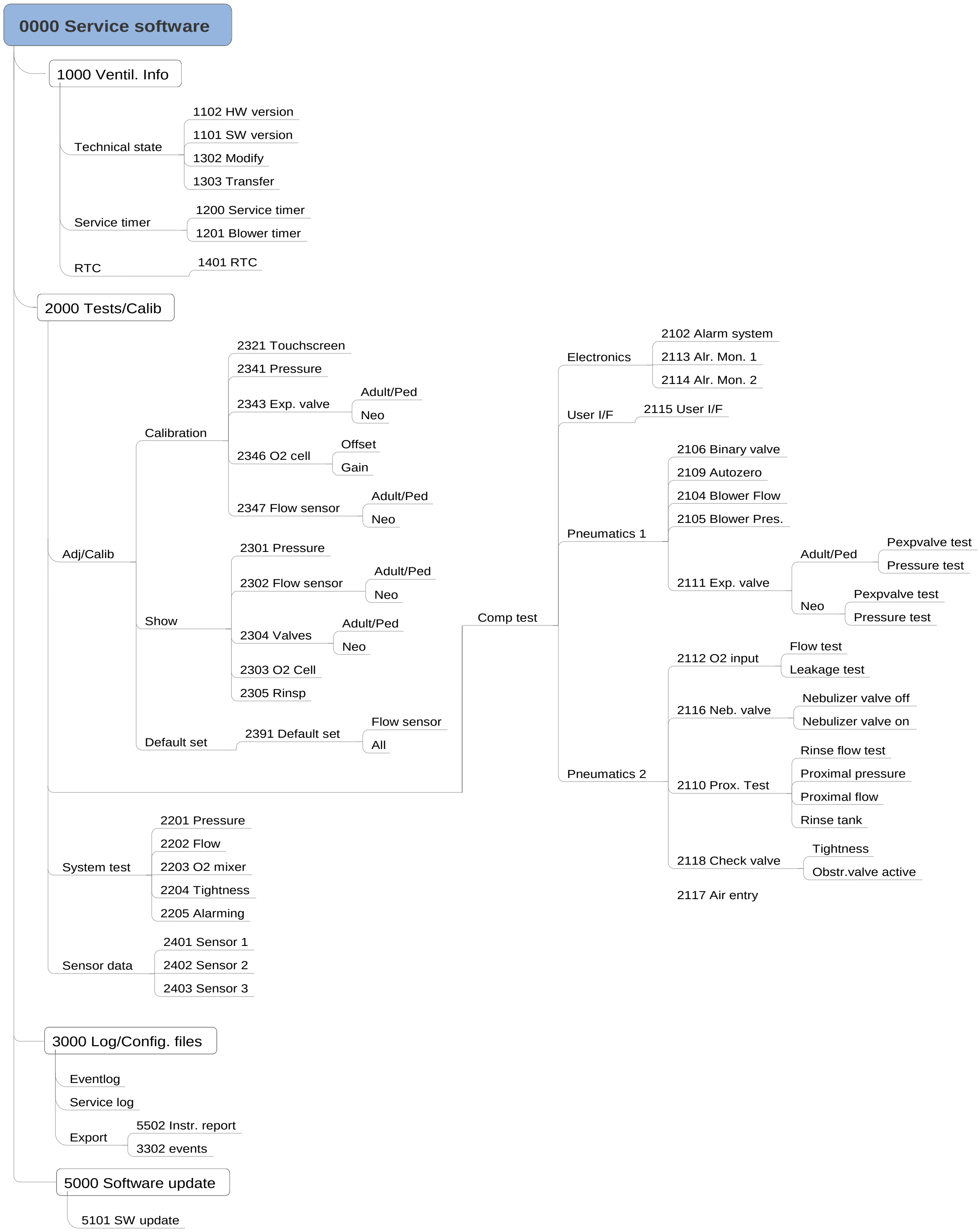


Fig. 38 Service software structure

9.4 Service Software Screen Layout

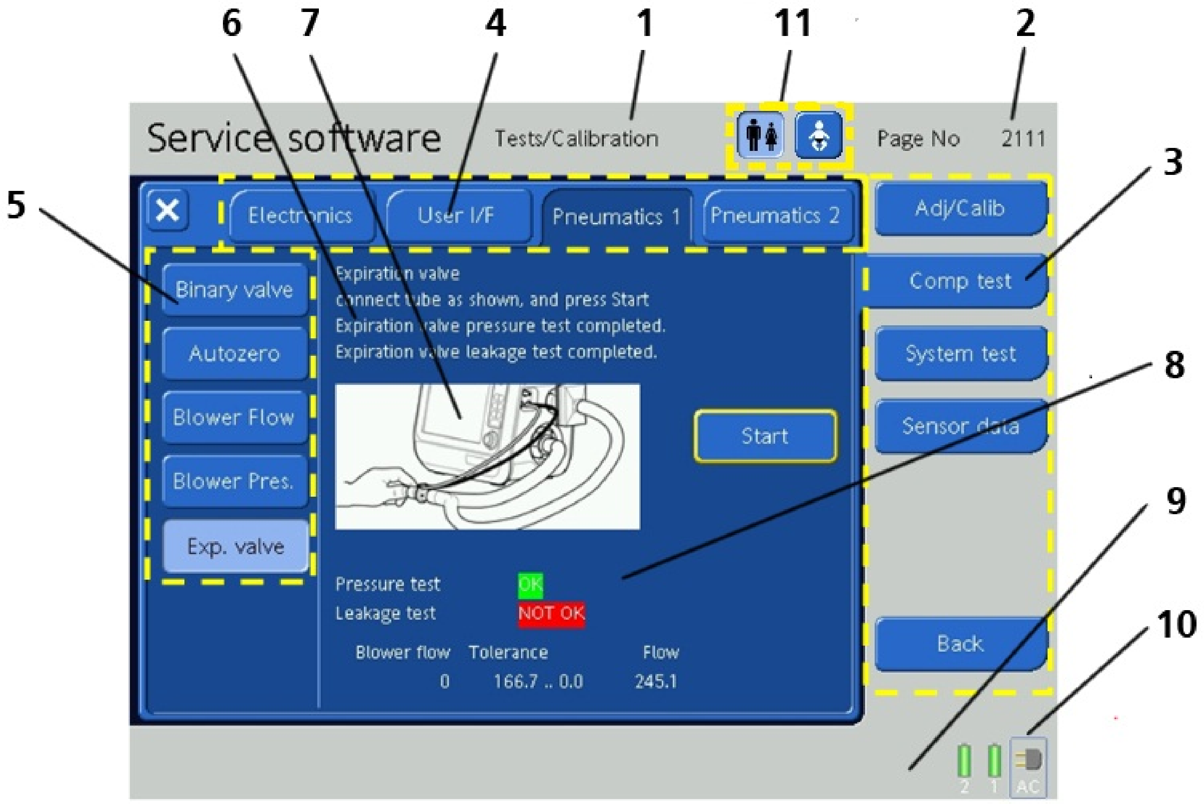
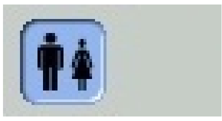
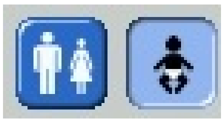
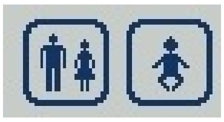


Fig. 39 Service Software Screen Layout

1	Header window
2	Page number
3	Menu tab layer 1
4	Optional menu tab layer 2
5	Optional menu tab layer 3
6	Test window dialog
7	Test window pictogram for test configuration
8	Test status and results indication
9	Alarm window
10	Power source symbols and battery charge indicator
11	Button to select between the Adult/ped. and neonatal relevant test's and calibrations (if the corresponding option is activated).

Icon / Button	Status	Description
	Adult/Ped. option installed only. Adult/Ped. mode is selected for calibration and test's.	– For HAMILTON-C1 units < SN6000

	Adult/Ped. mode selected for calibration and test's.	– For HAMILTON-C1 units ≥ SN6000
	Neonatal mode selected for calibration and test's.	
	A calibration / test is in progress	

9.5 Starting the Service Software

1 Connect the ventilator to mains power.

2 Press the **ON** (A) button located on the ventilator front panel and then press and hold the **100% O2** (B) and **Manual Breath** (C) buttons at the same time until the two corresponding green LEDs (D) light up.

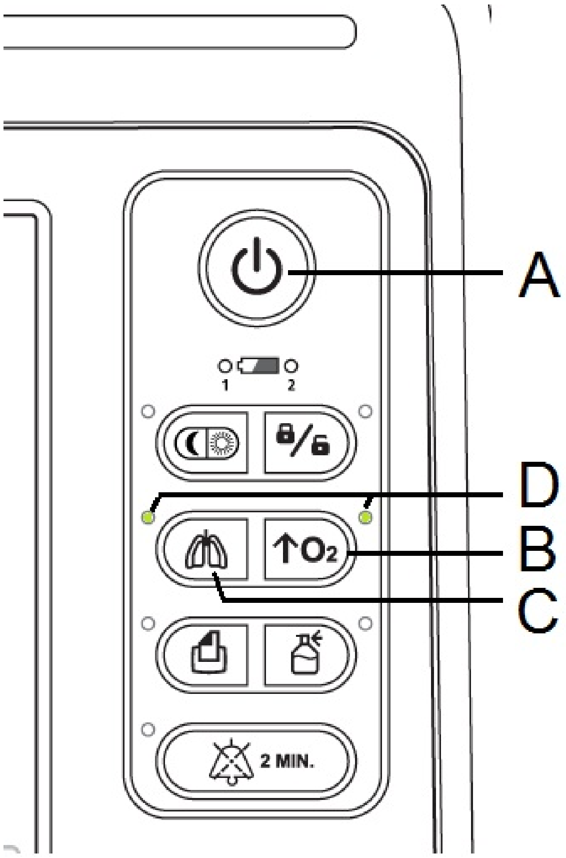


Fig. 40 Starting the Service Software

The bar indicates the progress of the start-up self-test procedure. The starting of the service software is shown in the main screen.

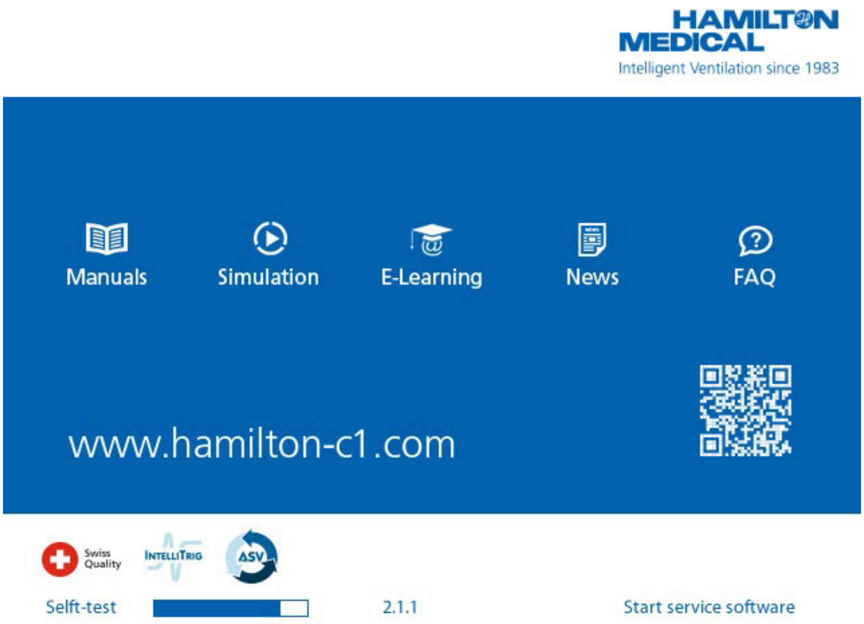


Fig. 41 Starting the Service Software

The start-up of the ventilator consists mainly of:

- System self check (RAM, ROM test, checksum) boot procedure
- Starting the operating system
- Starting and verifying technical state (Device Part Number, HW Components)
- Starting all SW processes
- Initializing the digital periphery:
  - Compatibility check of the FPGA on the ESM
  - EEPROMs checksum test
  - I/O PORTs
  - Serial interfaces
  - Network interface

- Switching on the power voltages (for the valves and the blower)
- Initializing the power periphery (enabling valves and blower)
- Instrument self-test:
  - Checking the SW version, and if a newer version was installed -> performing migration
  - Detecting the device's configuration, modules and options
  - Checking the HW versions
  - Checking the RTC (if it has been reseted due to power loss)
  - Loading the calibration values from the EEPROMs
  - Testing the sensors (values within range calibration values)
  - Testing the valves (on / off)
  - Testing the blower (short run)
  - Testing the lamps (on / off)
  - Testing the speaker (on / off feed back)

- Testing the buzzer (on / off feed back)

– Entering the ventilation start window or the service software

After the service software starts and the self-test has been finished, the main service software screen is displayed.

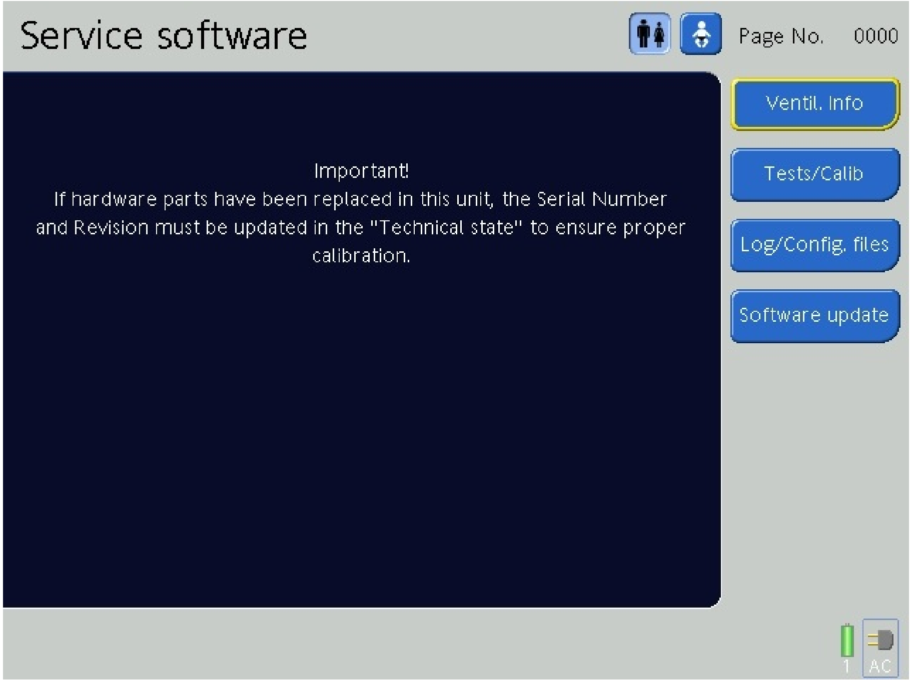


Fig. 42 The HAMILTON-C1 Main Service Software Screen

9.6 Print Screen

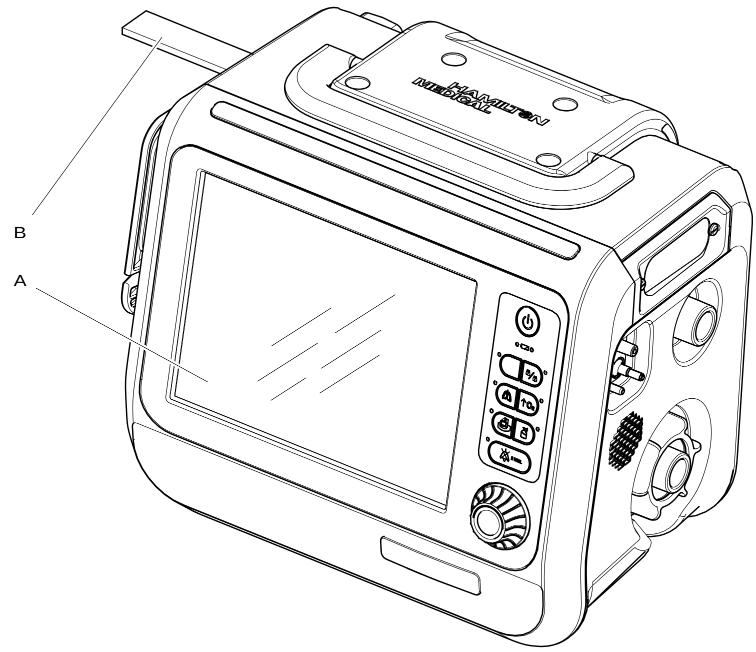


Fig. 43 Print Screen

The print screen function saves a JPG file of the current ventilator screen to a USB memory key (B). To create a screenshot, insert the USB memory stick and press the print screen key (A) until the corresponding LED lights up.

The USB memory stick can be removed when the print screen key LED is no longer lit.

The filename takes this format:

screenshot_yyyymmdd_HHMMss.jpg

where:

yyyy is the year

mm is the month

dd is the day

HH is the hour (in 24-hour format)

MM is the minute

ss is the second

Note	Specification for the USB memory stick: Filesystem: FAT or FAT32 Unpartitioned memory No operating system or security software installed

9.7 Ventilator Info

9.7.1 Ventilator Info Screens (Page No 1000)

From the main service software screen, press the **Ventil. Info** button.

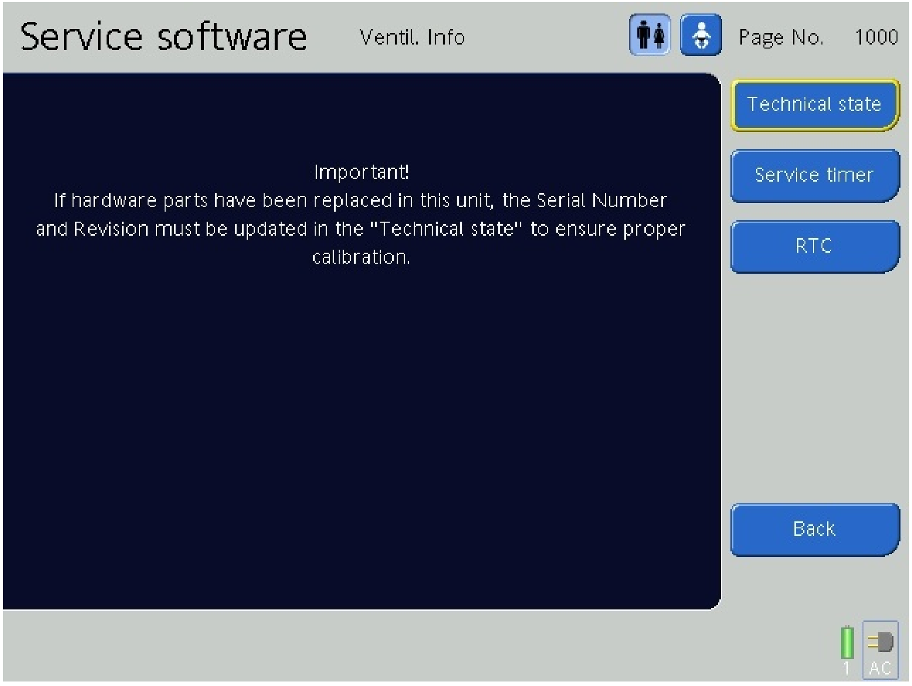


Fig. 44 The Ventilator Info Screen

On the ventilator info screen are the:

– *Technical state* button
– *Service timer* button
– *Real time clock (RTC)* button
– *Back* button (go back to the main menu)

9.7.2 Technical Hardware State (Page No 1102)

1 Touch the **Technical state** button to enter the technical state section.

2 Touch the **HW version** tab (if not already selected). The **HW version** tab displays the device name, part number, revision, serial number and timing information.

3 The information of the following components will be updated automatically from the HAMILTON-C1 during start-up:

- Battery 1
- Battery 2 (HAMILTON-T1 only)
- Control board
- Processor board
- Driver board
- Pressure sensor board
- Front panel board
- Flow sensor AIR (Qvent)
- Flow sensor O2 (QO2)
- O2 cell
- Option board

Record the hardware version information on the **HAMILTON-C1 Test Report**

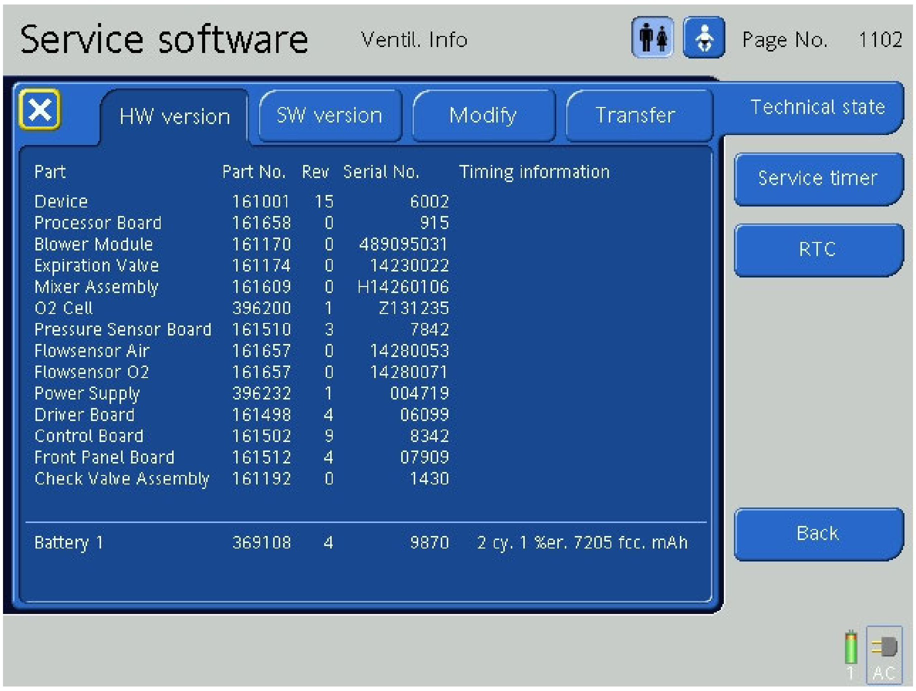


Fig. 45 Hardware version (Page No 1102)

1 In case the technical state is corrupt, or after upgrading from SW version 1.x to 2.x, the **Clean-up** button will appear.

2 Touch the **Clean-up** button to restore the structure of the technical state.

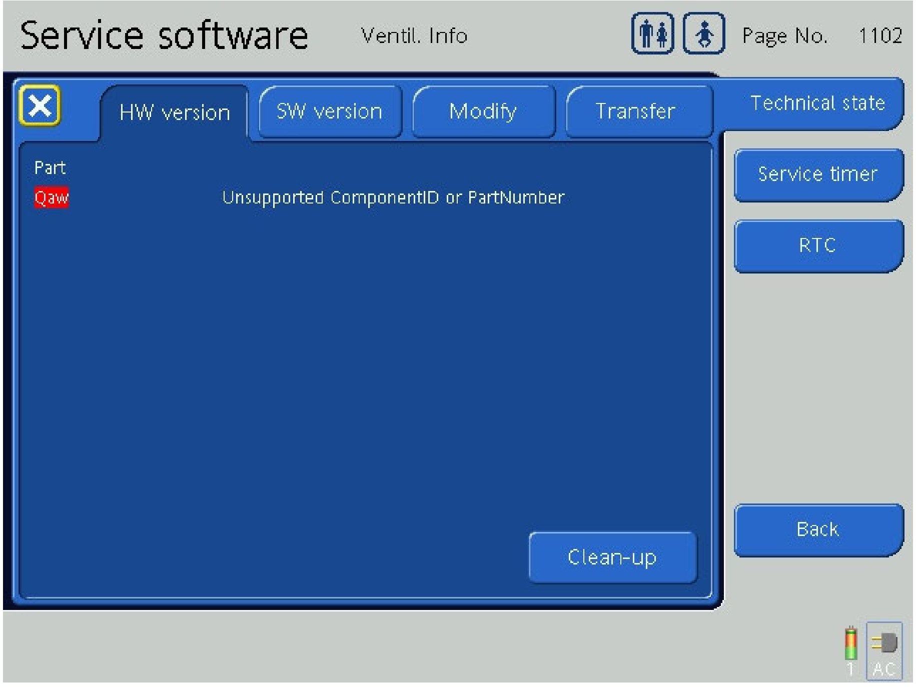


Fig. 46 Clean-up button (Page No 1102)

1 In case the technical state cannot be read out from the EEprom of a component, the unit will fail in self-test and alarm with “Technical state failed”. Other Technical faults will appear as after effect.

2 The HW version will display the part* which causes problem , highlighted in red. The **Clean-up** button also appears but has no function therefore. Check the cable connection and replace the defective component if necessary.

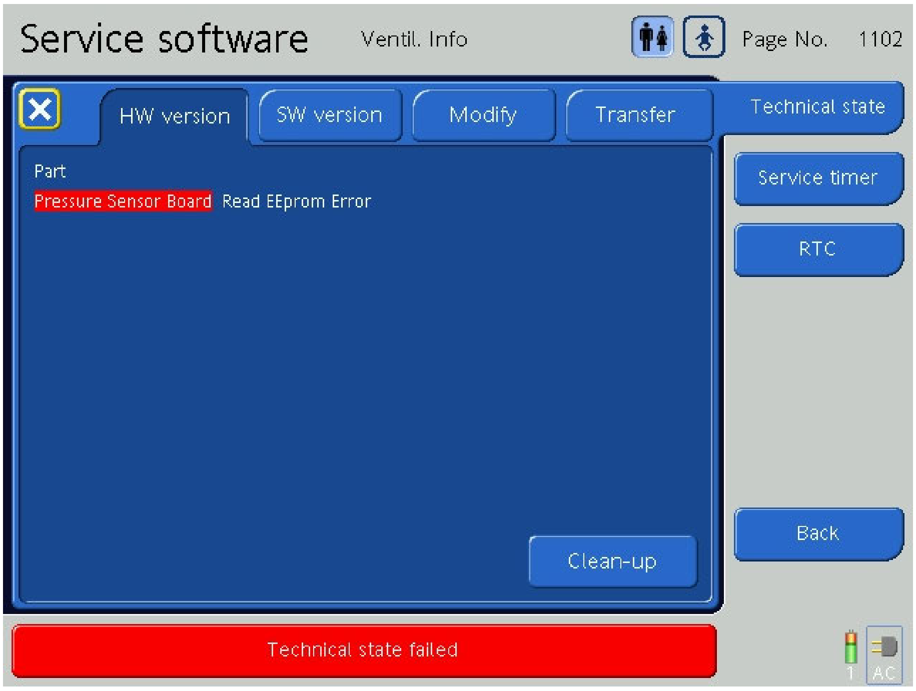


Fig. 47 EEprom read error (Page No 1102)

Note	* except the Flow sensor AIR and O2 as well as the O2 cell. If one of these three components cannot be read, the part will not be listed in the HW version tab. After Clean-up make sure all part no are selected correctly and the revision number as well the serial number has been entered.

9.7.3 Technical Software State (Page No 1102)

1 Touch the **Technical state** button to enter the technical state section.

2 Touch the **SW version** tab. The software version tab displays the device names and revisions of the operating software.

3 Record the software version information on the **1 Test Report**.

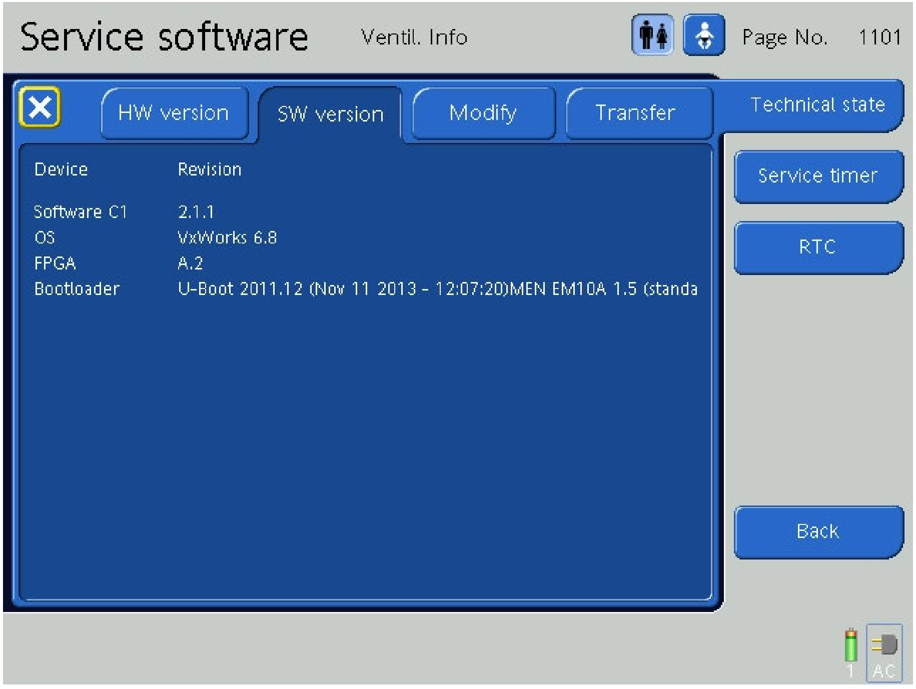
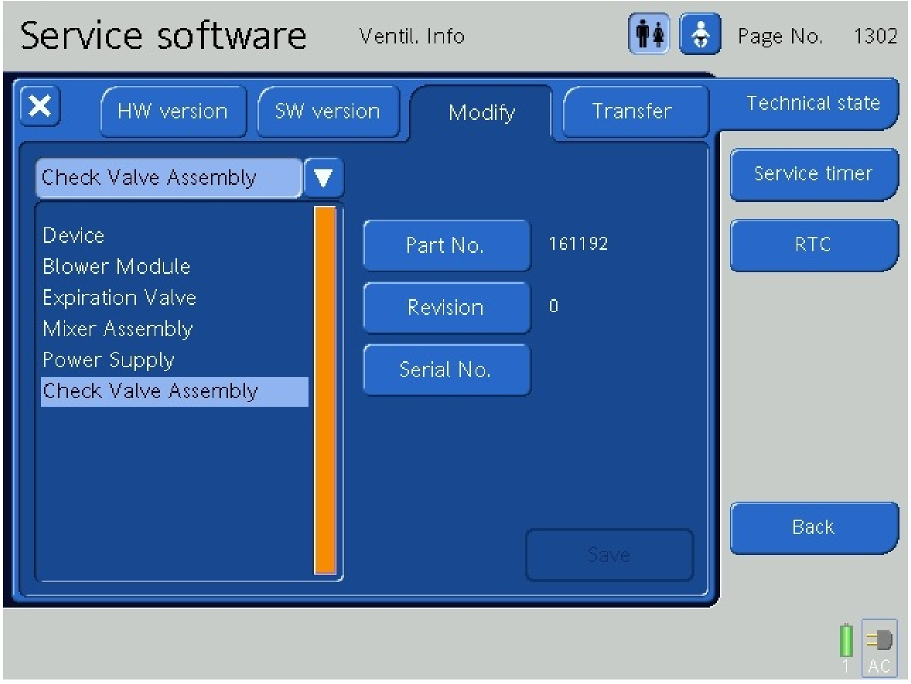


Fig. 48 Technical Software State (Page No 1102)

9.7.4 Modify (Page No 1302)

Note	Always update the technical state when an assembly as listed below has been replaced. Restart the device prior to perform the service software tests and calibrations.

1 The modify tab allows updating information when a part has been replaced. Touch the **Modify** button.



Select the hardware component you want to modify.

2 To change the serial - or, revision number touch the corresponding button and enter the number(s). Proceed with **Confirm**. When finished press the **Save** button.

3 To change the part number touch the Part No. button and select the correct number.

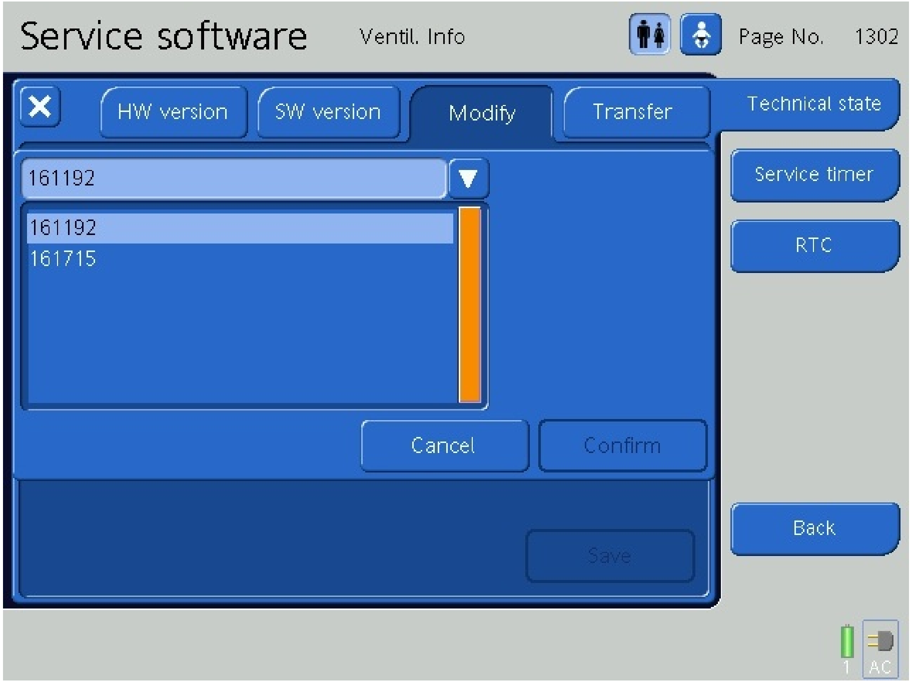


Fig. 49 The Service Entry Modify Tab Screen, Step 2

Component	Selectable Part No	Description
Blower Module	161170	HAMILTON-C1 units since SN1000
Expiration valve	161174	HAMILTON-C1 unit since SN1000
Mixer Assembly	161171	HAMILTON-C1 units < SN6000 (contains the TSI flow sensor O2)
	161178	
	161179	
	161609	HAMILTON-C1 units ≥ SN6000 (contains Sensirion flow sensor O2)Note: The PN 161609 is selectable only if Sensirion flow sensors (AIR+O2) are installed.
Power Supply	396232	HAMILTON-C1 units since SN1000
Check Valve Assembly	161243	HAMILTON-C1 units < SN6000. Note: The PN 161243 is selectable only if TSI flow sensor AIR is installed.
	161715	For internal purposes only. Do not use!
	161192	HAMILTON-C1 units ≥ SN6000 (with Obstr. valve) Note: The PN 161192 is selectable only if Sensirion flow sensor AIR is installed.
		With SW version 2.1.1 the Check valve assembly was added to the technical state. Make sure to select the correct part number of the check valve assembly.
		For HAMILTON-C1 units <SN6000: After upgrading from SW version 1.x to 2.x, the check valve assembly will be added to the technical state. The default PN will be set to PN 161243. The serial has no entry.
		For HAMILTON-C1 units ≥SN6000: Make sure to set Part No=161192 after an eventual control board replacement since the default value is PN 161243.

Note	Please make sure to select the correct part number . Cross check with the label of the spare part/ installation guide of MSP spare part.

9.7.5 Data Transfer (Page No 1303)

The technical state can be exported and imported to/from the USB memory stick. Ensure the USB memory stick is connected to the ventilator then touch the correspondingbutton.

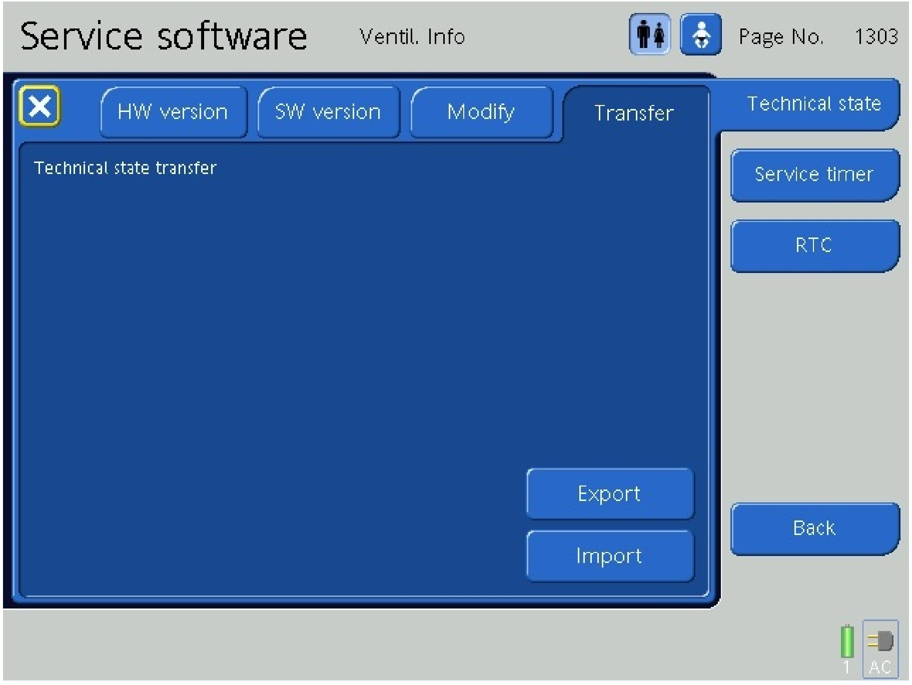


Fig. 50 Data transfer

Note	The format of the file is .csv (comma separated values) and can be edited with a text editor (e.g. Notepad, Wordpad). Do **not** use Excel for modifying the .csv file.

9.7.6 Service Timer (Page No 1200)

1. Touch the **Service timer** button to enter the Service timer section

On the **Service timer** tab, the total operating hours are displayed and the service timer hours are displayed since the last time the service timer was previously reset. The **Alarm limit** button allows to set the number of hours between service intervals to be changed.

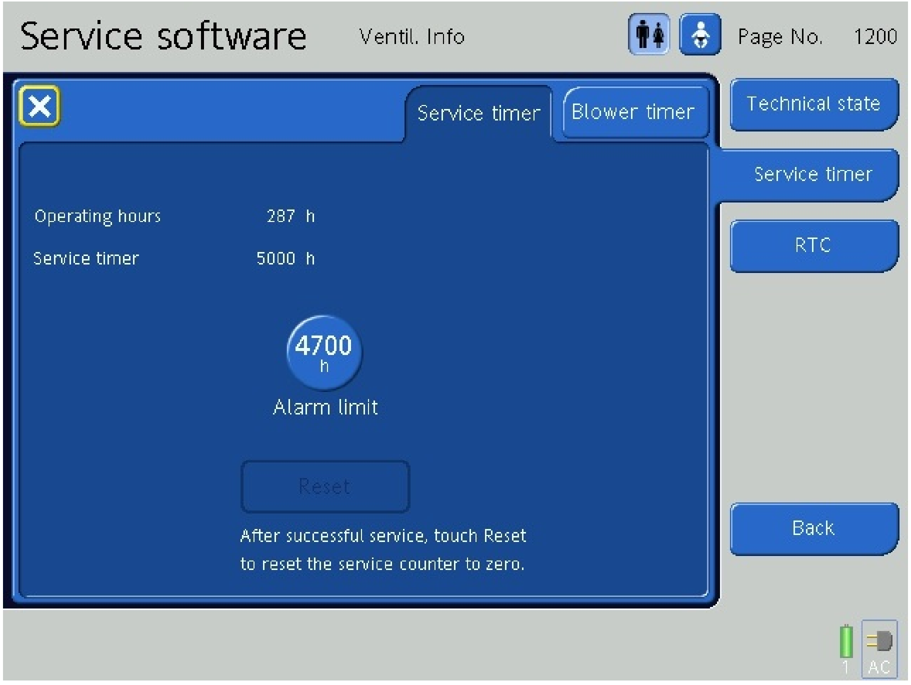


Fig. 51 The Service Timer Tab

2. After successful service, the service timer can be reset. To reset the counter do:

2.1. Touch the **Alarm limit** button and change the alarm limit by rotating the P+T knob.

2.2. Confirm by touching the **Alarm limit** button or by pressing the P+T knob.

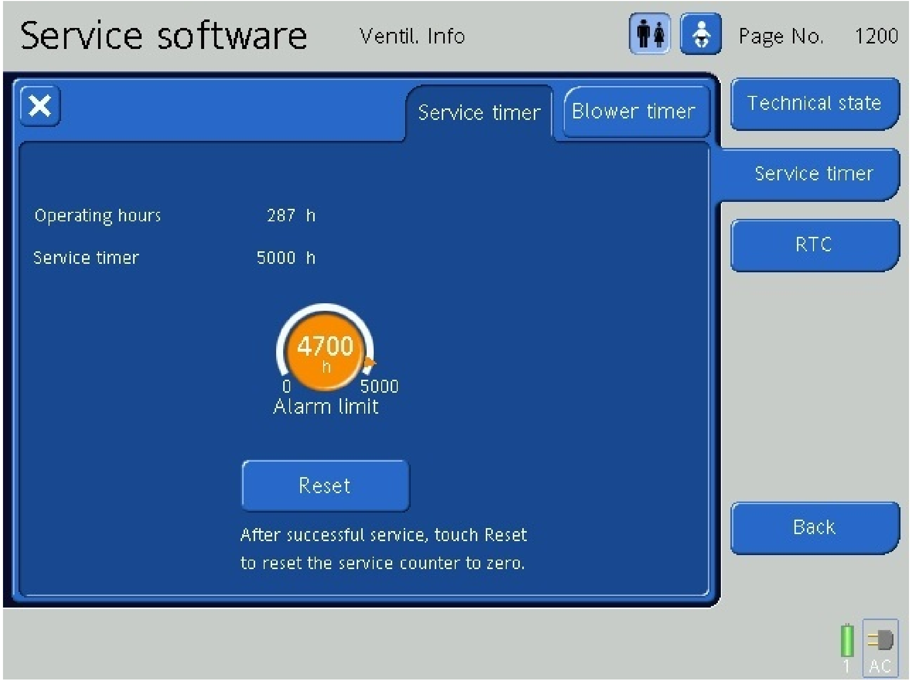


Fig. 52 Service Timer

2.3. Reset the service counter by touching the **Reset** button.

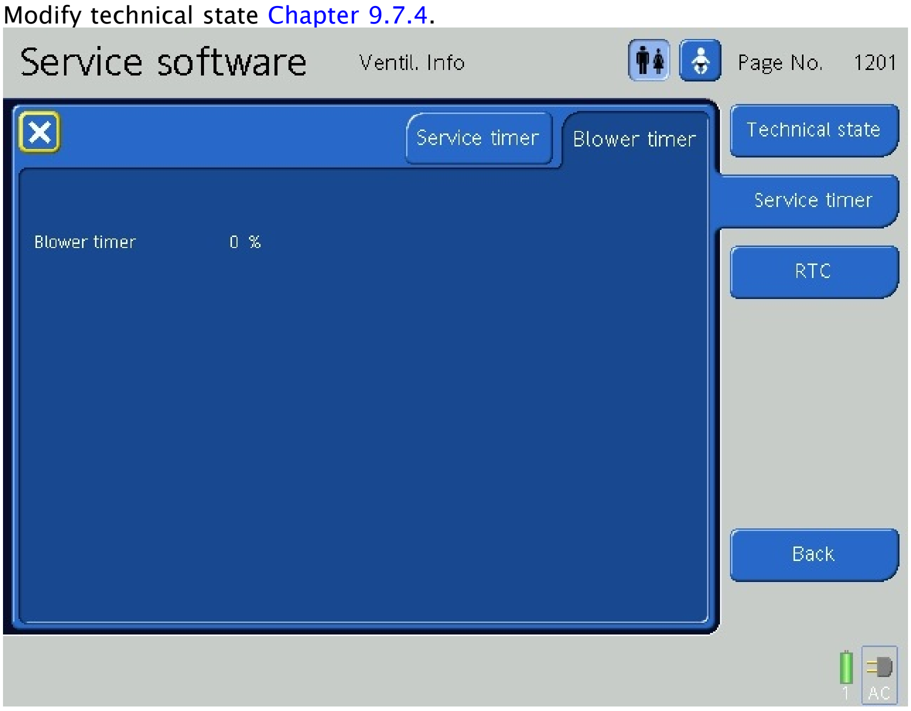
3. Record the operating hours and the service timer hours on the **HAMILTON Test Report**.

9.7.7 Blower Timer (Page No 1201)

1 Touch the **Blower timer** tab. On the **Blower timer** tab, the total blower operation time is displayed in percentage. The expected operation time (100%) is calculated based on the operating hours, temperature and rotation speed of the blower.

When 100% is reached the alarm “Blower service required” appears and the blower needs to be replaced. After replacement enter the serial number and revision number of the blower in the technical state and the blower timer will be reset.

Modify technical state Chapter 9.7.4.



2 Record the blower timer percentage on the **HAMILTON Test Report**.

9.7.8 Real Time Clock (RTC) (Page No 1401)

1. Check the current date and time and adjust if necessary:
   1 Select the value that needs to be adjusted by touching the corresponding button on the screen or by using the P+T knob until the desired button is highlighted.
   2 Change the number displayed by rotating the P+T knob.
   3 Confirm by touching the corresponding button on the screen again or pressing the P+T knob.
   4 Touch the **Set** button to set the values.
   5 Check the RTC status for “Battery OK” .

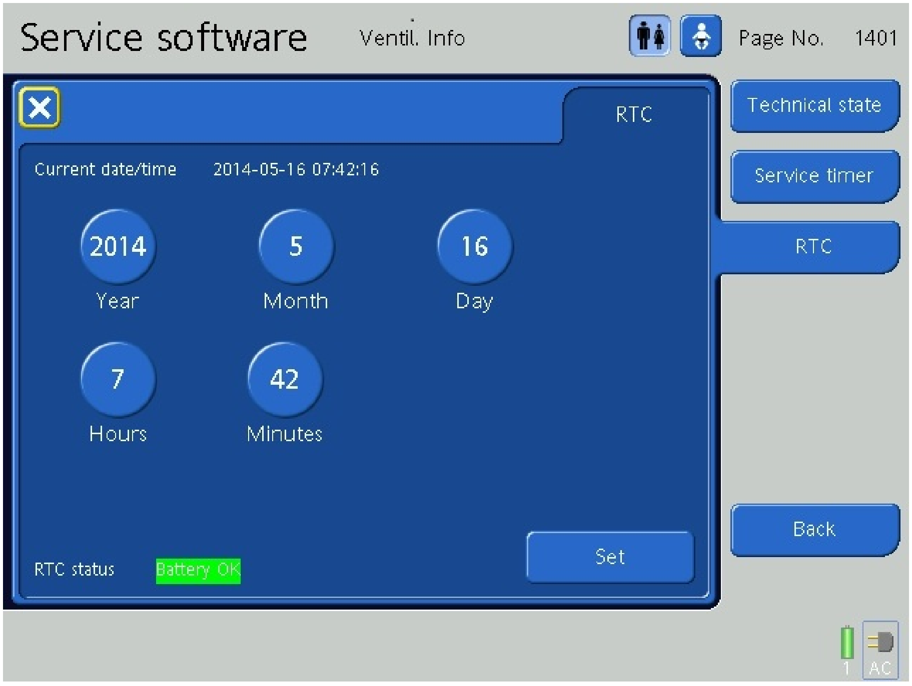


Fig. 53 Current Date and Time Reset, Step 1

9.8 Adjustment / Calibration (ADULT/PED.)

9.8.1 Overview Adjustment/Calibration

Adjustment/ Calibration	**Description**	**Component adjusted/calibrated**
Adj/Calib > Calibration> **Touchscreen** **(Page No 2321)** Chapter 9.8.2	Allows calibrating the coordinates of the touch controller. (4-Point calibration)	– Touchscreen
Adj/Calib > Calibration> **Pressure** **(Page No 2341)** Chapter 9.8.5	Allows to adjust the pressure sensor gain using an external pressure measurement as reference.	Pressure sensor: – Pvent_control – Pvent_monitor and Paw
Adj/Calib > Calibration> **Exp. valve** **(Page No 2343)** Chapter 9.8.9	The expiratory valve contains a voltage controlled linear valve (Expiratory proportional valve). The opening point of the valve depends on the contained spring. The goal of the expiratory valve calibration is to find the opening voltage of the valve, which we call Offset Voltage. Test sequence: A constant pressure is exerted on the inspiration outlet. The voltage on the expiratory valve is adjusted until the flow through the expiratory valve is in the required range. The calibration is done with 2 different pressures. The calibration reaches an end as soon as both, the high and the low offset are within a defined tolerance. At the end the average value of Voltage Offset high and low is stored and used by the software.	– Expiratory valve Adult / Ped. – Expiratory valve Neonantal
Adj/Calib > Calibration> **O2 cell** **(Page No 2346)** Chapter 9.8.7	The O2 cell calibration is separated into two parts:- **Offset** calibration calibrates the offset voltage of the amplifier circuit. - **Gain** calibration. During this 2-min calibration of the Oxygen cell, the ventilator delivers an increased oxygen concentration (if oxygen is connected in the high pressure mode) or 21% oxygen (if oxygen is connected in the low pressure mode or disconnected). It test's the cell and resets the calibration points specific to the cell in use.	– O2 cell
Adj/Calib> Calibration> **flow sensor** **(Page No 2347)** Chapter 9.8.8	This calibration checks and resets the calibration point specific to the flow sensor in use. The flow sensor is calibrated in both directions.	– External flow sensor Qaw (Adult/Ped) – External flow sensor Qaw (Neonatal)

9.8.2 Test / Calibration screens (Page No 2000)

From the Main Service Software Screen, touch the **Tests/Calib** button.

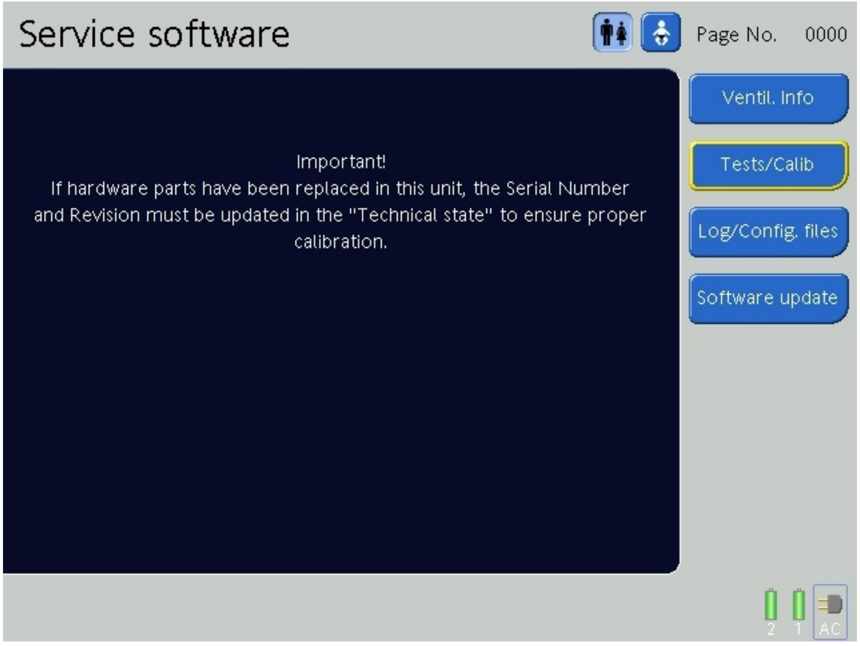


Fig. 54 The Main Service Software Screen

The Test/ Calibration screen gives access to the following submenu:

- *Adjustment / Calibration* button (Adj/Calib)
- *Component Test* button (Comp test)
- *System Test* button
- *Sensor Data* button
- *Back* button

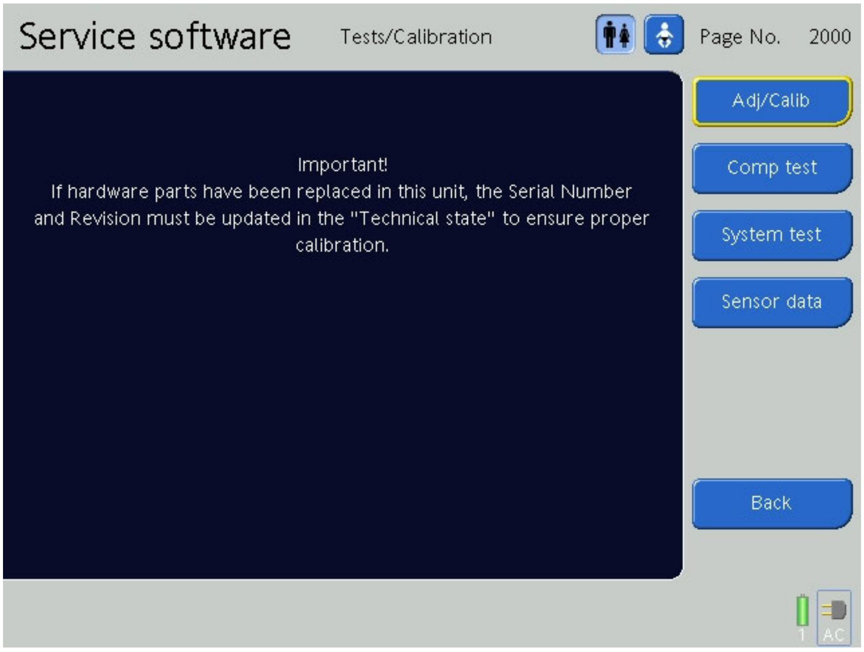


Fig. 55 Tests / Calibrations (Page 2000)

9.8.3 Calibration Tab

1. Touch the **Calibration** tab to enter the calibration section.

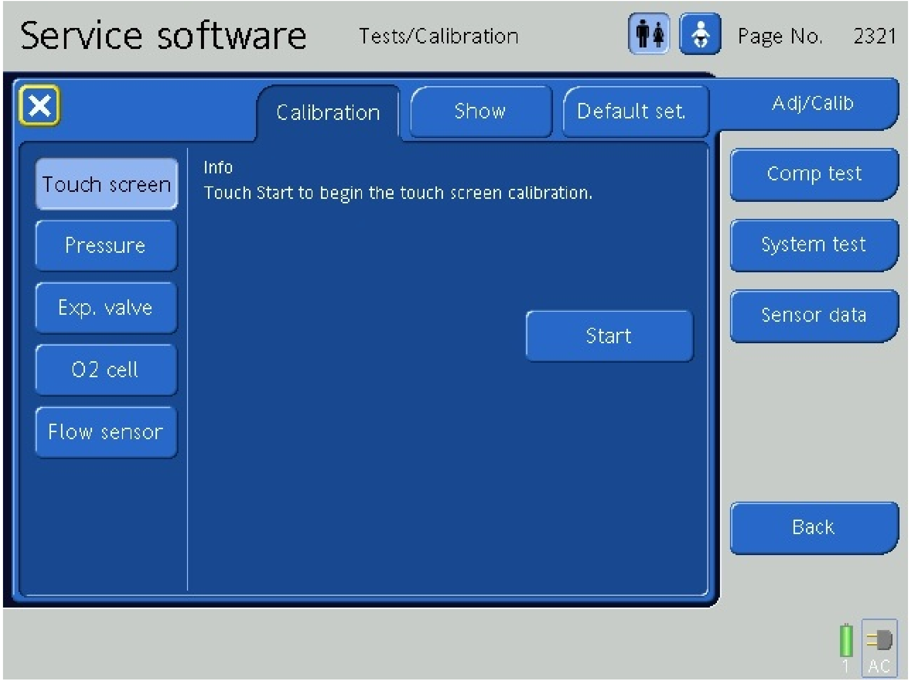


Fig. 56 The Calibration Tab

9.8.4 Touchscreen Calibration (Page No 2321)

1. Touch the **Touchscreen** button to enter the touchscreen calibration. Touch the **Start** button, then follow the screen prompts to touch the cursor when it appears in the corners and center of the screen.

Fig. 57 Start touch screen calibration

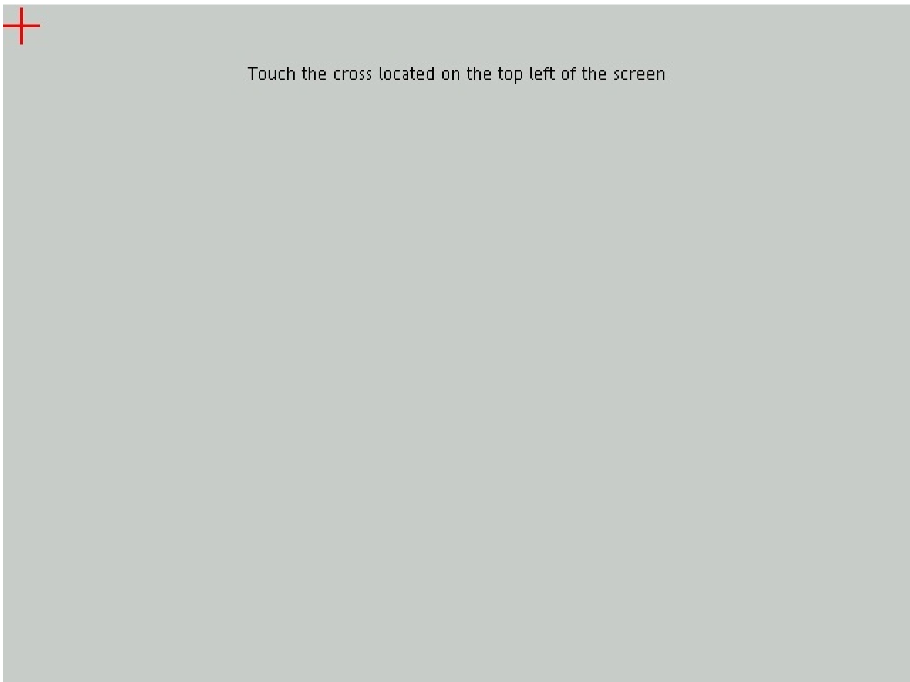


Fig. 58 Touch screen calibration top left

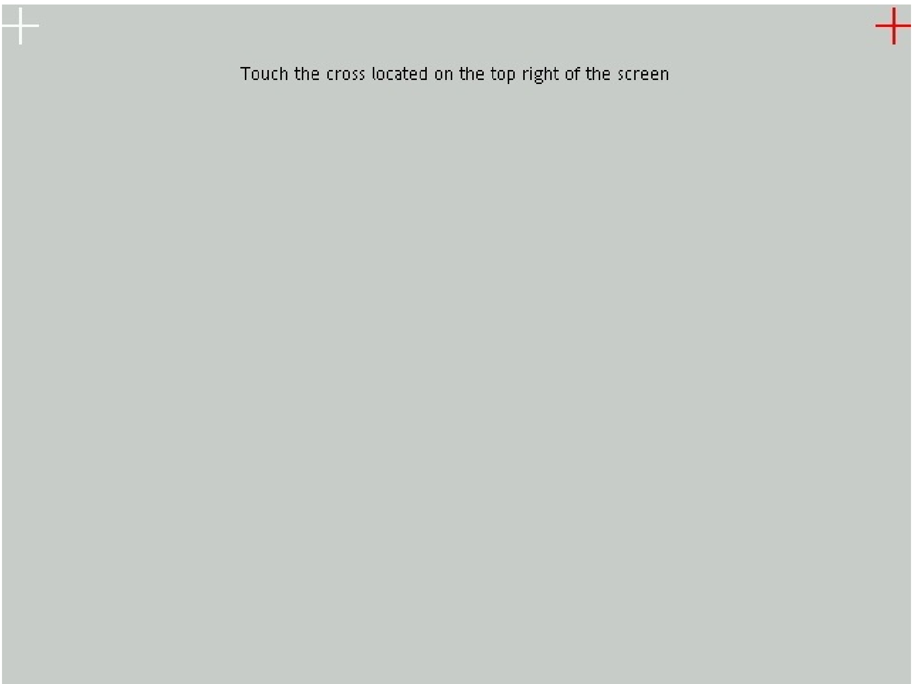


Fig. 59 Touch screen calibration top right

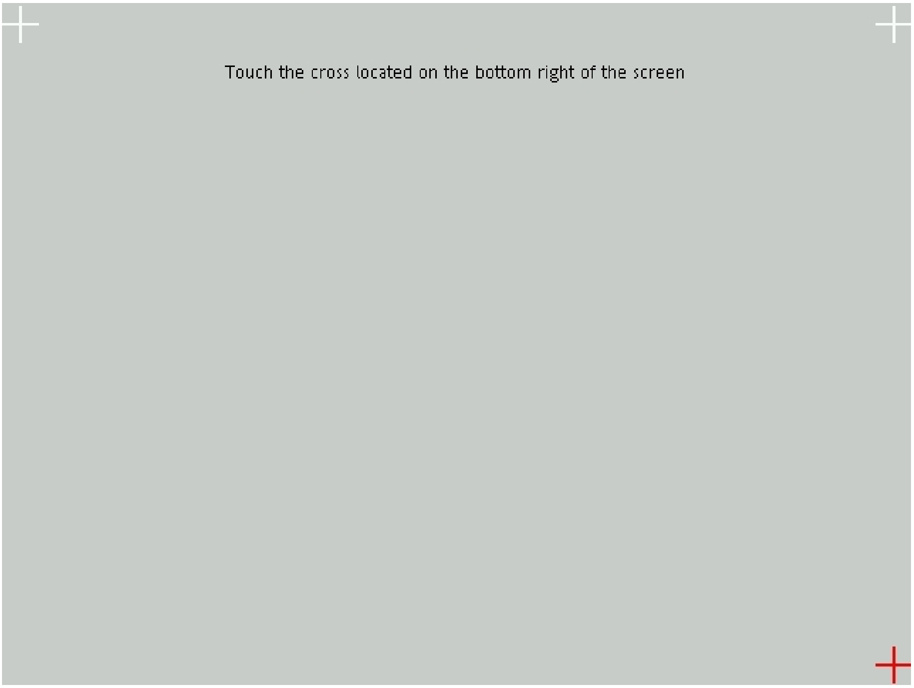


Fig. 60 Touch screen calibration bottom right

Fig. 61 Touch screen calibration bottom left

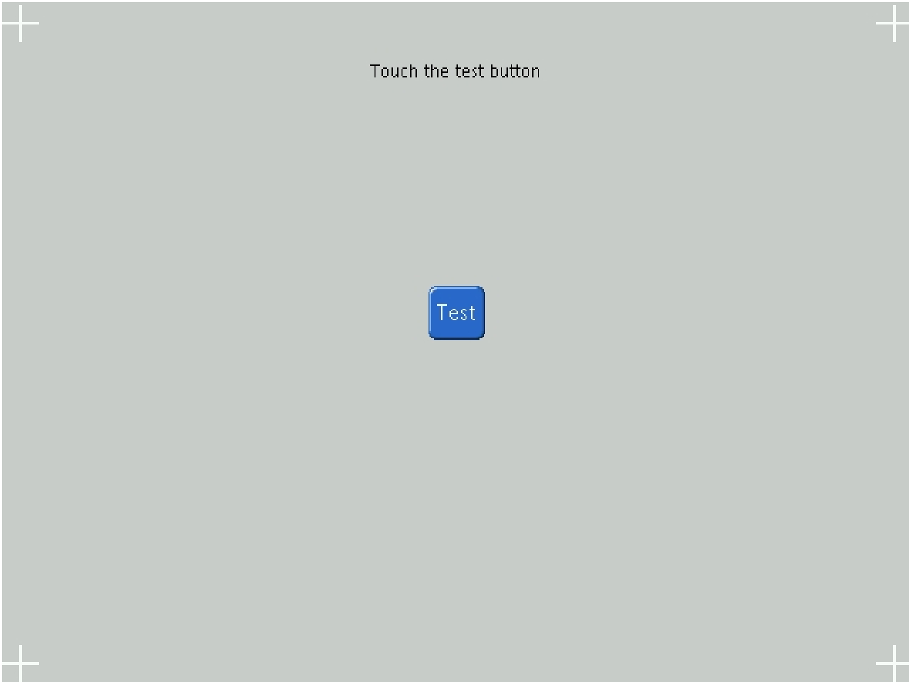


Fig. 62 Touch screen calibration test button

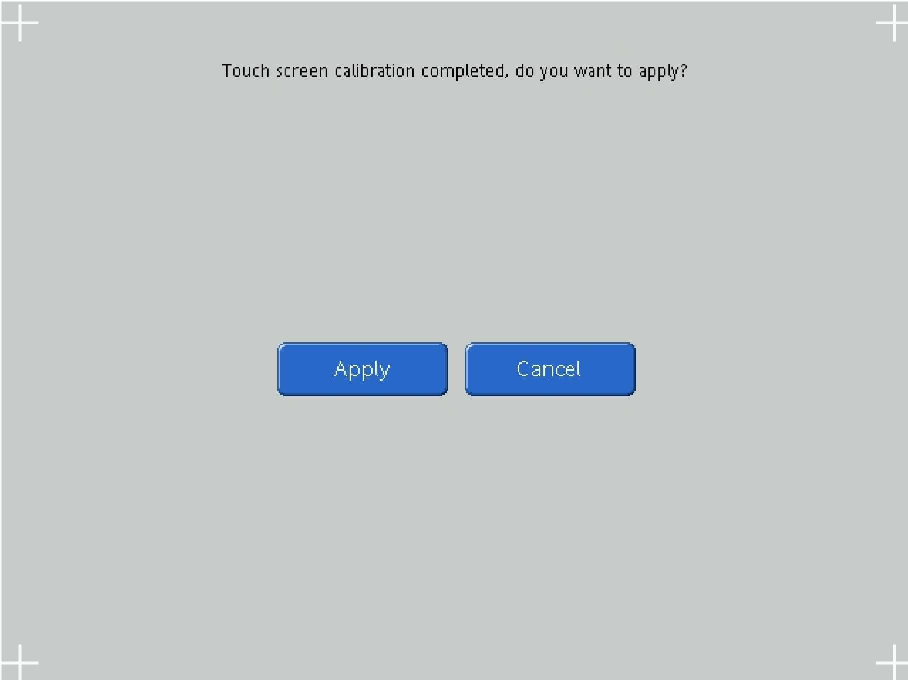


Fig. 63 Apply new touchscreen calibration values

2. The Info message **Touch screen calibration values saved** confirms the completion of the touch screen calibration.

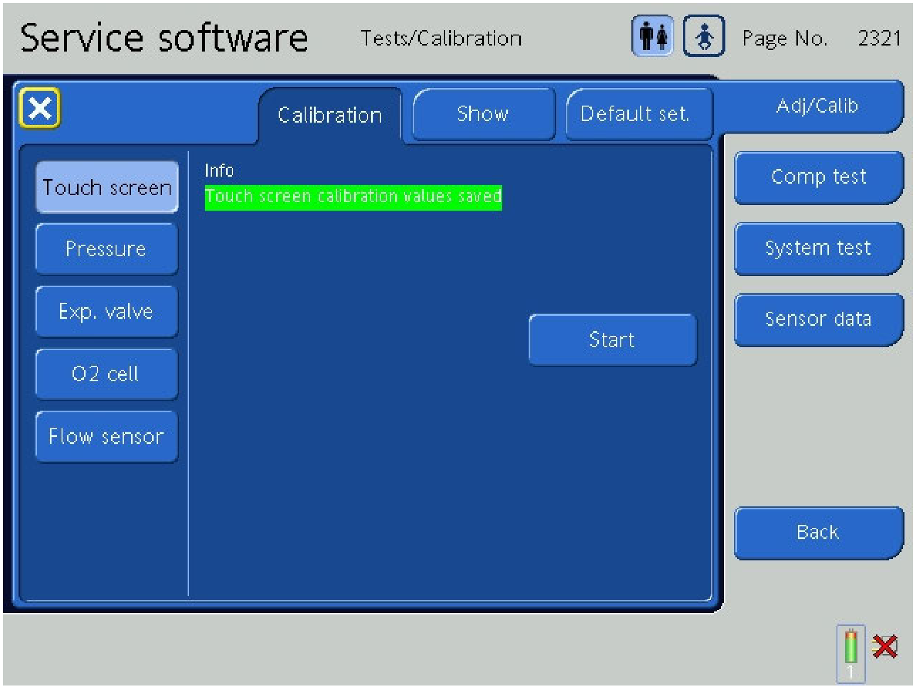


Fig. 64 Touchscreen calibration values saved

9.8.5 Pressure Adjustment (Page No 2341)

1. Touch the **Pressure button** to enter the pressure calibration.

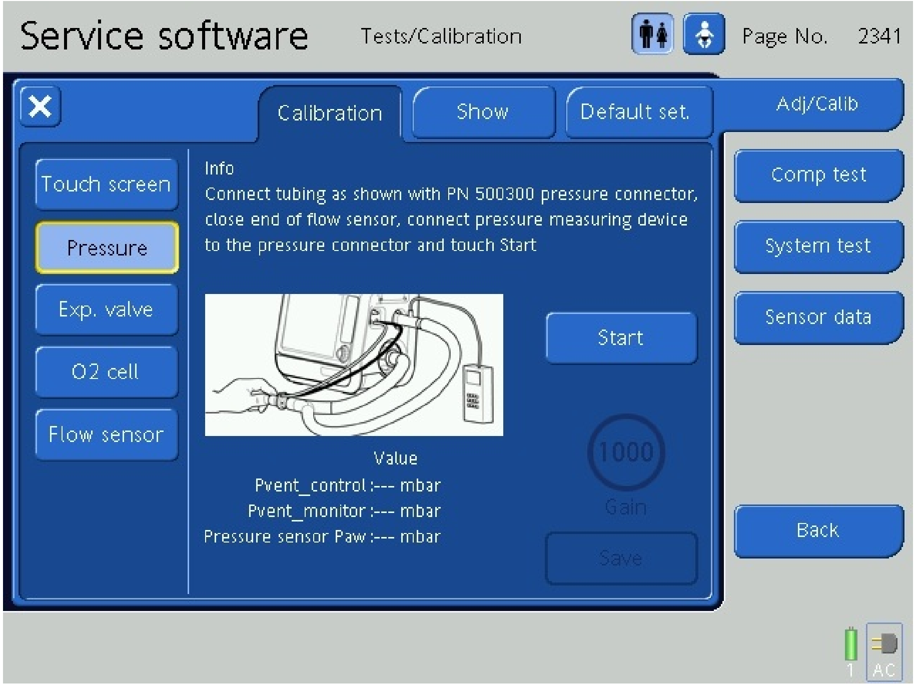


Fig. 65 Pressure calibration

2. Set up test configuration 1.

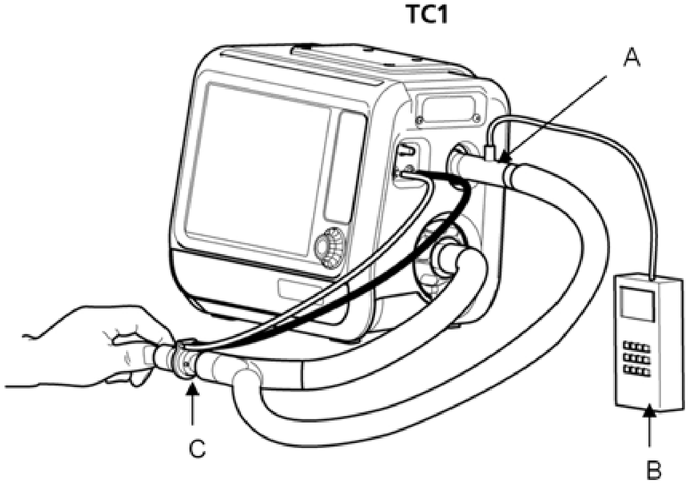


Fig. 66 Test configuration 1

Legend:

A	Pressure connector (PN 500300)
B	External pressure gauge
C	Close the flow sensor outlet

3. To begin with the adjustment touch the **Start** button.

4. Touch the **Gain** button and adjust the **Gain** value by rotating the P+T knob. Confirm by pressing the PT knob.

   Adjust the **Gain** until the external pressure gauge shows **50 mbar**, +/- 0.5 mbar (51 cmH2O, +/- 0.5cmH2O).

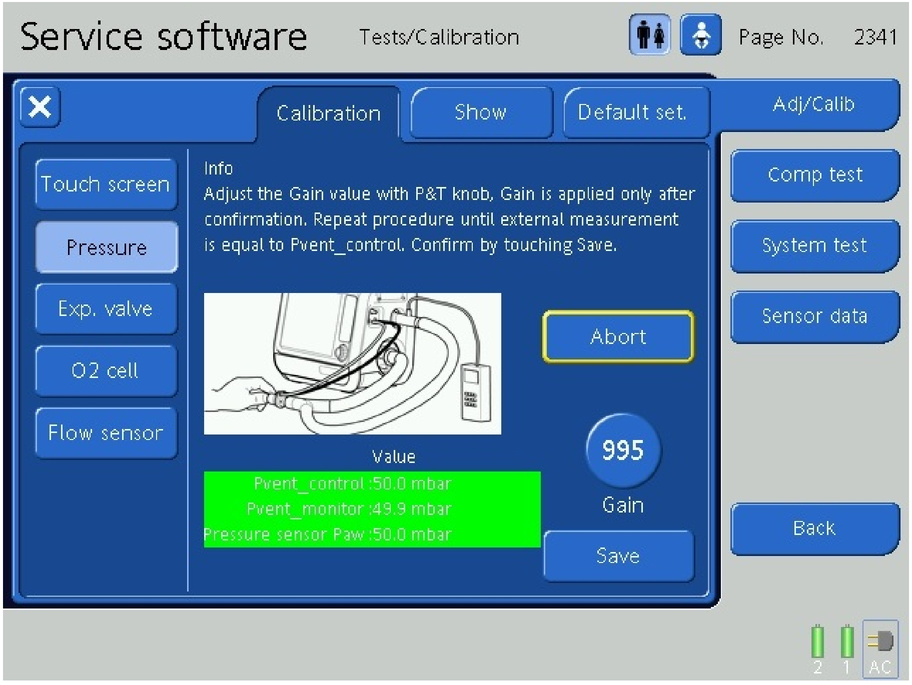


Fig. 67 Gain value adjustment

5. After completion touch **Save** button to store the gain value. Record the **Gain** value on the **Ventilator Test Report**.

9.8.6 Expiratory Valve Calibration (Page No 2343)

1. Touch the **Exp. valve** button to test the expiratory valve calibration.

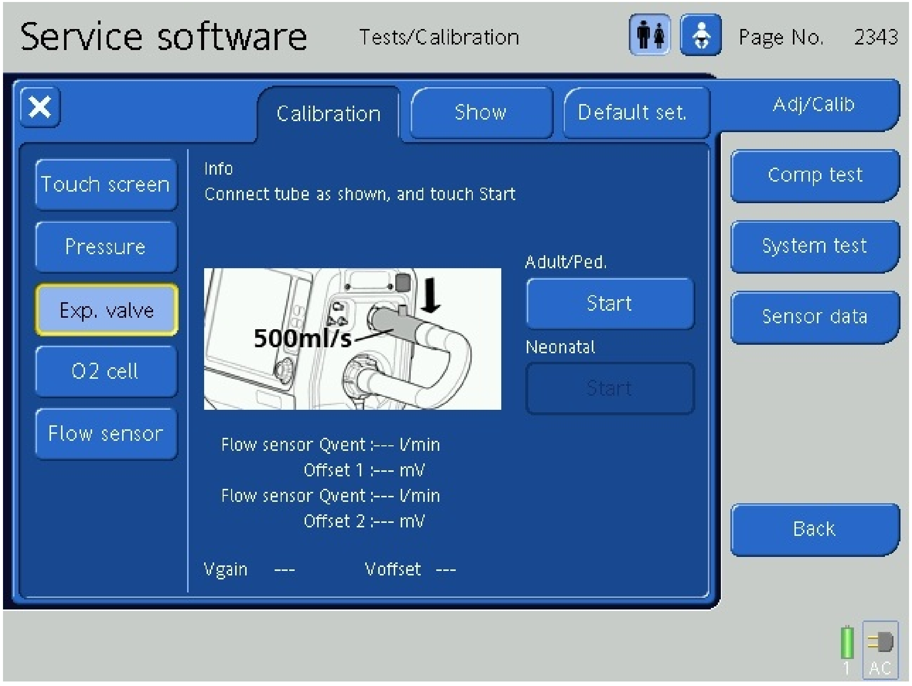
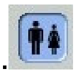


Fig. 68 Adult expiratory valve calibration (Page No 2343)

2. Select the adult mode by touching the adult button in the window header. 

3. Set up test configuration 2 and make sure the adult expiratory valve cover is installed.

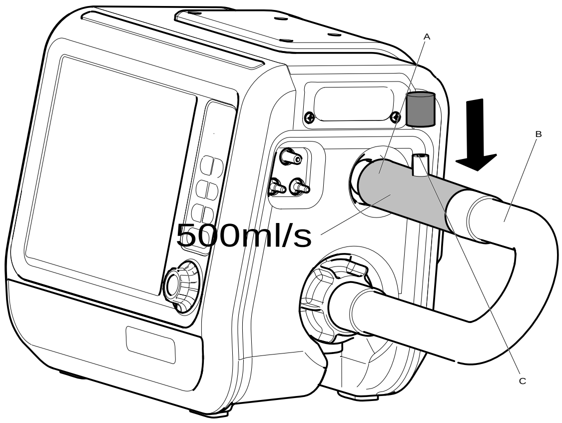


Fig. 69 Test configuration 2

Legend:

A	Capillary tube 500ml/s (PN 500290)
B	Silicone tube 22mm 35cm (PN 260100)
C	Close the capillary tube connector (e.g. use a clamp PN 279812, Figure *Test configuration 2*)

4. Touch the **Start** button (Adult/Ped.) to begin with the calibration. The calibration runs automatically, as indicated by the flow sensor Qvent, Offset 1 and Offset 2 values changing during the calibration process.

Note	Due to the sensitivity of the system the capillary tube 500ml/s is used in order to have a defined resistance. The calibration can take a few minutes. Vgain is not used and remains set to 1000.

Vgain and Voffset values are shown as soon as the calibration is successfully completed.

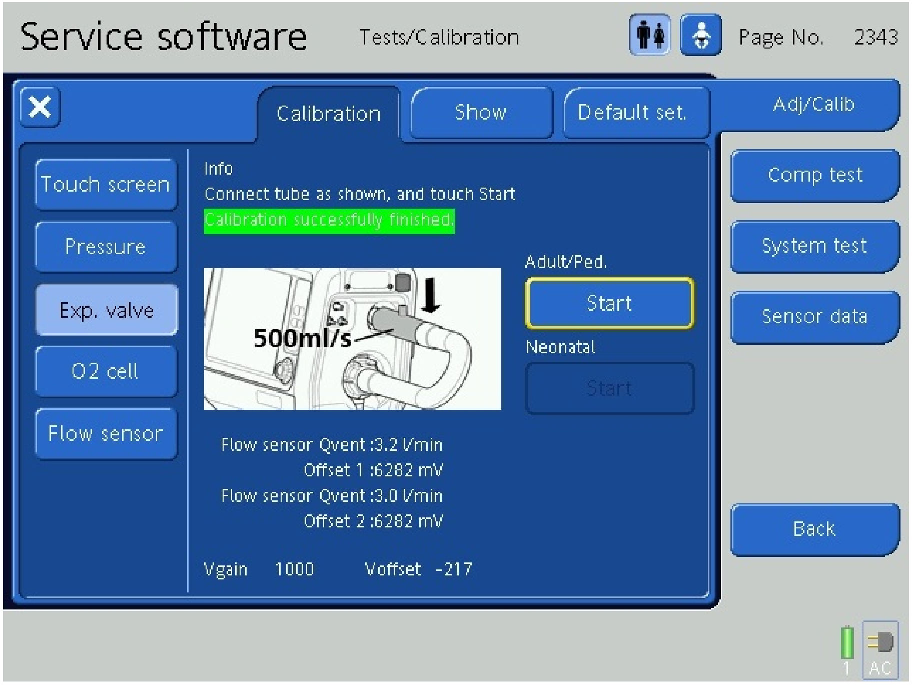
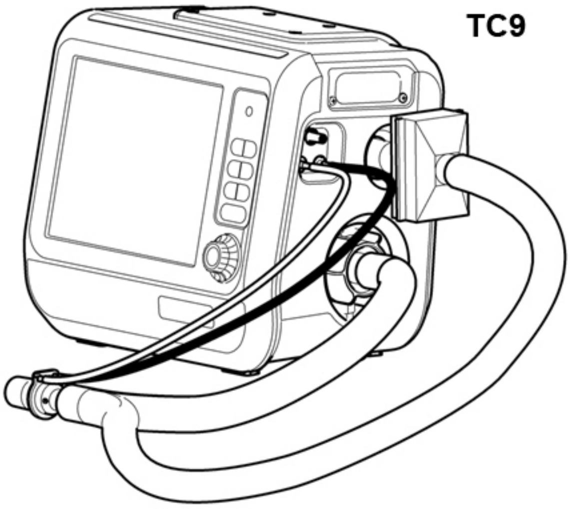


Fig. 70 Adult expiratory valve calibration

5. Record the Voffset value on the **HAMILTON Test Report**.

9.8.7 O2 Cell Calibration (Page No 2346)

1.



Set up test configuration 9.

2. Touch the **O2 cell** button to enter the O2 cell calibration.

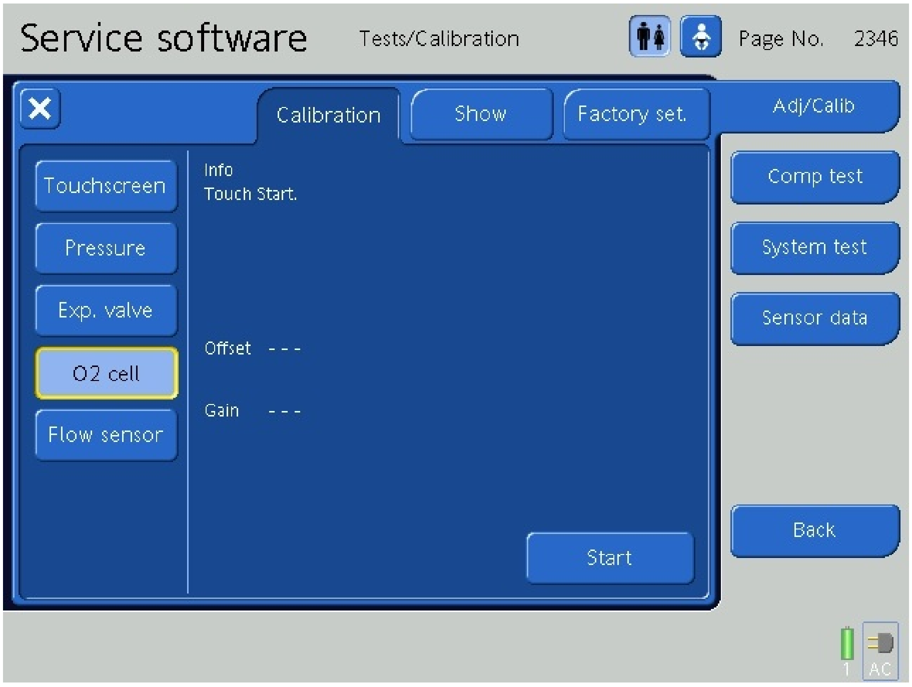


Fig. 71 O2 Cell calibration (Offset)

3. To start the **Offset** calibration touch the **Start** button. Do not disconnect the O2 cell for the offset calibration.The result is indicated with OK/ not OK.

4. The O2 cell **Gain** calibration starts automatically after the Offset calibration is completed. The progress bar shows the current state.

.

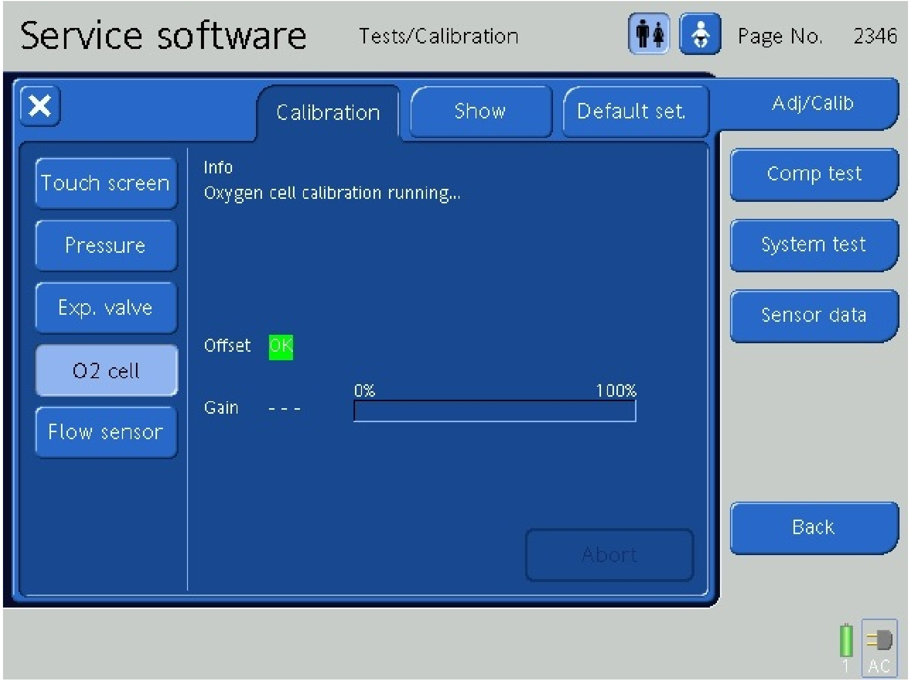


Fig. 72 O2 cell calibration (Gain)

5. The gain calibration takes approx. 2 minutes. The result is indicated with OK/ not OK and the completion is displayed with the Info message.

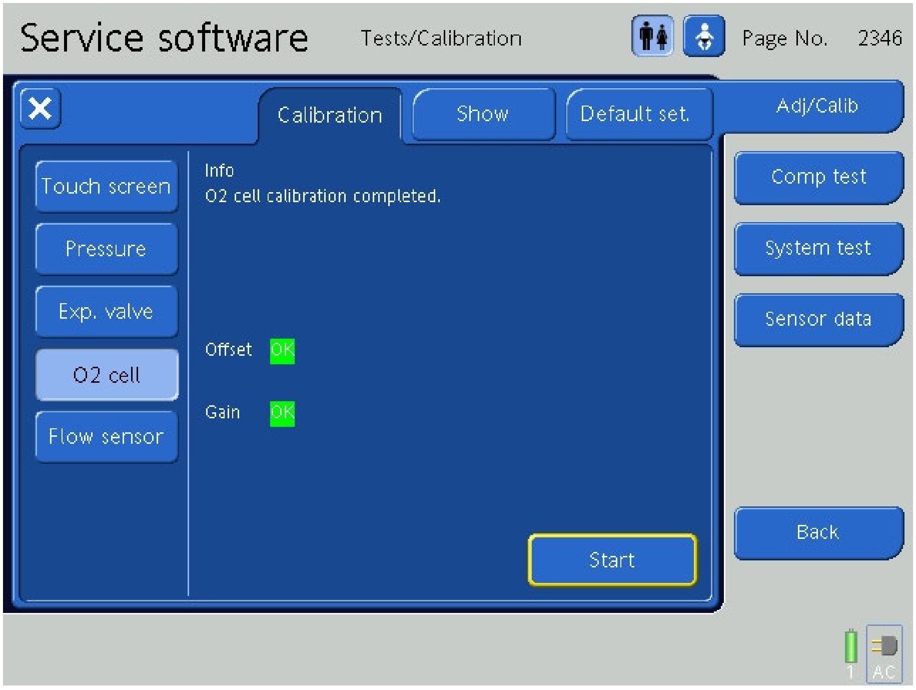


Fig. 73 O2 Cell calibration completed

9.8.8 Flow Sensor Calibration (Page No 2347)

1. Touch the **Flow sensor** button to enter the flow sensor valve calibration

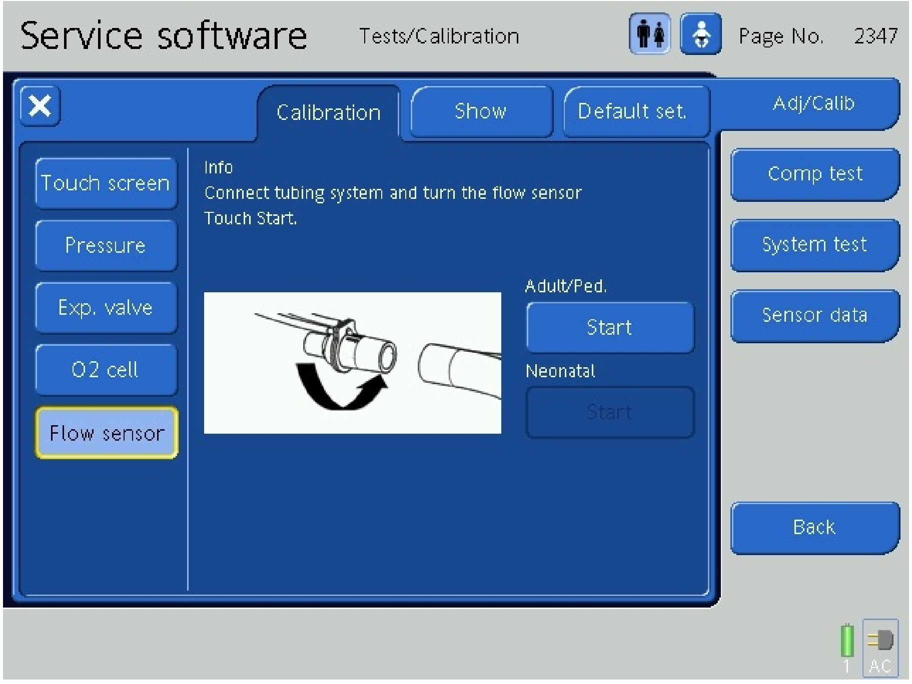
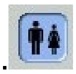


Fig. 74 Adult/Ped. flow sensor calibration (Page No 2347)

2. Select the adult mode by touching the adult button in the window header. 

3. Connect the ventilator with the adult breathing circuit (Test configuration 9)

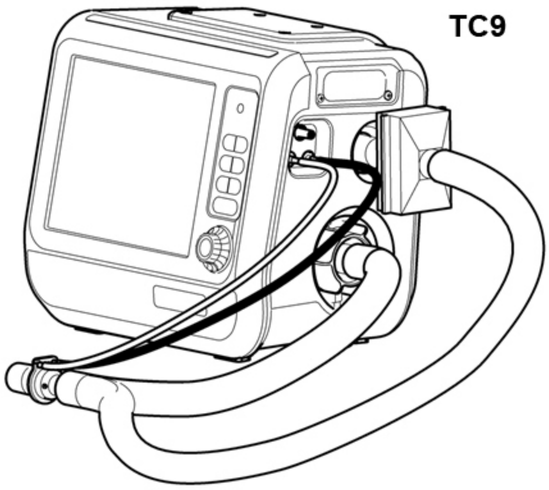
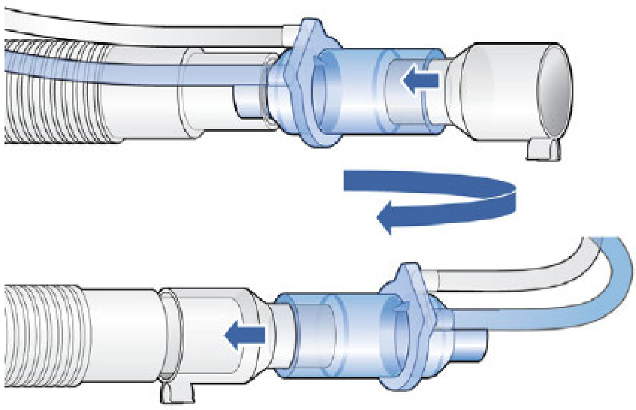


Fig. 75 Test Configuration 9

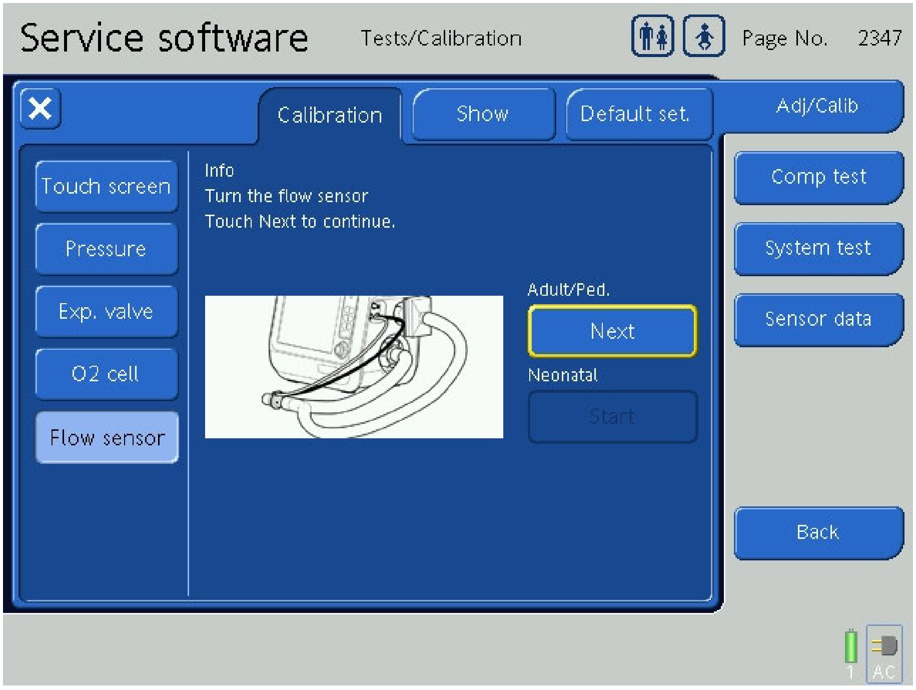
4. **Turn** the flow sensor prior to start.

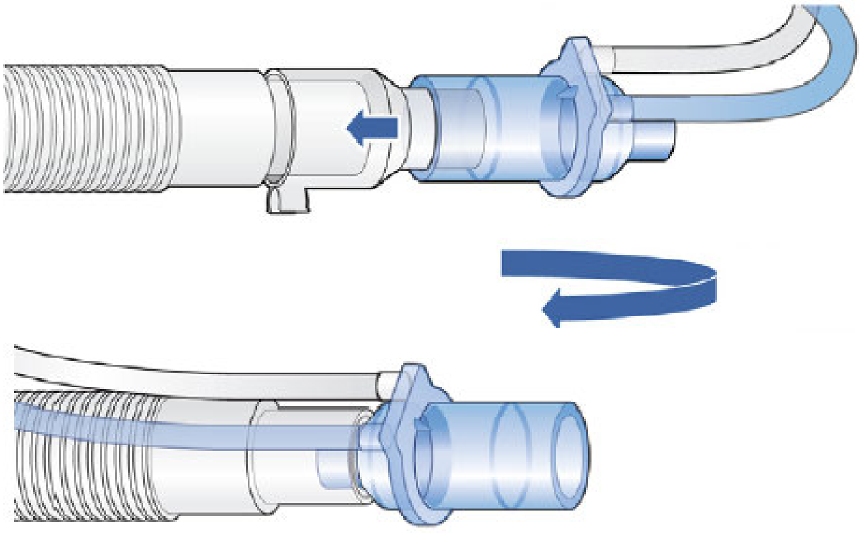


5. Start the Adult/Ped. flow sensor calibration by touching the **Start** button.

6. **flow sensor calib started** will be displayed.

7. **Turn** back the flow sensor when instruction is given and proceed by touching the **Next** button.





8. **flow sensor calibration successful** will be displayed after completion.

9.8.9 Calibration/ Adjustment values (Page No 2301-2304)

1. Touch the **Show** tab to display the calibration values.

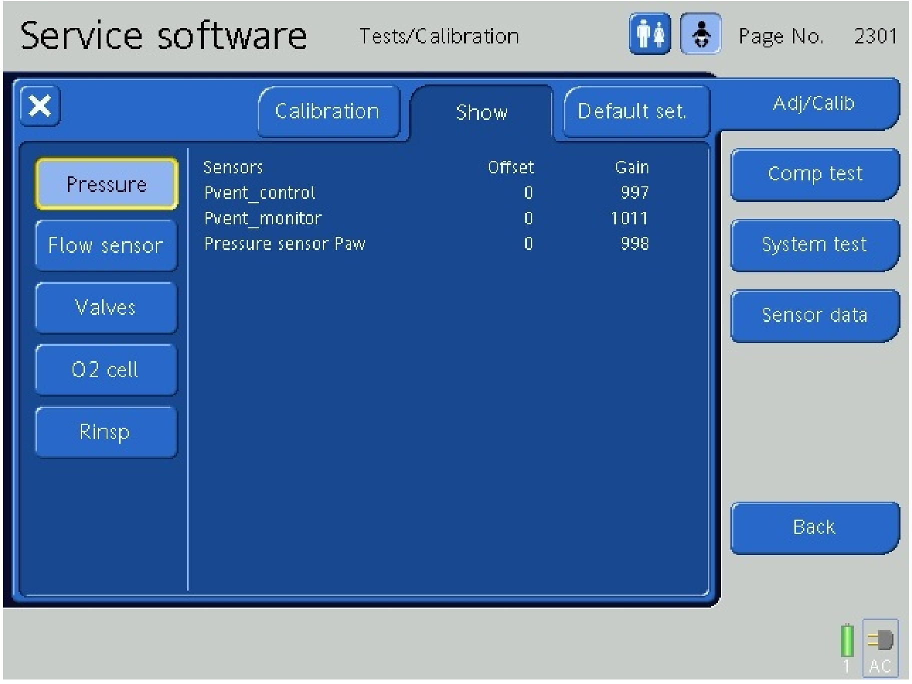


Fig. 76 Calibration/ Adjustment Values

Pressure sensor (Page No 2301)

1. Touch the **Pressure** button to display the offset and gain values of the pressure sensors (Pvent_control, Pvent_monitor and Paw).

Flow sensor (Page No 2302)

1. Touch the **flow sensor** button to display the inspiratory flow and expiratory flow values at different pressures. To display the adult/ped. or the neonatal valve calibration values touch the corresponding button in the window header.

Note	The system saves only one set of the flow sensor calibration values. E.g. if the last flow sensor calibration was done with adult/ped. flow sensor and a new flow sensor calibration will be perfomed with neonatal flow sensor, the calibration values adult/ped. will be overwritten by the neonatal values.

Valves (Page No 2304)

1. Touch the **Valves** button to display the offset and gain values of the expiratory valve. To display the adult/ped. or the neonatal valve calibration values touch the corresponding button in the window header.

O2 cell (Page No 2303)

1. Touch the **O2 cell** button to display the offset and gain values of the O2 cell.

These values are included in the instrument report export (see Log/Config.Files->Export) Chapter 9.14.3

Rinsp (Page No 2305)

1. Touch the **Rinsp** button to display the calibration values of the inspiratory tube resistance.

9.8.10 Default Settings (Page No 2391)

CAUTION	If calibration is not possible due to a corrupted calibration file, set to default settings. Repeat all calibrations and test's.

1 Touch the **Default set.** tab.
2 Touch the **Set** button.
3 To reset the flow sensor calibration values only touch the **Flow sensor** button. To reset all calibration values touch the **All** button.
4 Touch the **Confirm** button to reset to the default settings.

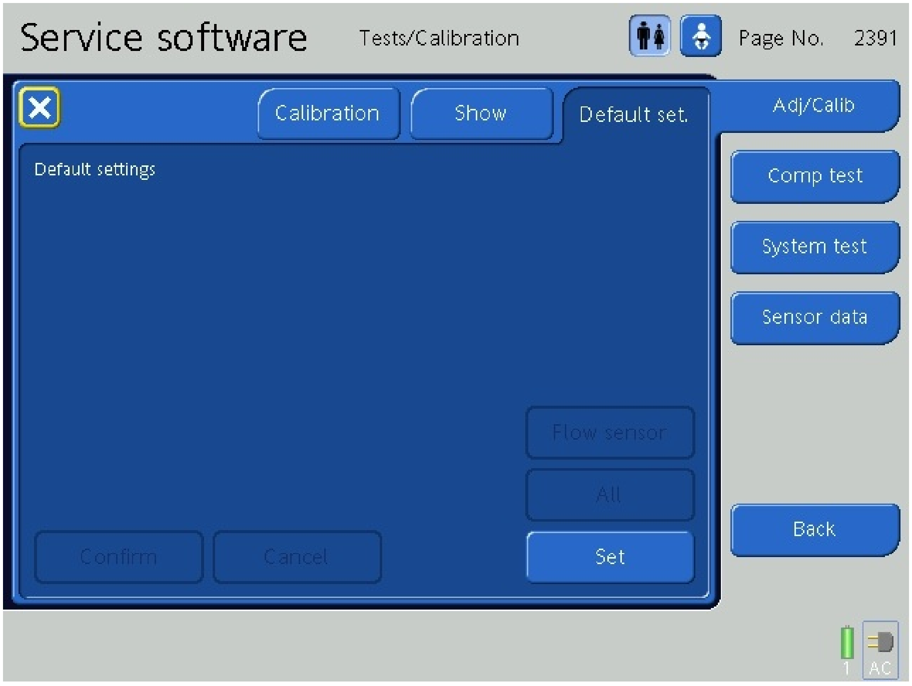


Fig. 77 Default settings (Page No 2391)

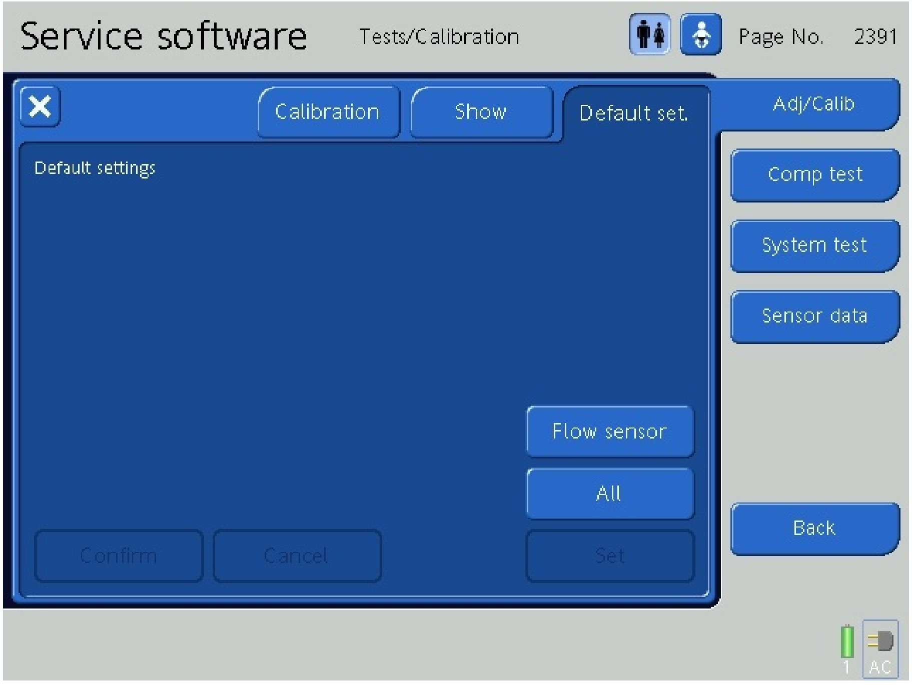


Fig. 78 Set Flow sensor or All calibration values to default

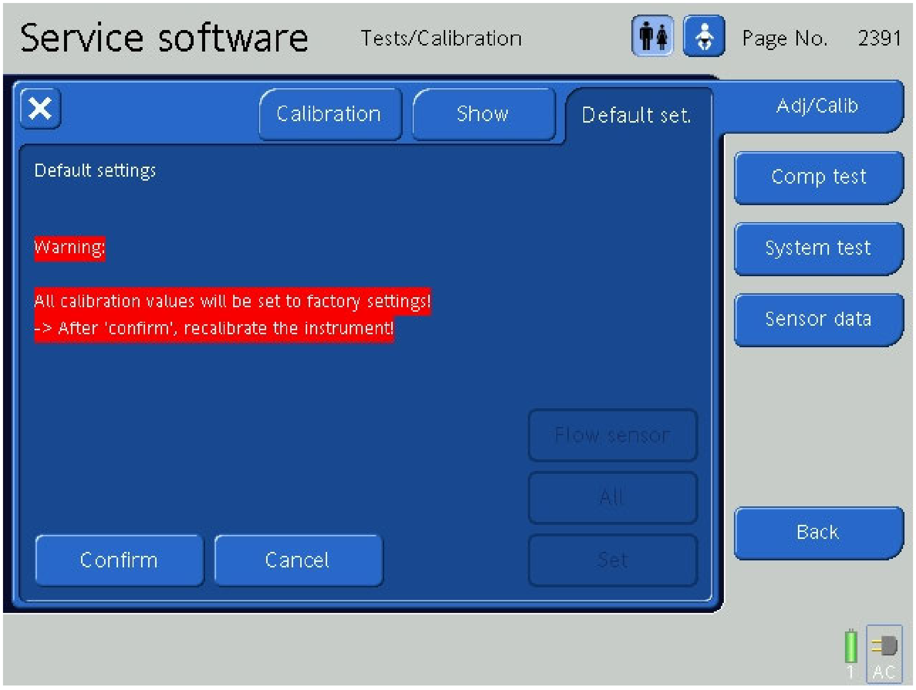


Fig. 79 Confirm setting to default

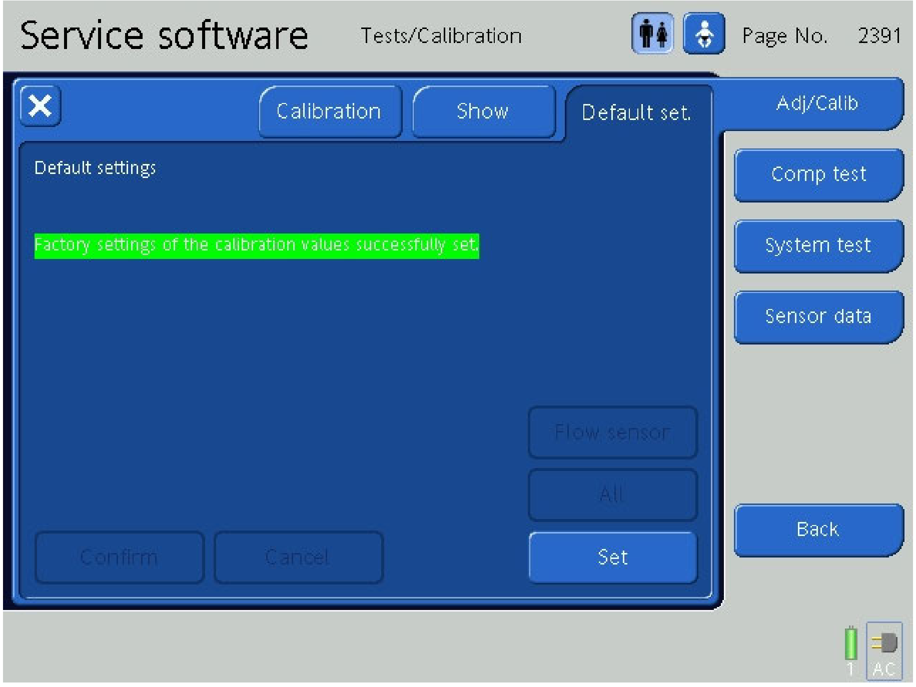


Fig. 80 Default settings succesfully set

9.9 Component Test (ADULT/PED.)

1. Select **Comp test** tab to enter the component test section.

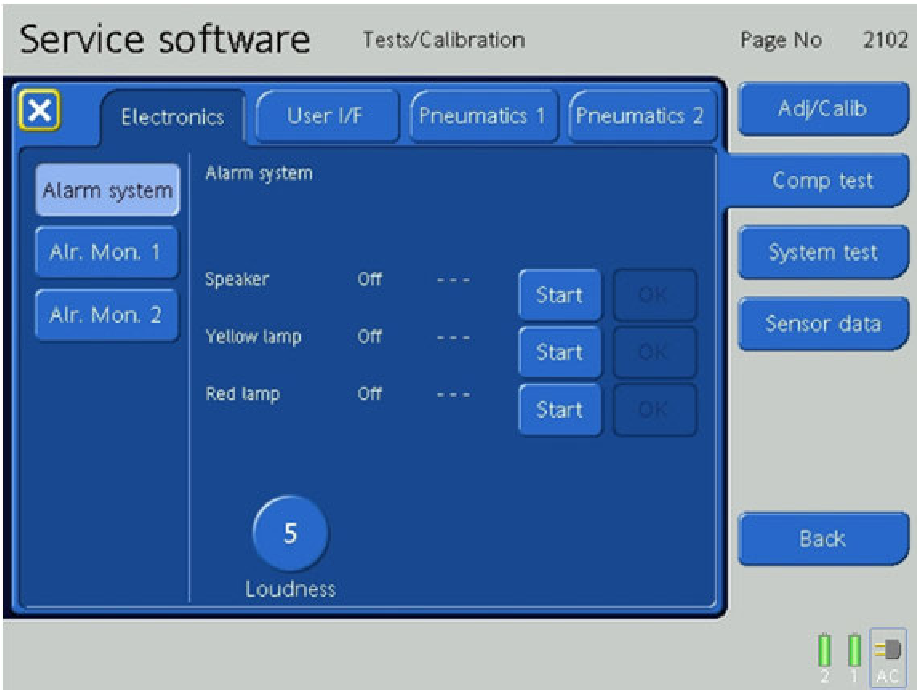


Fig. 81 Component Test

9.9.1 Overview Component Test

Component Tests	Description	Component tested
Electronics > **Alarm system** **(Page No 2102)** Chapter 9.9.2.1	This test allows activating the components related to the alarm system, it also test's the loudness levels. The test result needs to be confirmed manually.	– Loudspeaker – Alarm lamp lights red or yellow, depending on the alarm
Electronics > **Alarm Mon. 1** **(Page No 2113)** Chapter 9.9.2.2	(Steps 1 — 6) These test's diagnose the alarm monitoring system components. (Step 7-8) Testing the ambient mode. This test consists of setting the blower to achieve a certain pressure and a certain flow for 5s, afterwards the instrument will be switched to ambient mode causing the blower to stop. The Qvent is used to ensure the blower has stopped. The ambient mode has activated the alarm silence LED and the buzzer. The test result needs to be confirmed manually. (Step 9-10) This test checks the alarm in case of fan failure. It requires stopping the fan mechanically with the help of a Torx T10 by inserting it through the hole extra made for this test. The hole is a guide allowing to stop the fan without touching its propeller.	– Alarm silence button and LED – Ambient mode – Buzzer – Fan
Electronics > **Alarm Mon. 2** **(Page No 2114)** Chapter 9.9.2.3	This test activates the software watchdog. The test result has to be confirmed manually. Afterwards the ventilator needs to be restarted.	– Watchdog (software tasks)
User I/F > **(Page No 2115)** Chapter 9.9.3	With this test the user interface related components can be activated in order to check the interaction of the hardkeys with the GUI, hardkey combination can also be tested. Diming the screen and alarm lamp is tested using the day/night button. The P+T knob has 16 steps. The test is to see that all 16 steps register with the ventilator.	– P+T knob – Hardkeys + LED's – Backlight (day/night brightness)
Pneumatics 1> **Binary valve** **(Page No 2106)** Chapter 9.9.4.1	This test checks the auto zero valves during operation and autozeroing sequence. A constant pressure is applied. Both status, "running" and "autozero", are tested for the following valves: Pvent_monitor, PFlowsensor.	– Auto zero valves – Pvent_monitor Pflowsensor
Tests/Calib > Comp test > Pneumatics 1> **Autozero** **(Page No 2109)** Chapter 9.9.4.2	The test is repeating the autozero sequence 5 times under a defined pressure.	Auto zero of: – Pressure sensor Paw – Flow sensor Qaw – Pvent_monitor – Pvent_control
Tests/Calib > Comp test > Pneumatics 1> **Blower flow** **(Page No 2104)** Chapter 9.9.4.3	Several flows (ml/s) will be set as target to the blower and the achieved blower speed in rpm measured by the Hall sensor should be within the difened tolerance.	Blower

Tests/Calib > Comp test > Pneumatics 1> **Blower pressure** **(Page No 2105)** Chapter 9.9.4.4	Several pressures are set as target to the blower and the achieved pressure measured by the pressure sensor Pvent_monitor should be within the given tolerance.	Blower
Tests/Calib > Comp test > Pneumatics 1> **Exp. valve** **(Page No 2111)** Chapter 9.9.4.5	This test checks the expiratory valve, pressure sensors, and the expiratory proportional valve. -Pexpvalve test: While the patient system is tightened and the expiratory proportional valve is fully closed, the Pressure Sensors Pexpvalve and Pvent_control will be compared and have to be equal. Afterwards the expiratory proportional valve will be opened and the pressure sensor Pexpvalve must measure zero. -Pressure test: Several pressures are set as target to the blower and expiratory valve with a defined base flow. The pressures are measured by Paw and have to be within the defined tolerance.	– Expiratory valve adult/ped. – Pressure sensor Pexpvalve – Expiratory proportional valve

Component Tests	Description	Component tested
Tests/Calib > Comp test > Pneumatics 2> **O2 input** **(Page No 2112)** Chapter 9.9.5.1	For this test the ventilator needs to be connected to high pressure oxygen. Several flows will be set as target to the O2 mixer valve. The oxygen flow is measured by the internal flow sensor QO2 and has to be within a certain tolerance. In a second test the leakage is tested.	O2 mixer assembly
Tests/Calib > Comp test > Pneumatics 2> **Neb. valve** **(Page No 2116)** Chapter 9.9.5.2	For this test the ventilator needs to be connected to high pressure oxygen. In this test the proximal flow sensor is used to measure the generated flow when the nebulizer valve is closed and open states. The test results successfully if the measured Qaw matches to the defined tolerances.	Nebulizer valve

Component Tests	Description	Component tested
Tests/Calib > Comp test > Pneumatics 2> **Prox. Test** **(Page No 2110)** Chapter 9.9.5.3	This test consists of four parts: -Rinse flow test: This test requires checking the rinse flow manually by immersing the 2 flow tubes in a glass of water as depicted. The number of bubbles has to be approximately equal on each outlet. The blower is set to a constant pressure and the rinse flow valve is open in 5-seconds-breath cycles in order to provide the rinse flow tank with gas. The test result needs to be confirmed manually. -Proximal pressure: This test allows checking the proximal pressure of the external flow sensor. Two different pressures are applied consecutively by the blower through the inspiratory port. The achieved pressure is measured by the pressure sensor Paw and has to be within the tolerance. -Proximal flow: A certain flow is set as target to the blower, controlled by the internal flow sensor Qvent. The flow through the proximal flow sensor is measured by the internal differential pressure sensor Qaw and has to be within a certain tolerance. -Rinse tank: This test checks the tightness of the Rinse flow tank. A defined pressure will be applied from the blower while the inspiratory port is blocked manually. The rinse flow valve is open in order to fill the tank for a few seconds. Afterwards the rinse flow valve is closed and the pressure in the rinse flow tank should remain the same for a certain time. The pressure is then tested by the pressure sensor Paw. It has to be within the defined tolerance.	– Rinse flow – Pressure sensor Paw – Proximal flow sensor Qaw – Rinse flow valve – Rinse flow tank
Tests/Calib > Comp test > Pneumatics 2> **Check valve** (**Page No 2118**) Chapter 9.9.5.4	**With check valve assembly PN 161243 (HAMILTON-C1 < SN6000):** -Check valve (161243): This test pressures up the test lung to a certain pressure. Afterwards the flow sensor Qaw measures if there is a certain flow flowing backwards into the system ensuring the check valve works properly.	-Check valve and bypass
	With check valve assembly PN 161192 (HAMILTON-C1 ≥ SN6000): —Tightness This test pressures up the test lung to a certain pressure. Afterwards the flow sensor Qaw measures if the check valve assembly is tight. -Obstr. valve active This test pressures up the test lung to a certain pressure. Afterwards the obstruction valve will be opened. The flow sensor Qaw measures if the pressure can be released within a defined time frame.	-Check valve and obstruction valve

Tests/Calib > Comp test > Pneumatics 2>	This test allows checking the filter pressure sensor Pfilter with and without an obstructed filter.	– HEPA filter – Pressure sensor Pfilter
Air entry		
(Page No 2117) Chapter 9.9.5.5		

9.9.2 Electronics

1. Select the **Electronics** tab (if not already selected).

9.9.2.1 Alarm System (Page No 2102)

1. Touch the **Electronics** tab to enter the test's of the alarm system.

   Touch the **Alarm system** to enter the test's of the speaker and alarm lamp.

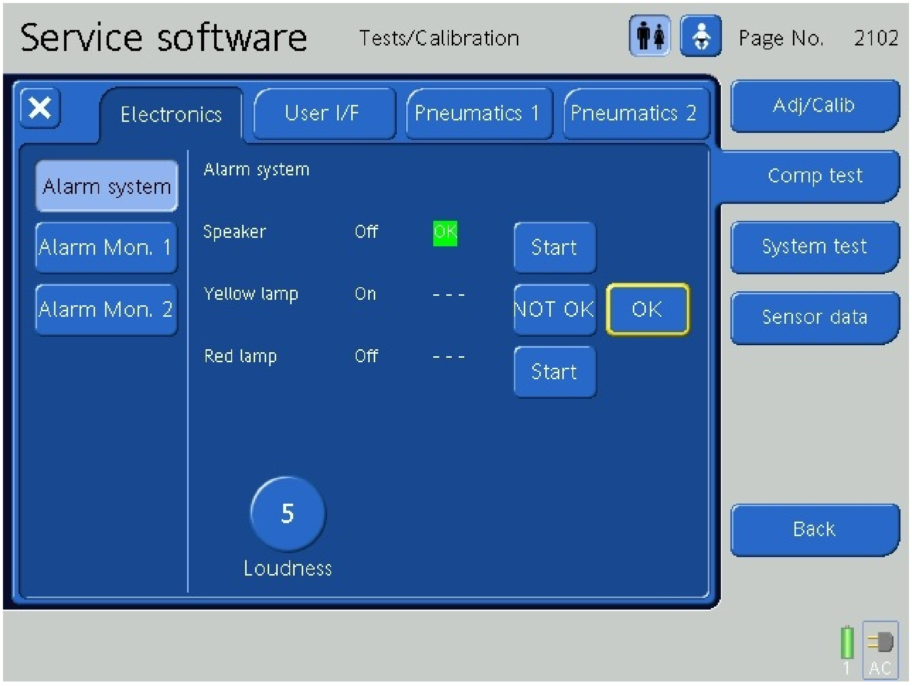


Fig. 82 Alarm System (Page No 2102)

2. Speaker test: Touch the **Start** button and confirm with **OK/NOT OK** if the loudspeaker is audible.

3. Yellow lamp: Touch the **Start** button and confirm with **OK/NOT OK** if the yellow lamp is ON.

4. Red lamp: Touch the **Start** button and confirm with **OK/NOT OK** if the red lamp and the alarm silence LED are ON. (HAMLTON-C1 units < SN6000)

   Red lamp: Touch the **Start** button and confirm with **OK/NOT OK** if the red lamp and the alarm silence LED are blinking. (HAMLTON-C1 units ≥ SN6000)

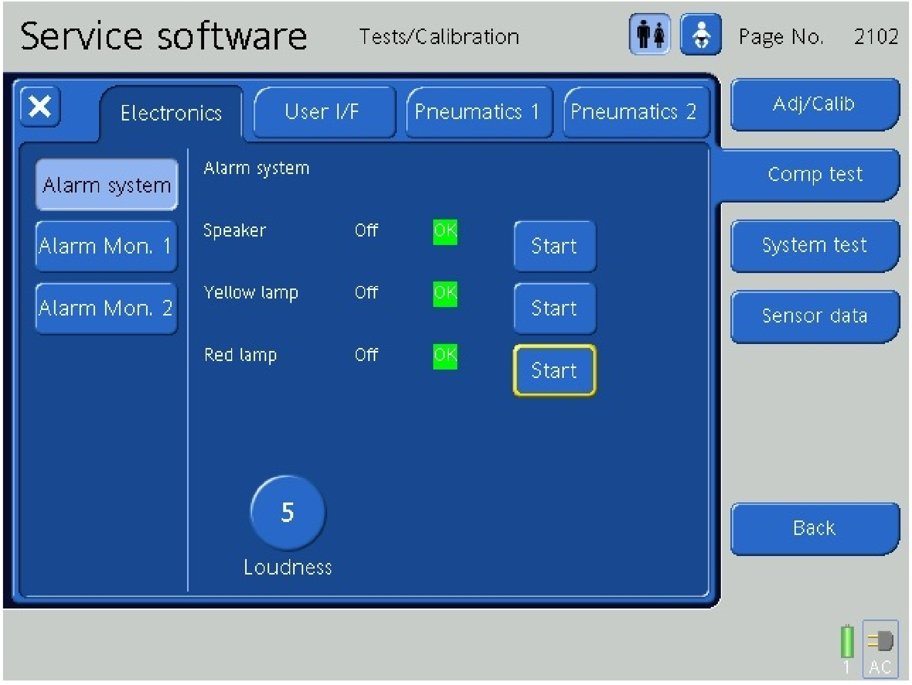


Fig. 83 Alarm System (Page No 2102)

5. Use the **Loudness** button to set and check the loudness range 1-10. Check if there is no distorted sound in the loudness range 1-10.

Note	This loudness setting also sets the loudness for the **System test Alarming**. To check the alarm sound on High-, Medium-, Low-Prio Alarm on loudness range 1-10, set here the loudness and perform the **System test Alarming.** Chapter 9.10.6

9.9.2.2 Alarm Monitor Test 1 (Page No 2113)

1. Touch the **Alarm Mon.1** button to enter the alarm monitor test's.
2. Touch the **Start** button to start the test procedure, which consists of 10 steps.

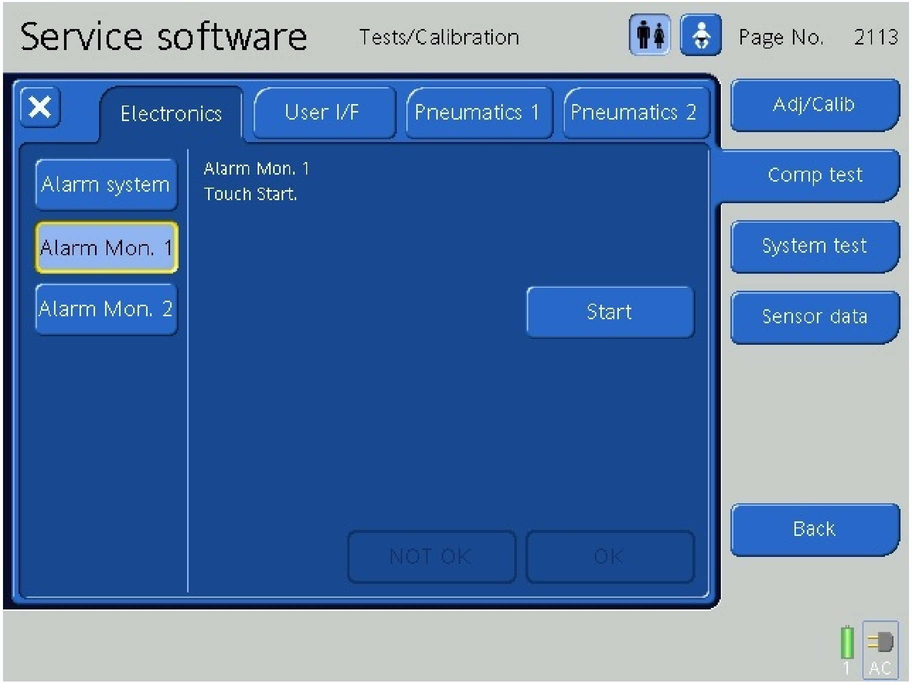


Fig. 84 Alarm monitor 1 test, start

3. Confirm with **OK/NOT OK** that the alarm silence LED is blinking.

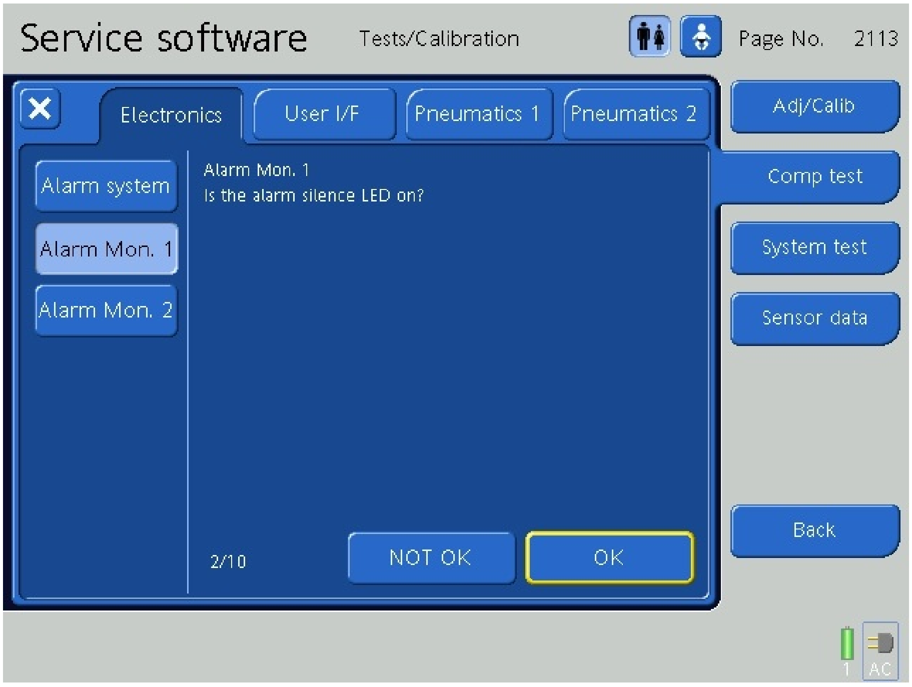


Fig. 85 Alarm monitor 1 test, step 1/10

4. Confirm with **OK/NOT OK** that the alarm silence LED is on.

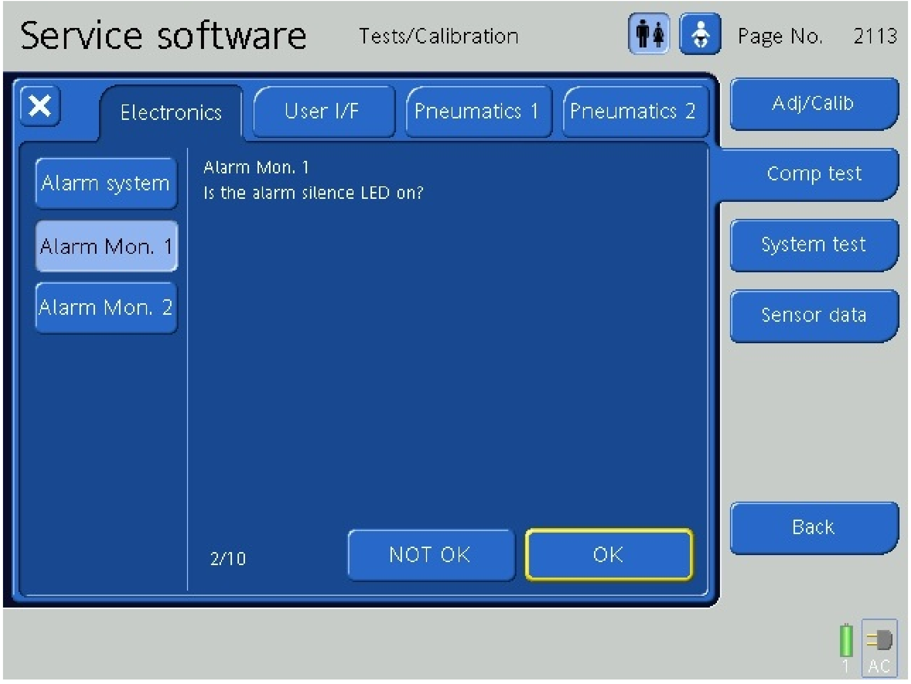


Fig. 86 Alarm monitor 1 test, step 2/10

5. Press the **alarm silence** key.

Confirm with **OK/NOT OK** that the alarm silence LED is on.

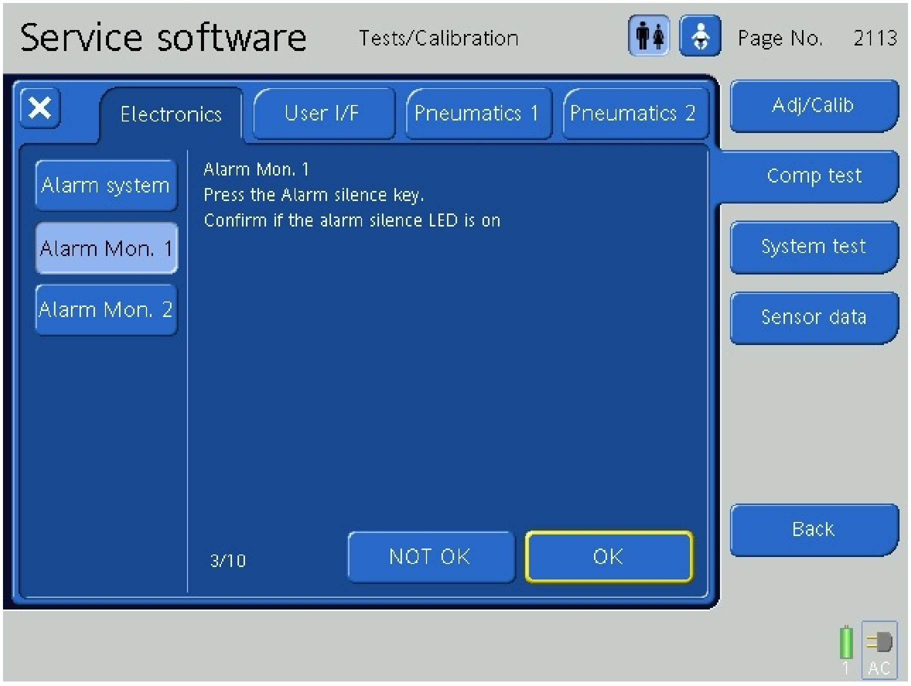


Fig. 87 Alarm monitor 1 test, step 3/10

6. Confirm with **OK/NOT OK** that the alarm silence LED is off.

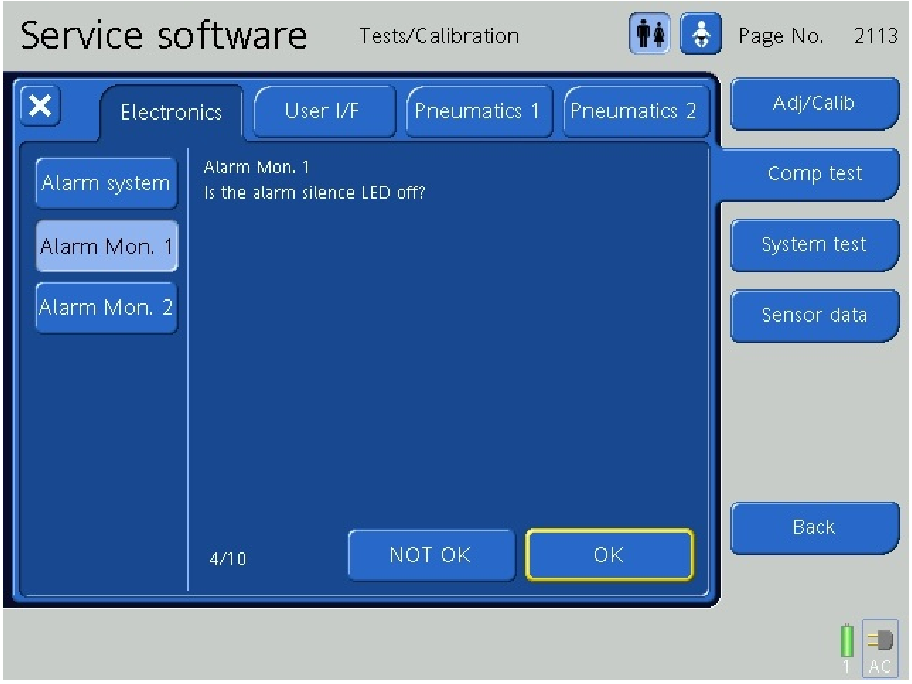


Fig. 88 Alarm monitor 1 test, step 4/10

7. Press the **alarm silence** key.

   Confirm with **OK/NOT OK** that the alarm silence LED stays off.

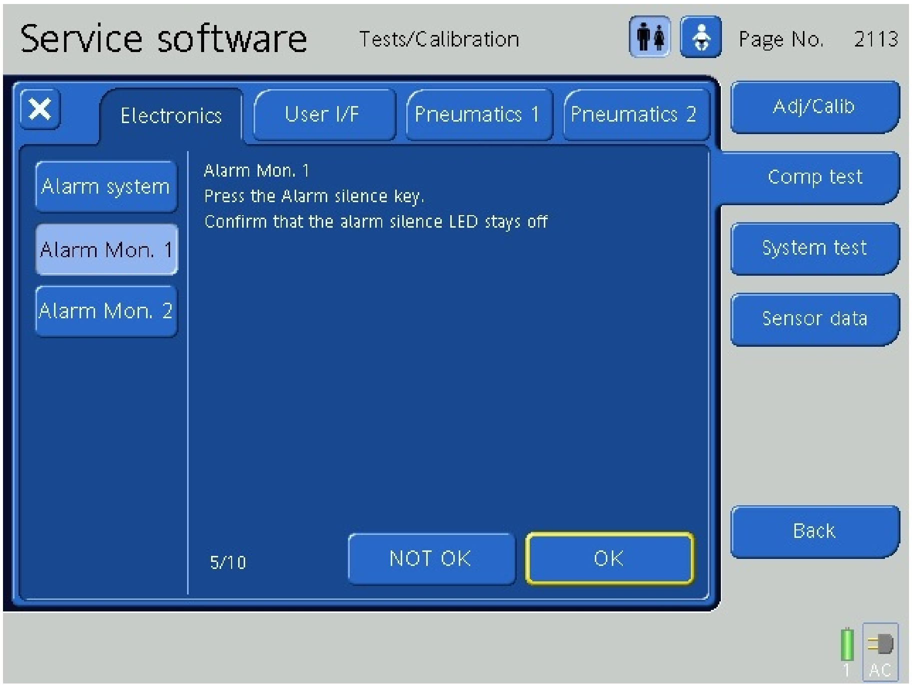


Fig. 89 Alarm monitor 1 test, step 5/10

8. Press the **alarm silence** key.

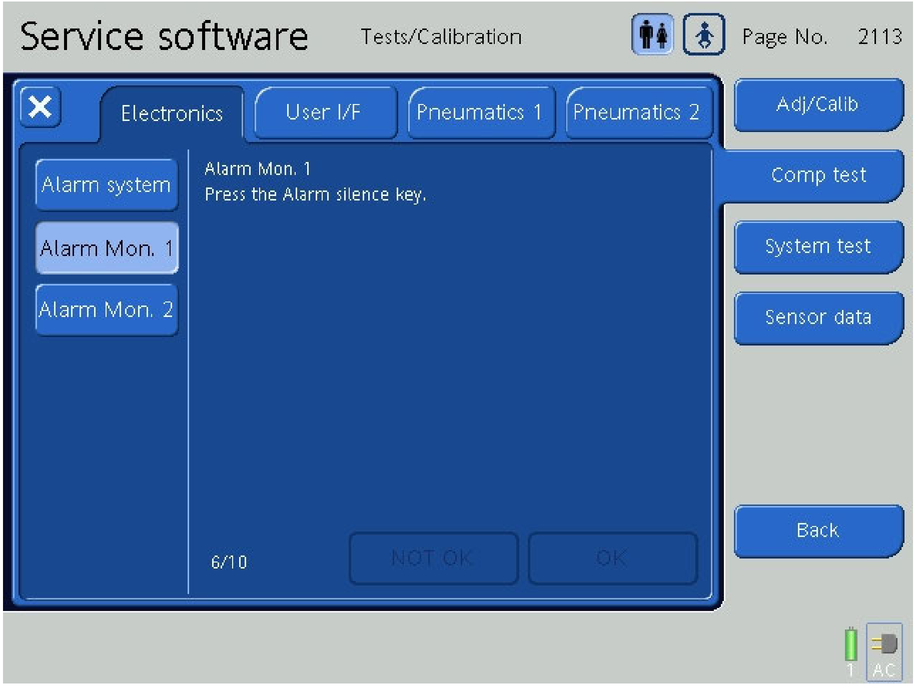


Fig. 90 Alarm monitor 1 test, step 6/10

9. Disconnect the inspiratory and expiratory tubes.

   Touch the **Next** button to continue and to start the testing of the ambient mode.

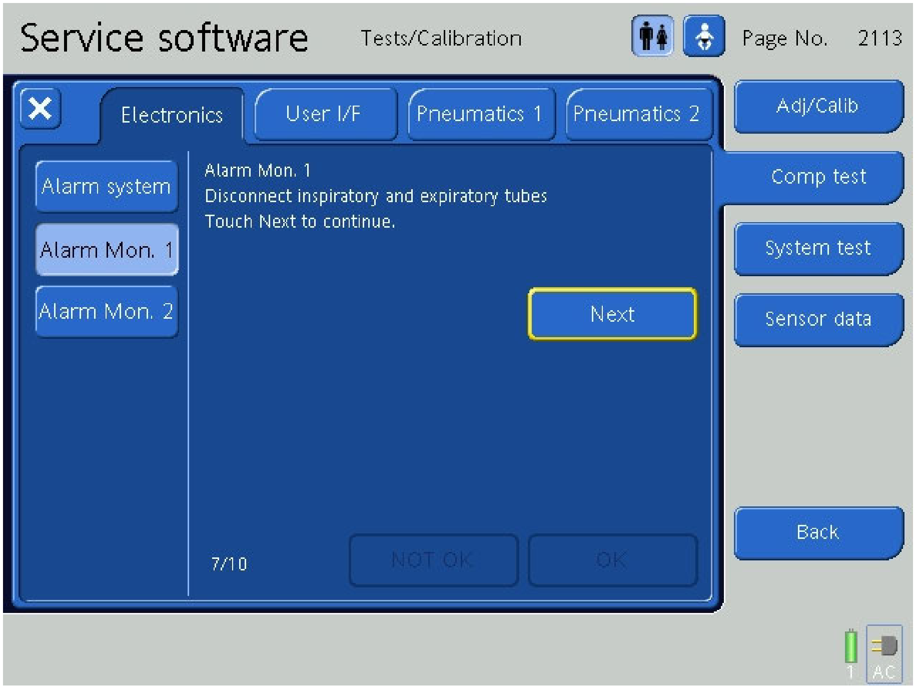


Fig. 91 Alarm monitor 1 test, step 7/10

10. The ambient mode test is in progress.

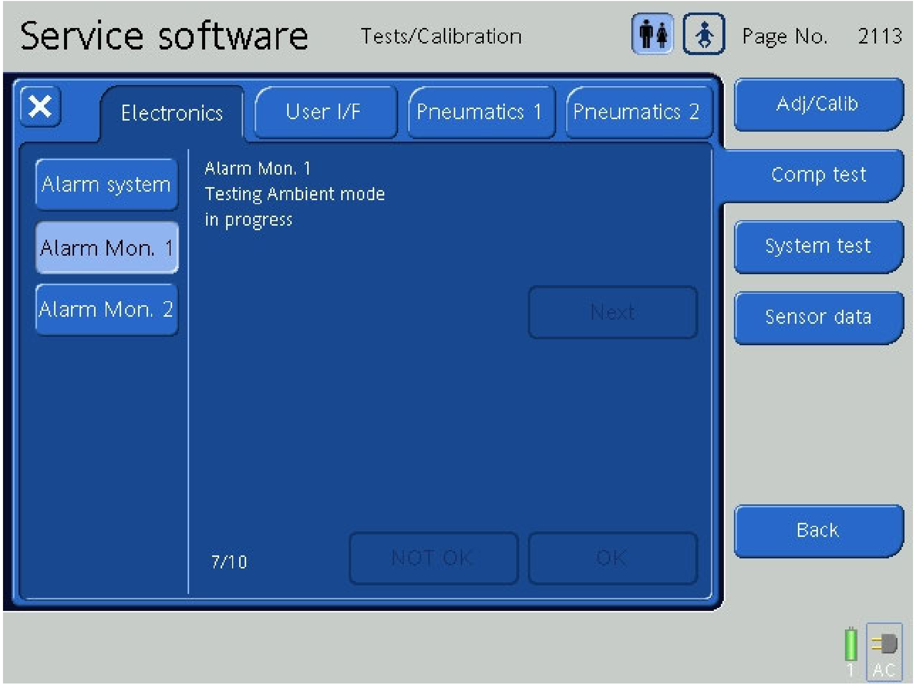


Fig. 92 Alarm monitor 1 test, step 7/10 in progress

11. Confirm with **OK/NOT OK** that the alarm silence LED is ON and the buzzer sounds.

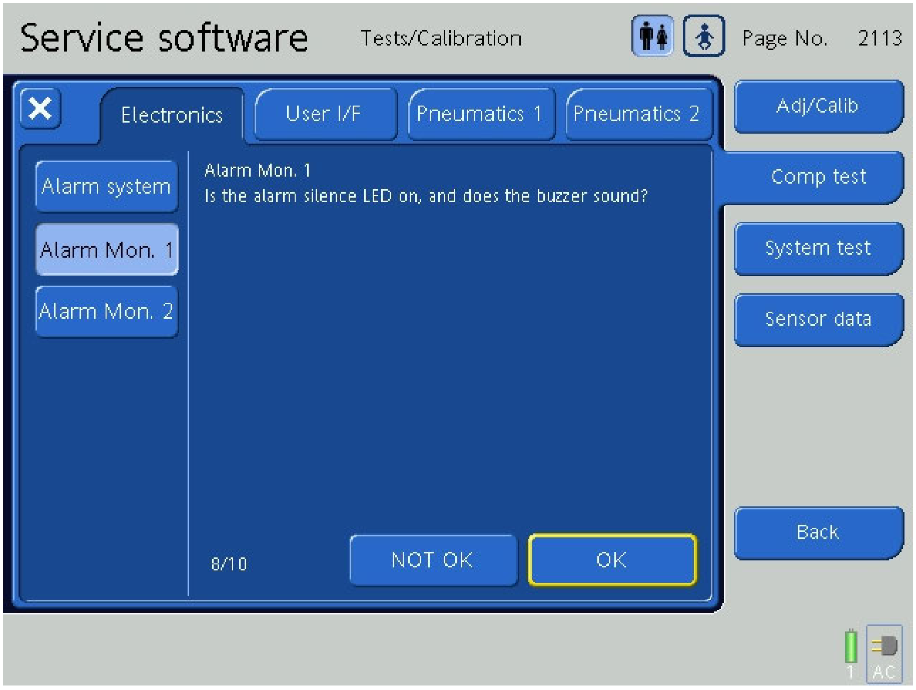


Fig. 93 Alarm monitor 1 test, step 8/10

12. Stop the fan until the alarm “Fan failure” appears. Use e.g Torx T10 to stop the fan as shown. The hole is a guide allowing to stop the fan without touching its propeller.

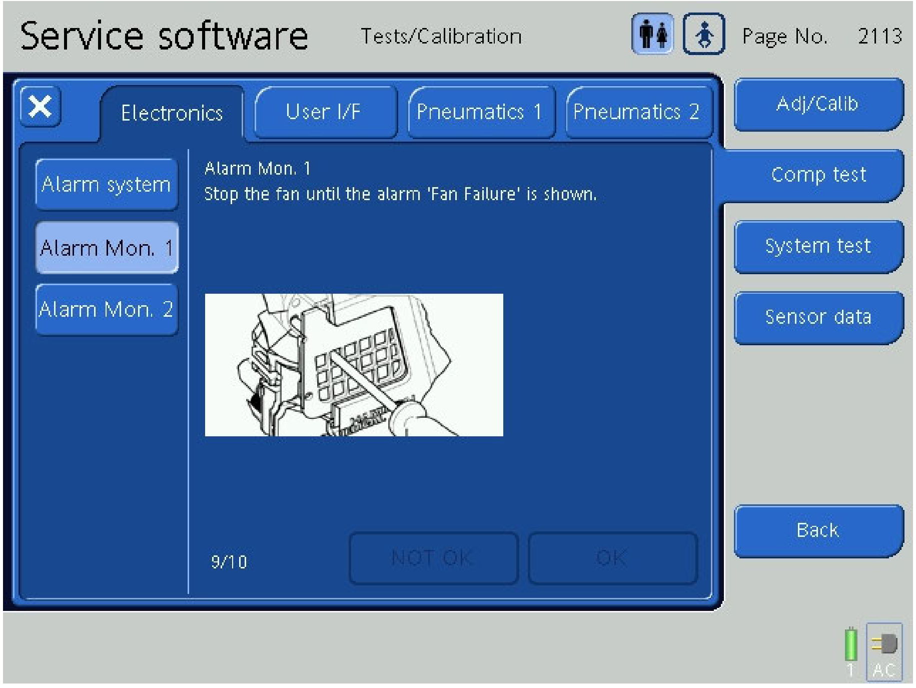


Fig. 94 Alarm monitor 1 test, step 9/10

13. Release the fan when the message “Fan failure” has appeared.

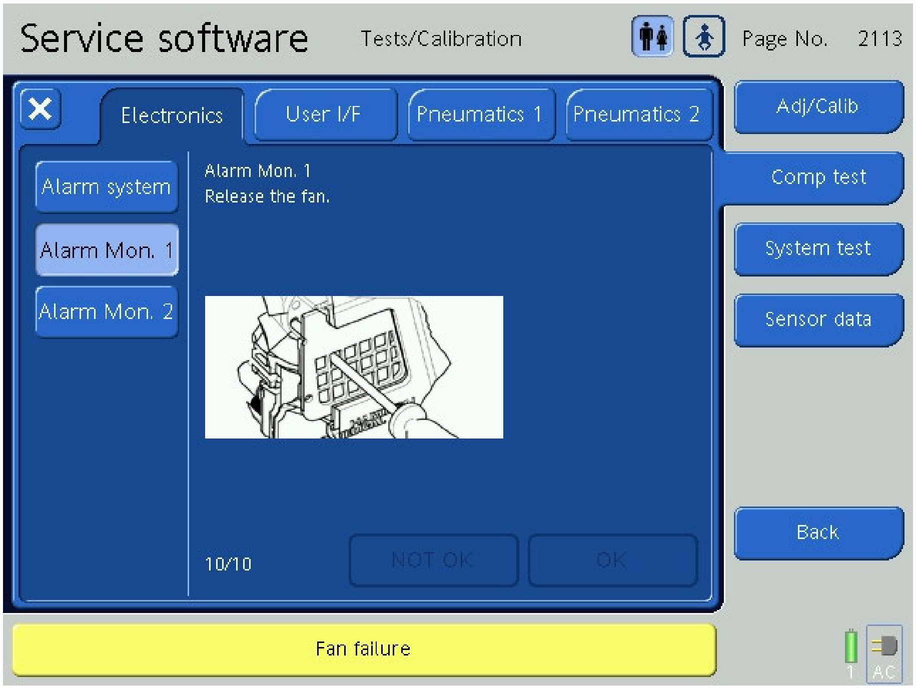


Fig. 95 Alarm monitor 1 test, step 10/10

14. The completion of the test procedure is confirmed by the green highlighted message “Test completed”.

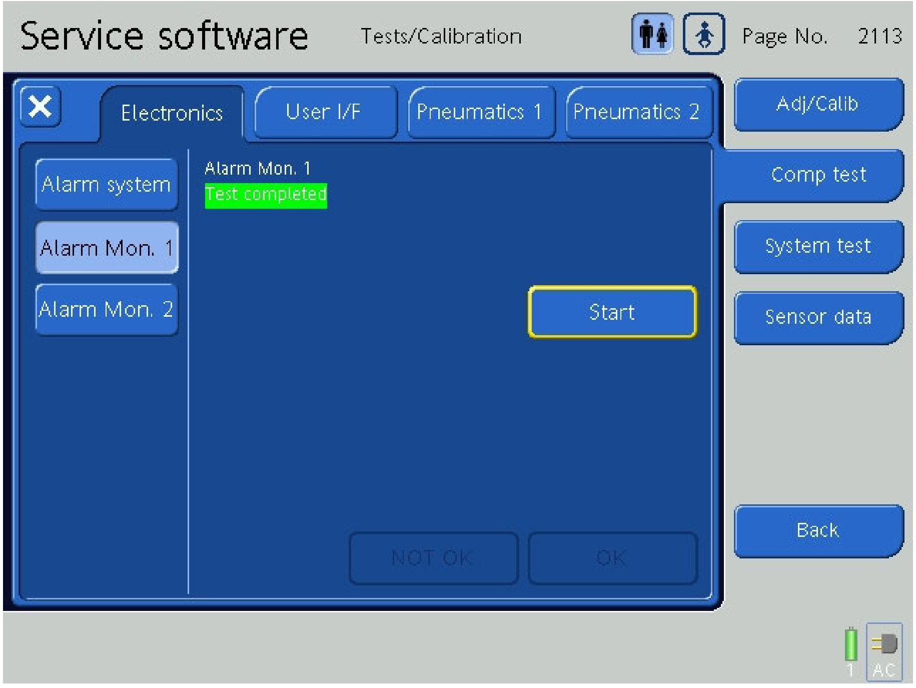


Fig. 96 Alarm monitor 1 test, completed

9.9.2.3 Alarm Monitor Test 2 (Page No 2114)

1. Touch the **Alarm Mon.2** button to enter the watchdog, alarm LED and buzzer test.
2. Touch the **Start** button to activate the watchdog.
3. The alarm LED should blink and the buzzer should sound. Some watchdog technical fault will be displayed and logged in service log.
4. Confirm success by touching the **OK/ NOT OK** button. The result of this test will be stored in the service log.
5. Reboot the unit.

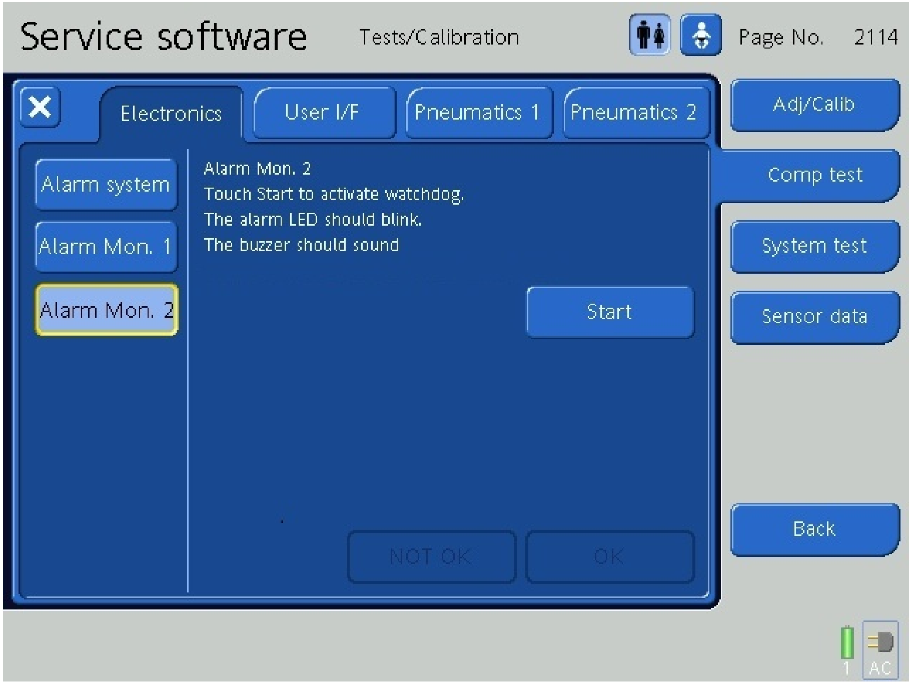


Fig. 97 Alarm Monitor Test 2 (Page No 2114)

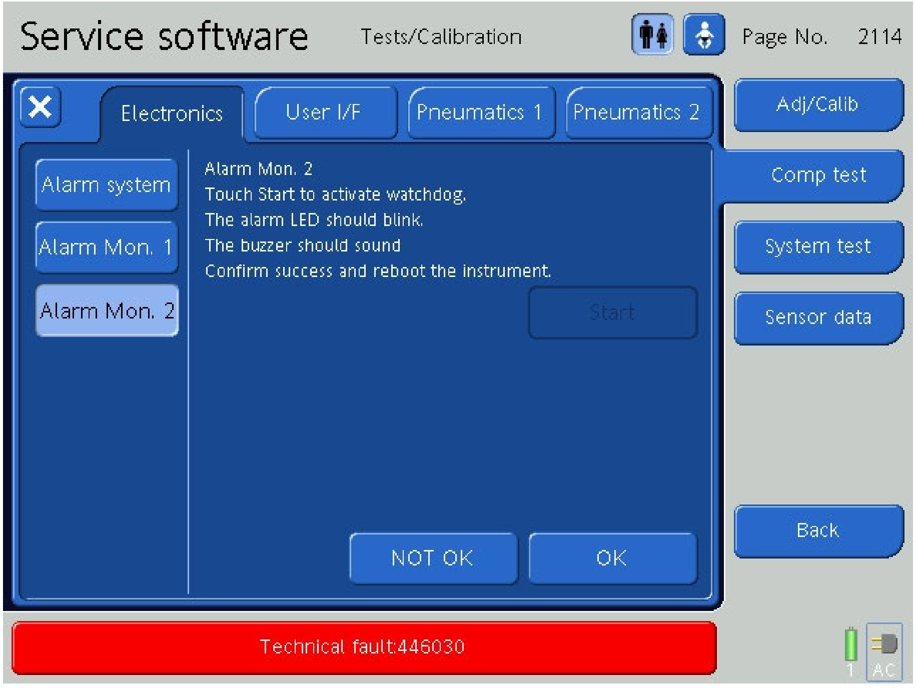


Fig. 98 Alarm monitor test 2 (Page No 2114), Watchdog activated

Fig. 99 Alarm monitor test 2 (Page No 2114), confirm

9.9.3 User Interface (Page No 2115)

1. Touch the **User I/F** tab to enter the user interface test's.

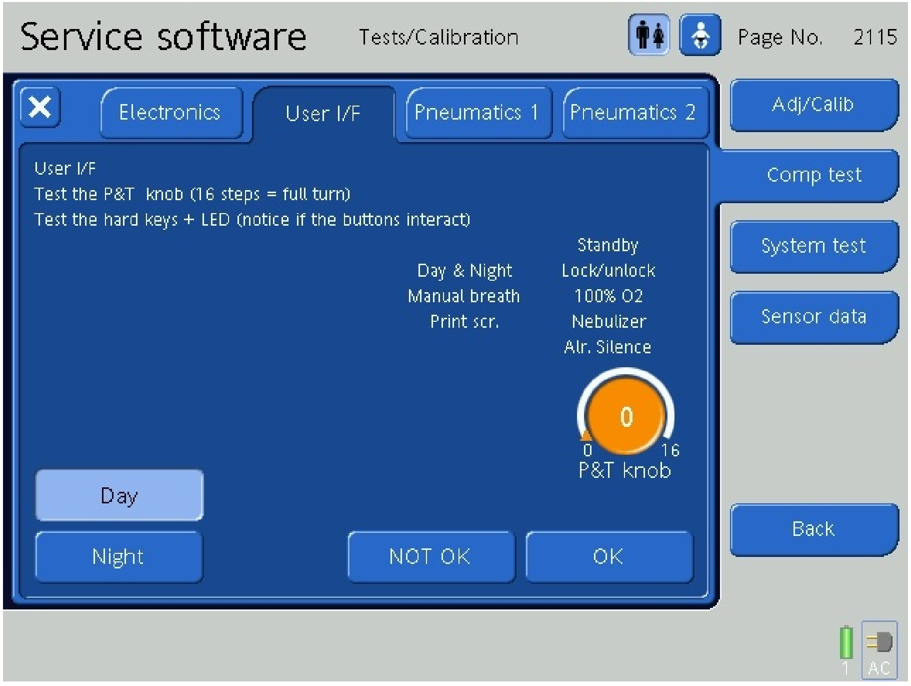


Fig. 100 User interface, P+T knob (Page No 2115)

2. Press P+T knob and check the functioning of the P+T knob by turning it (16 steps = full turn).

3. Press the hard keys, and take note if the keys become lit.

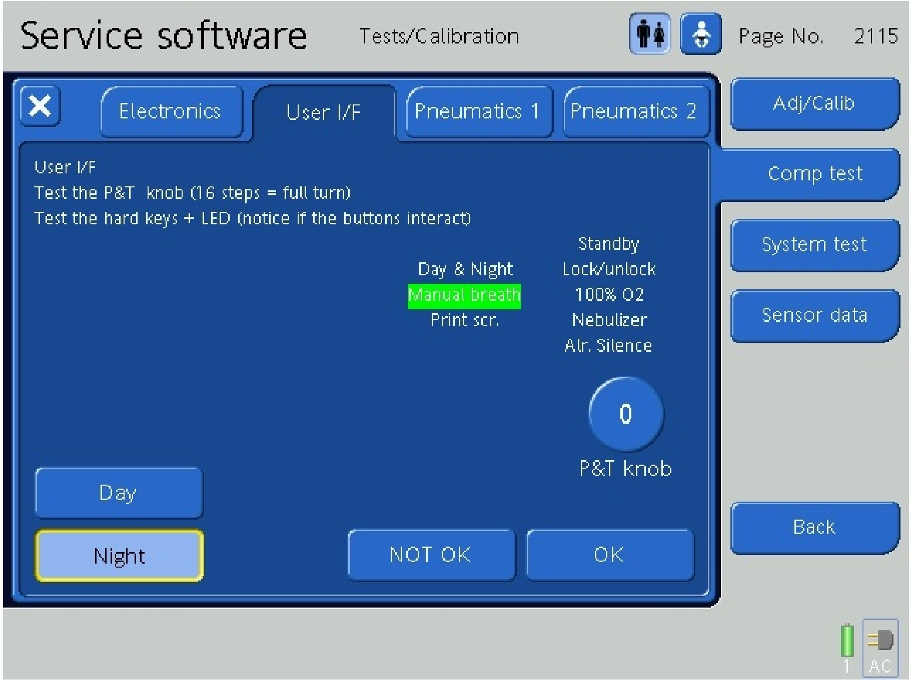


Fig. 101 User interface, hardkeys

4. Touch the **Night/Day** button to switch between the two display brightnesses.

Fig. 102 User interface, day/night brightness

5. Confirm function with **OK/NOT OK**.

9.9.4 Pneumatics 1

1. Touch the **Pneumatics 1** tab to enter the test's of binary valves, autozero, blower flow, blower pressure, and the expiratory valve test's.

9.9.4.1 Binary Valves (Page No 2106)

1. Touch the **Binary valve** button for testing the binary (autozero) valves.

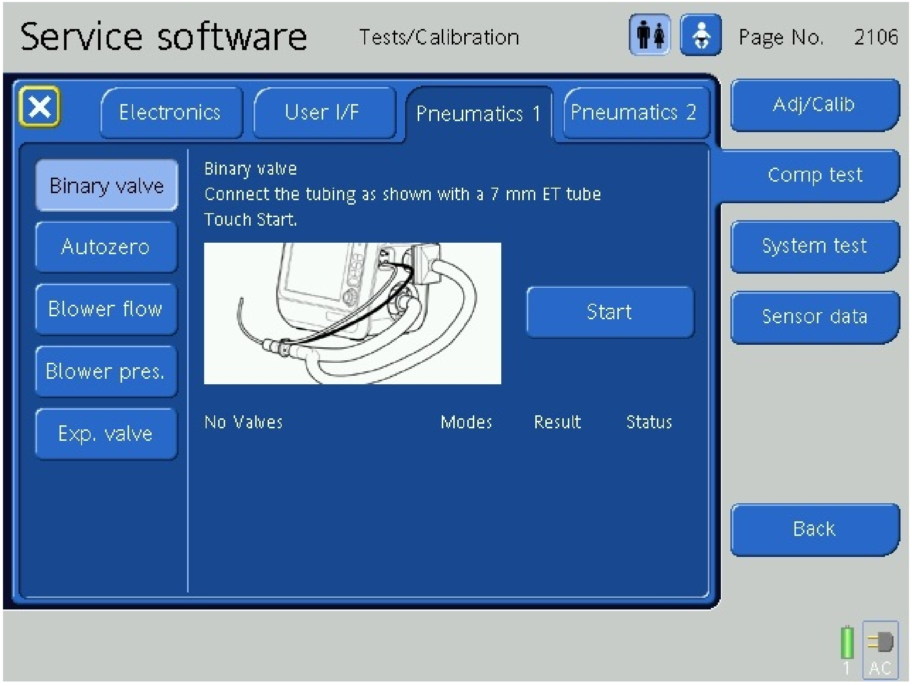


Fig. 103 Binary Valves (Page No 2106)

2. Set up test configuration 3.

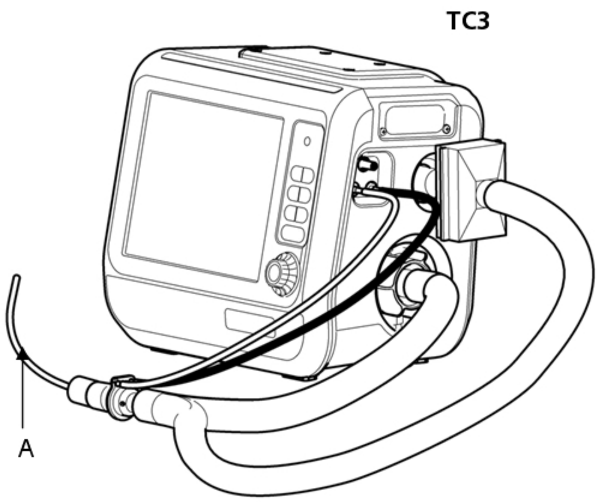


Fig. 104 Test Configuration 3

Legend:

A) 7mm ET-Tube, adult (PN151813)

3. Touch the **Start** button to start the test.

   The test runs automatically as indicated by **Component Test Binary Valves Running** on the screen. This test checks the autozero valves during operation and autozering sequence.

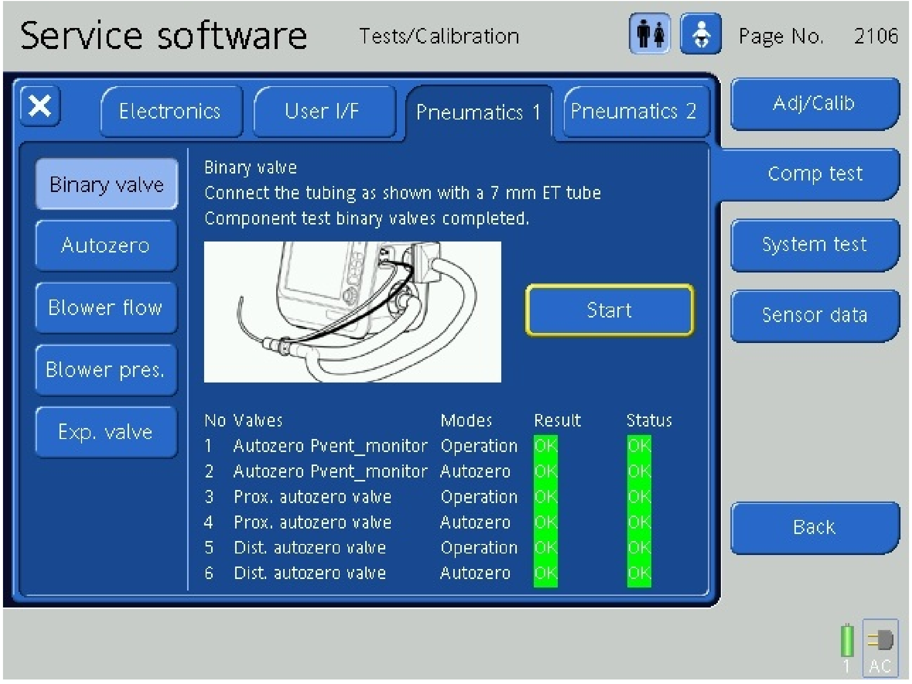


Fig. 105 Binary Valves (Page No 2106), test completed

4. After the test's completion the result (**OK/NOT OK**) and status (OK/ SHORTCIRCUIT/ INTERRUPTION) are displayed.

9.9.4.2 Autozero (Page No 2109)

1. Touch the **Autozero** button to test the sensors: Paw, Qaw, Pvent_monitor and Pvent_control when autozeroing.

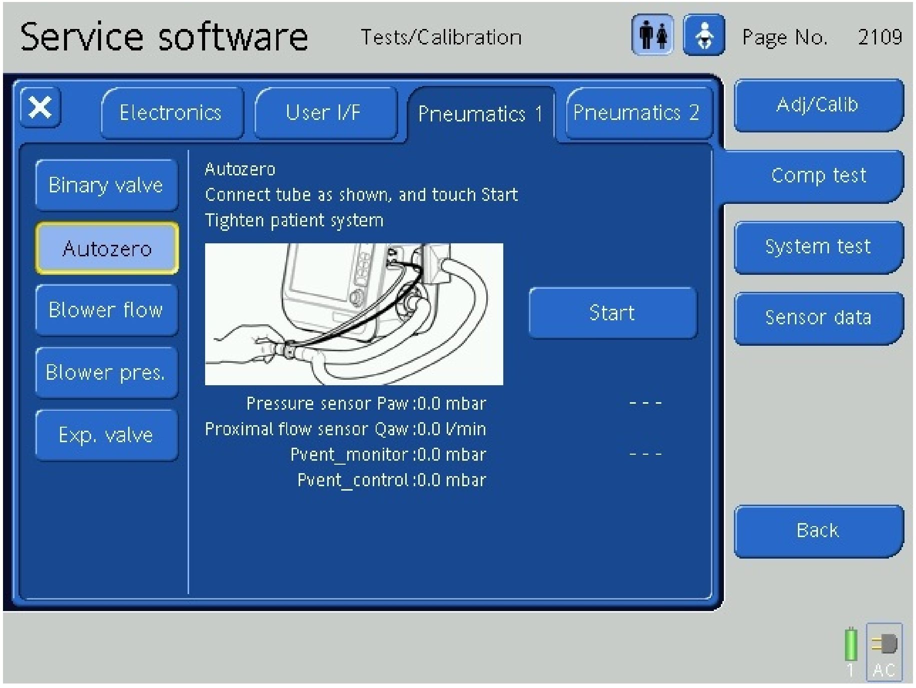


Fig. 106 Autozero (Page No 2109)

2. Set up test configuration 4.

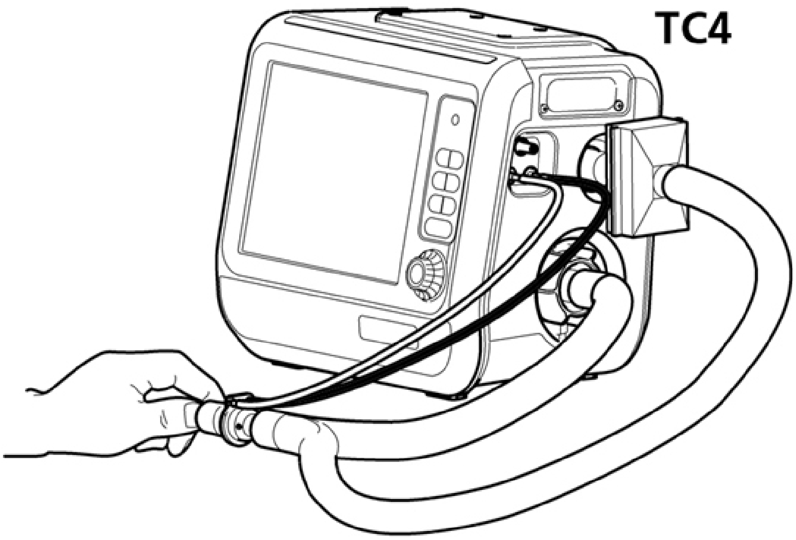


Fig. 107 Test Configuration 4

3. Touch the **Start** button to start the autozero test.

   The test runs automatically indicated by **Autozero running...** on the screen. After the test's completion, the result and status are displayed.

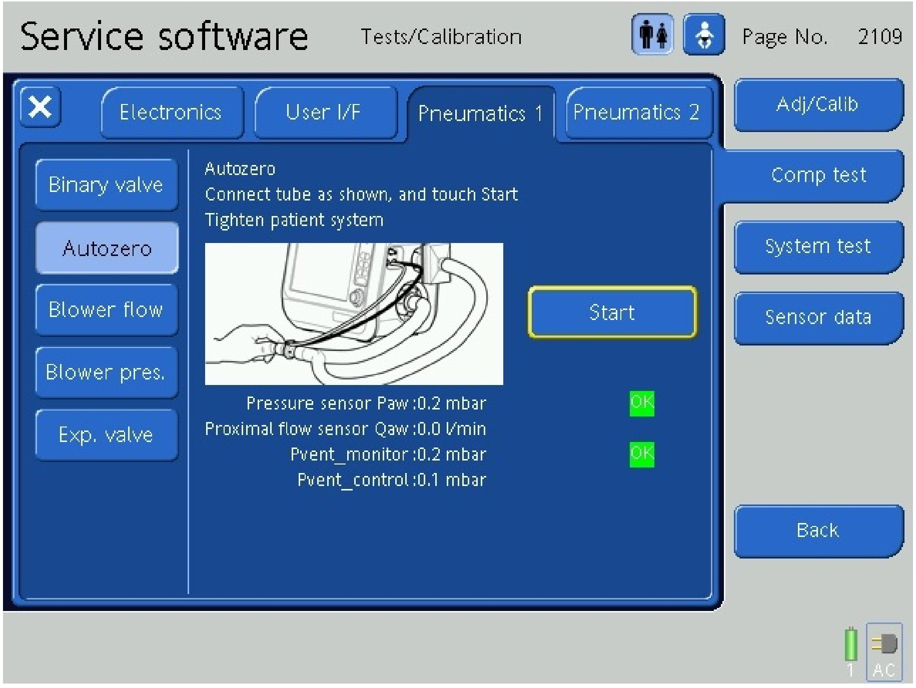


Fig. 108 Autozero (Page No 2109) , completed

9.9.4.3 Blower Flow (Page No 2104)

1. Touch the **Blower Flow** button for test the blower flow.

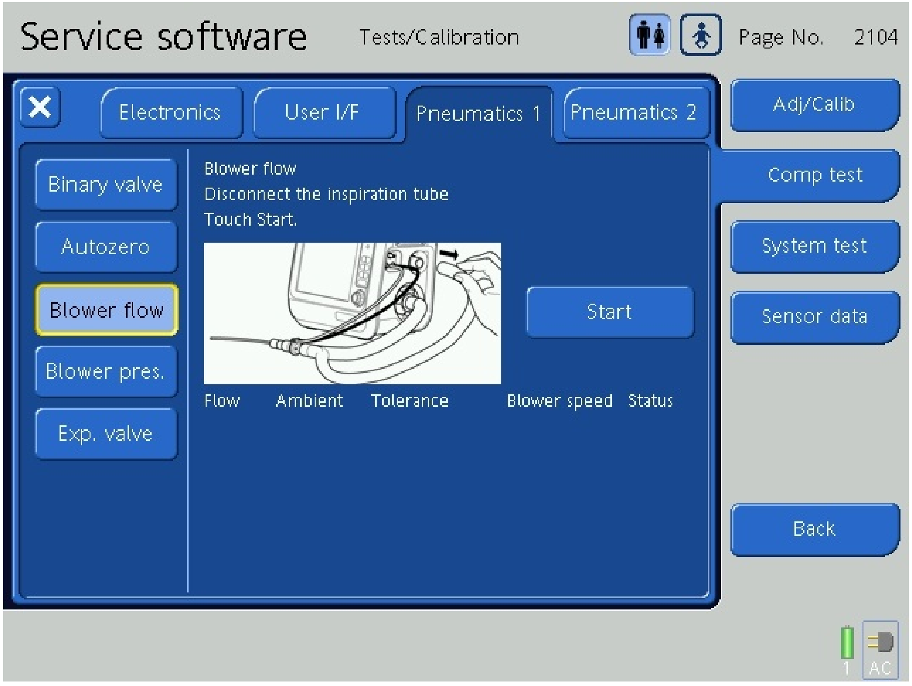


Fig. 109 Blower Flow (Page No 2104)

2. Set up test configuration 5.

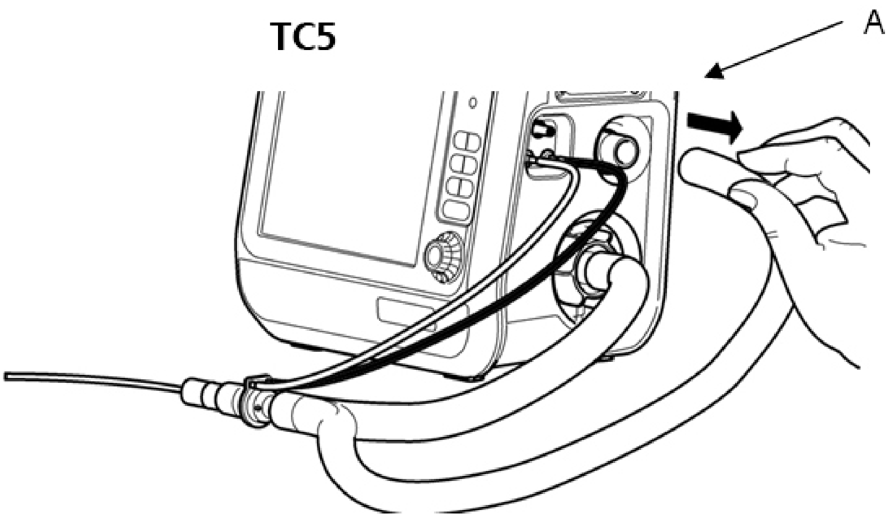


Fig. 110 Test Configuration 5

Legend:

A) Disconnect the inspiration tube.

3. Touch the **Start** button to start the blower flow test.

   The test runs automatically as indicated by **Component test blower flow running...** on the screen. After the test completion the result is displayed with **OK/NOT OK.**

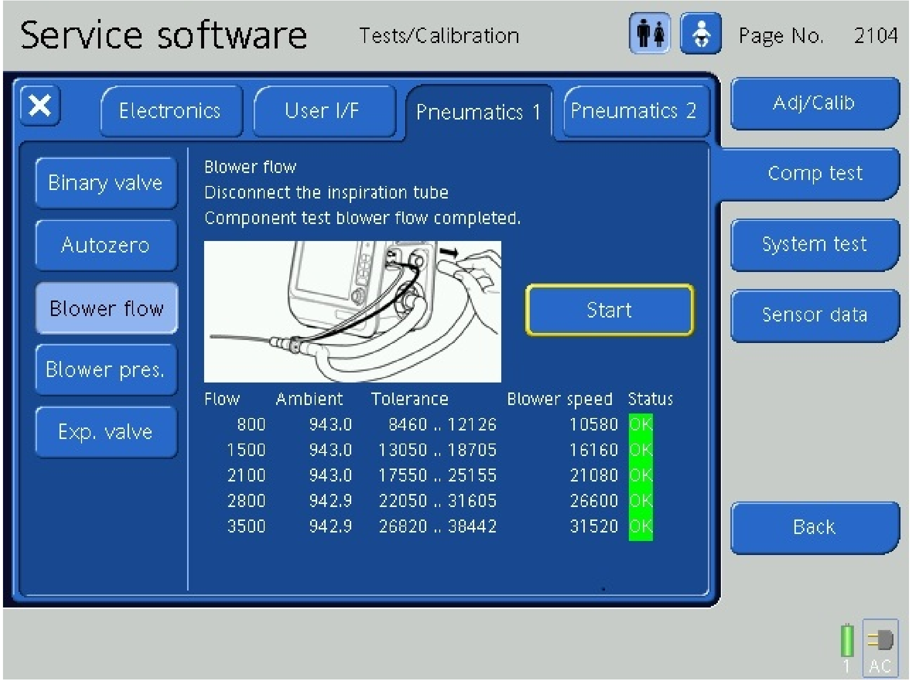


Fig. 111 Blower Flow (Page No 2104), completed

9.9.4.4 Blower Pressure (Page No 2105)

1. Touch the **Blower Pres.** button to test the blower pressure.

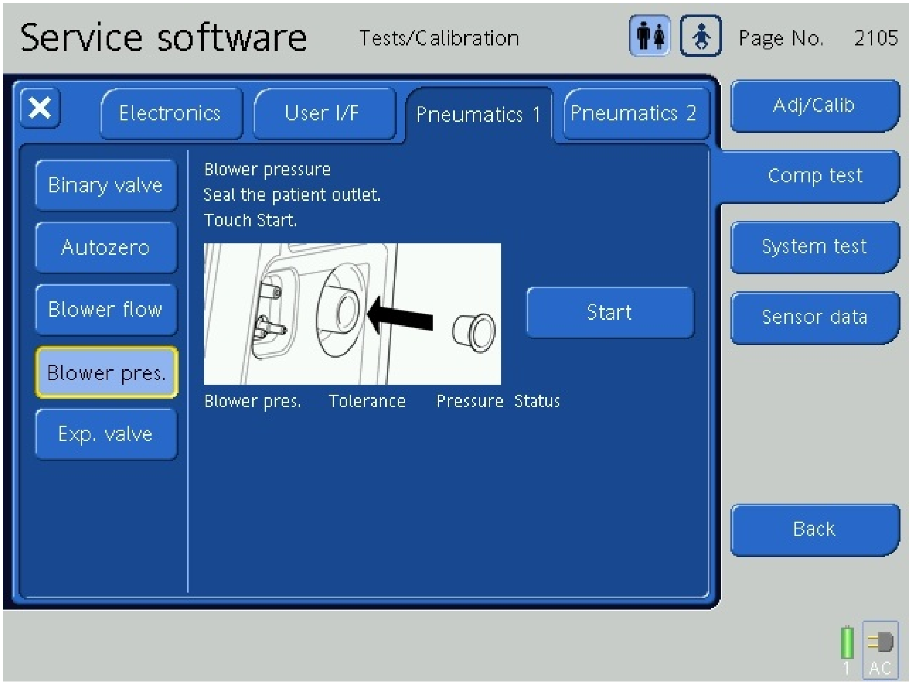


Fig. 112 Blower Pressure (Page No 2105)

2. Set up test configuration 6.

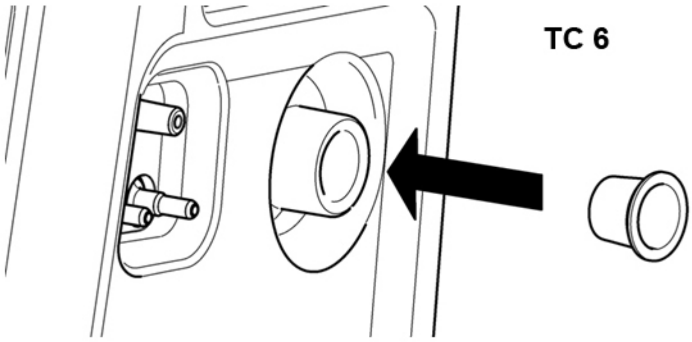


Fig. 113 Test Configuration 6

3. Touch the **Start** button to start the test.

   The test runs automatically as indicated, by **Component test blower pressure running...** on the screen. After the test completion the result is displayed with **OK/NOT OK.**

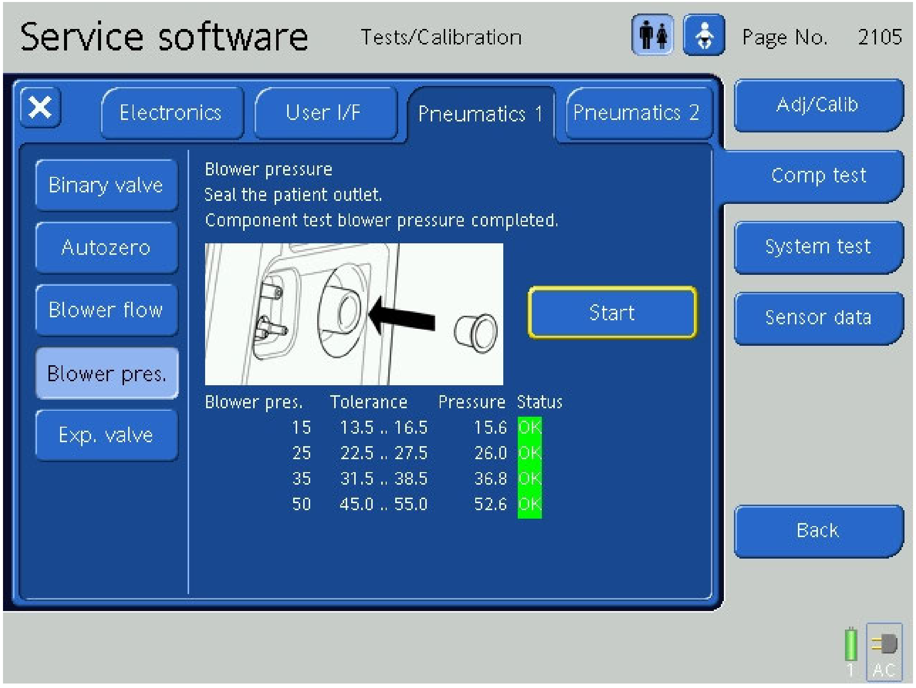


Fig. 114 Blower pressure (Page No 2105), completed

9.9.4.5 Expiratory Valve (Page No 2111)

1. Touch the **Exp. valve** button to test the expiratory valve.

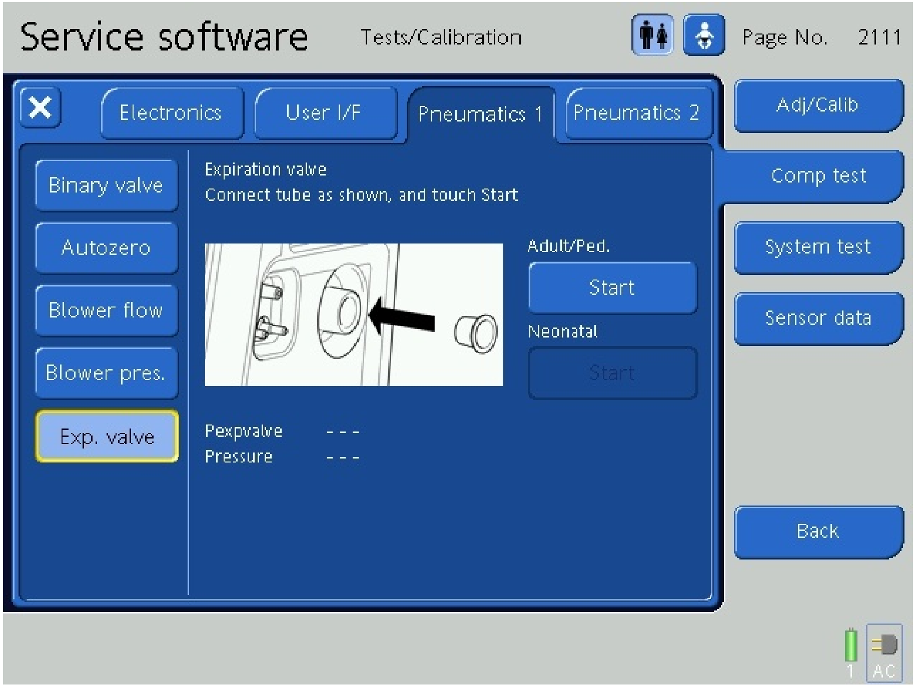
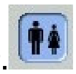


Fig. 115 Adult/Ped. expiratory valve test (Page No 2111)

2. Select the adult mode by touching the adult button in the window header. 

3. Set up test configuration 6 and make sure the adult/ped. expiratory valve cover is installed.

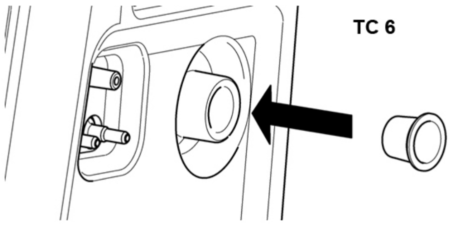


Fig. 116 Test configuration 6

4. Touch the **Start** button to start the Pexpvalve test.

   The test runs automatically indicated by **Pexpvalve pressure test in progress**... on the screen. After the test completion the result is displayed with **OK/NOT OK**.

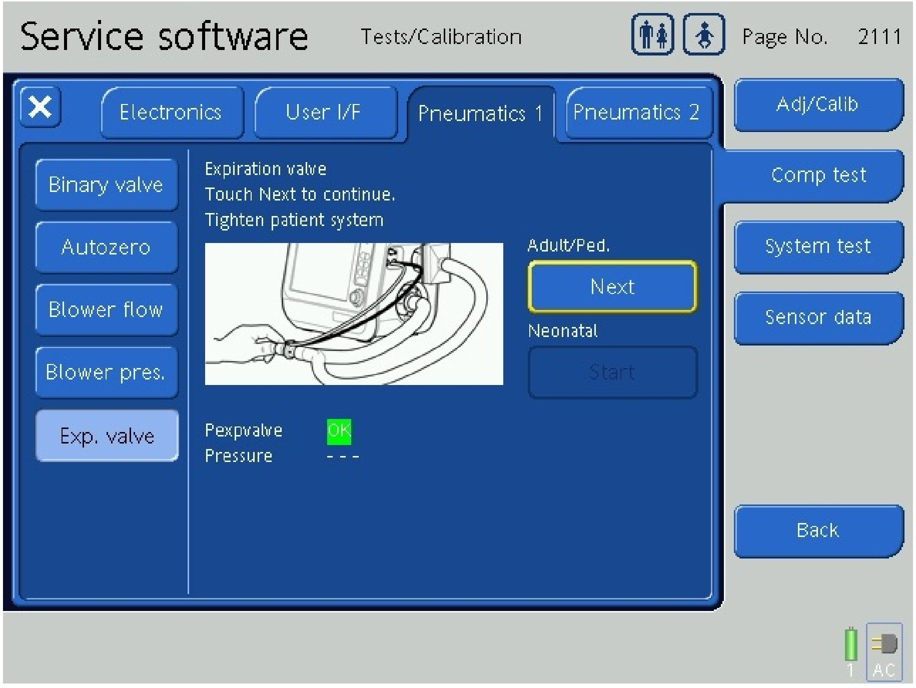


Fig. 117 Adult/Ped. expiratory valve (Page No 2111), Pexpvalve test

5. For pressure test set up test configuration 4.

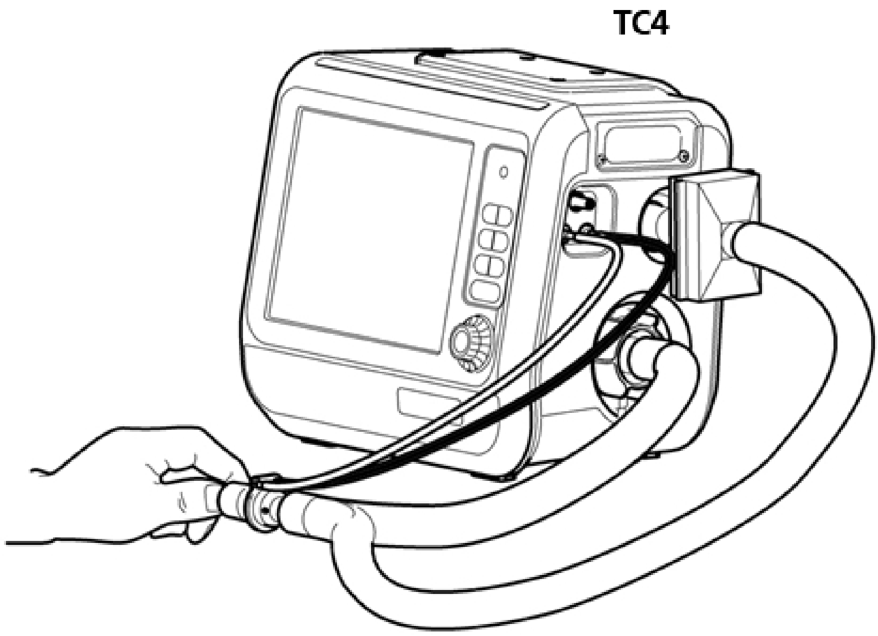


Fig. 118 Test Configuration 4

6. Touch the **Next** button to start the pressure test.

7. The test runs automatically as indicated by **Expiration valve pressure test in progress...** on the screen. After the test completion the result is displayed with **OK/NOT OK.**

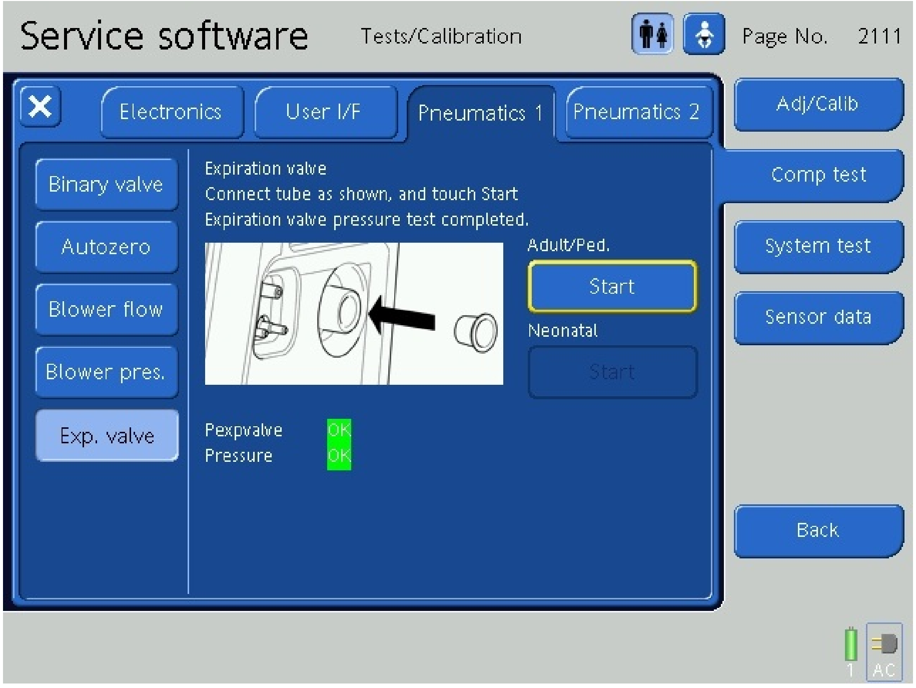


Fig. 119 Adult/ped. expiratory valve (Page No 2111), Pressure test

9.9.5 Pneumatics 2

1. Touch the **Pneumatics 2** tab to enter the test's of:

- O2 input
- Nebulizer valve
- Proximal flow and pressure
- Rinse flow
- Rinse flow tank
- Check valve assembly
- Air entry (HEPA Filter)

9.9.5.1 O2 Input (Page No 2112)

1. Touch the **O2 input** button for testing the O2 input (flow and leakage).

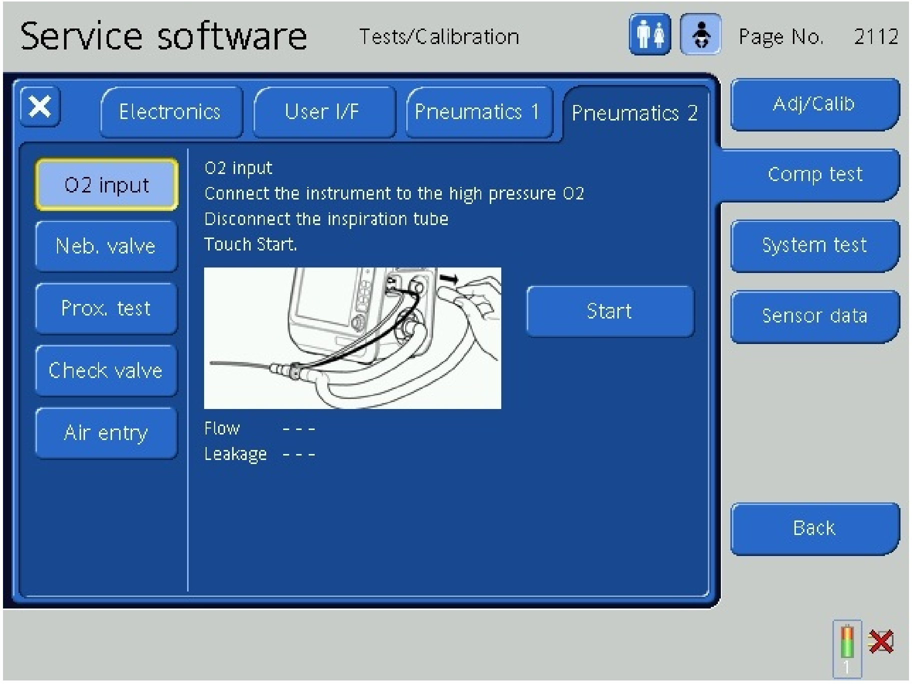


Fig. 120 O2 input (Page No 2112)

2. Set up test configuration 5.

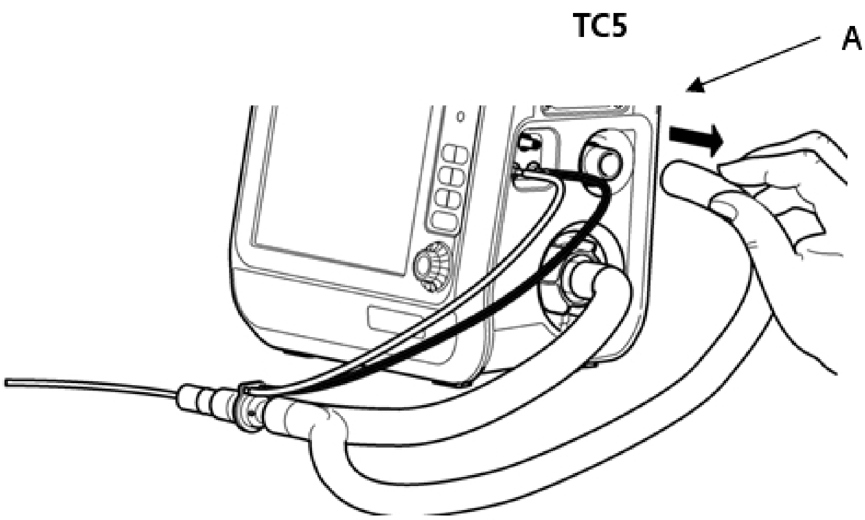


Fig. 121 Test configuration 5

Legend:

A) Disconnect the inspiratory tube.

3. Connect the ventilator to high-pressure O2 (HPO).

4. Touch the **Start** button to start the flow test.

The **Flow test** runs automatically, indicated by **O2 valve flow test in progress**... on the screen. After the test completion the result is displayed with **OK/NOT OK.**

The **Leakage test** starts automatically after the flow test indicated by **O2 valve flow test in progress**... on the screen.

The result is displayed with **OK/NOT OK** when test completed.

Note	In case the test fails, connect the inspiratory tube and repeat the test.

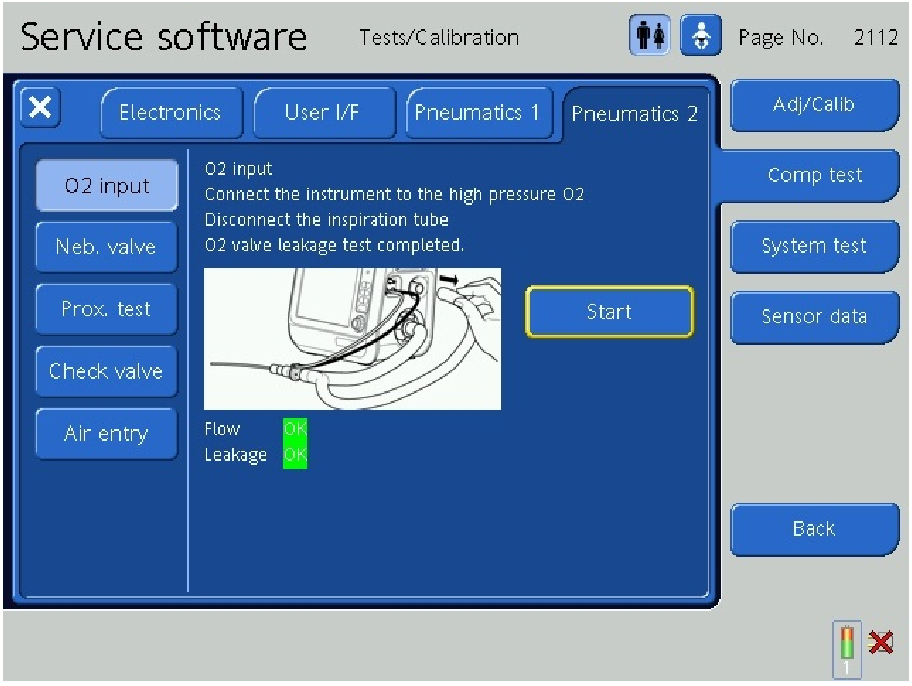


Fig. 122 O2 input (Page No 2112)

9.9.5.2 Nebulizer Valve (Page No 2116)

1. Touch the **Neb. valve** button to test the nebulizer valve.

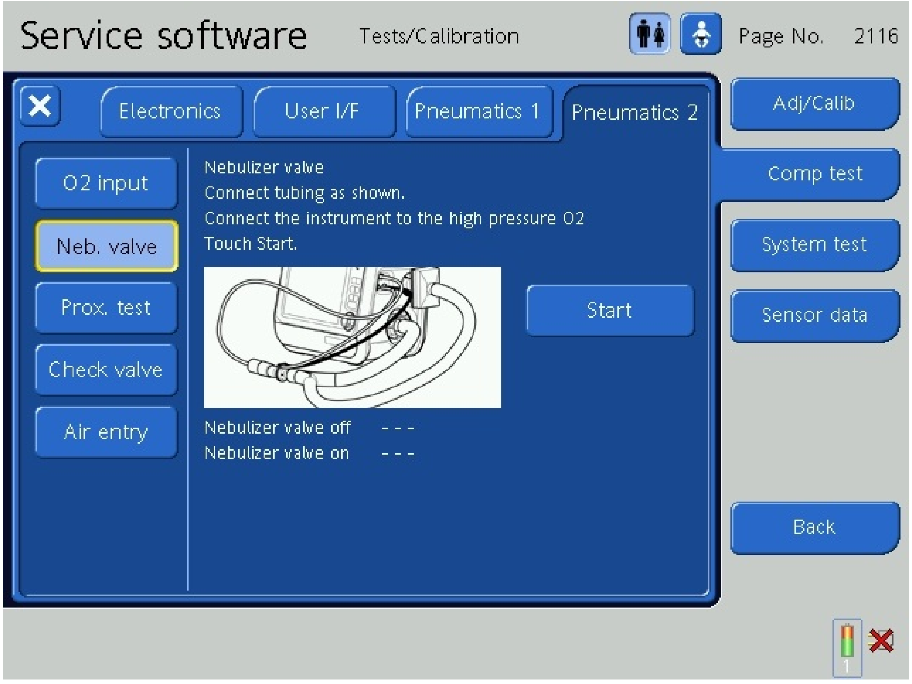


Fig. 123 Nebulizer valve (Page No 2116)

2. Set up test configuration 7.

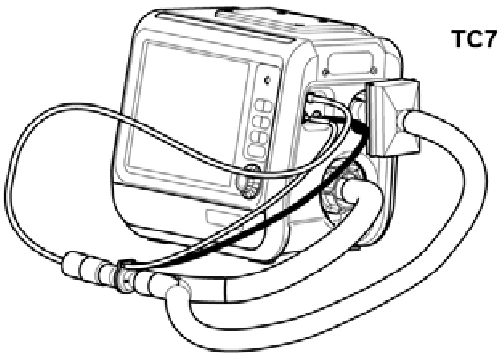


Fig. 124 Test Configuration 7

3. Connect the ventilator to high pressure O2 (HPO).

4. Touch the **Start** button to start the nebulizer on/off test.

   The test runs automatically indicated by **Nebulizer valve test is running**... on the screen. After the test completion the result is displayed with **OK/NOT OK**.

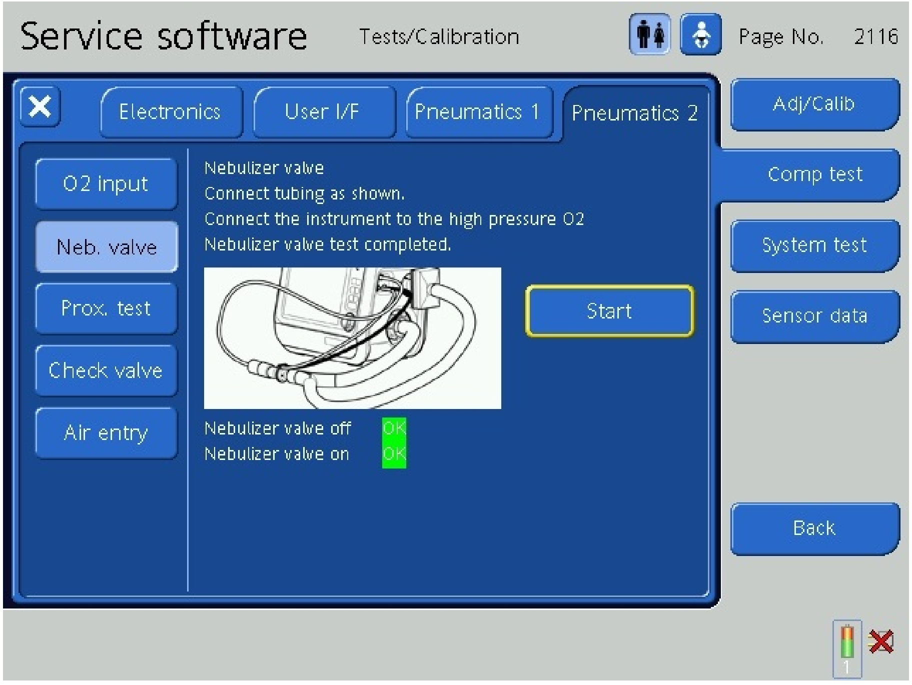


Fig. 125 Nebulizer valve (Page No 2116)

5.

Note	The service software cannot detect small leaks of the nebulizer internal connection. Carry out additional nebulizer tightness checks. Refer to Chapter 9.16

9.9.5.3 Proximal Test (Page No 2110)

1. Touch the **Prox. Test** button to test the rinse flow, proximal pressure, proximal pressure, and Rinse tank.

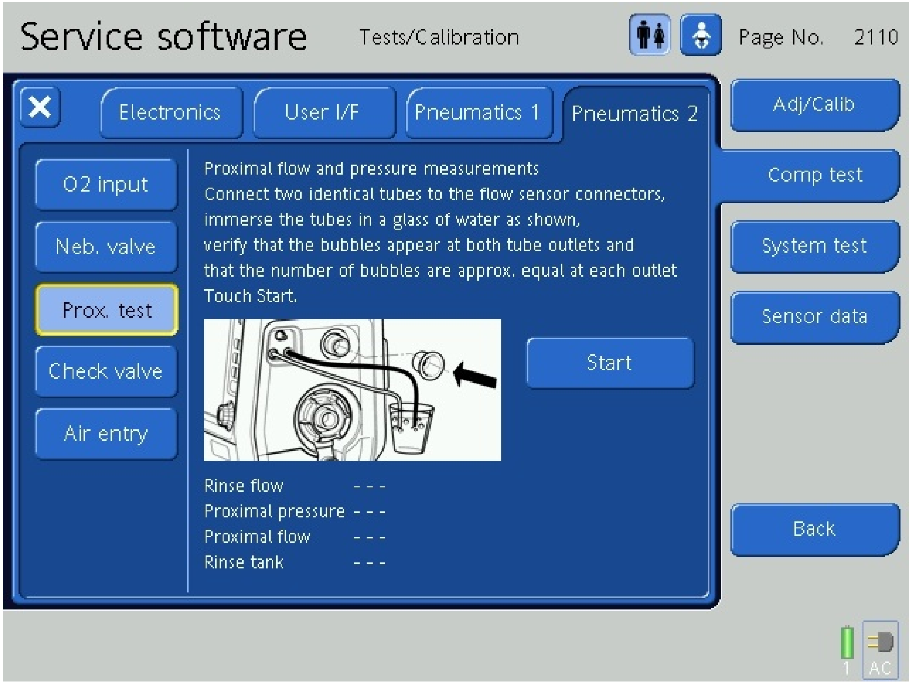


Fig. 126 Proximal Test (Page No 2110)

2. Set up test configuration 8.

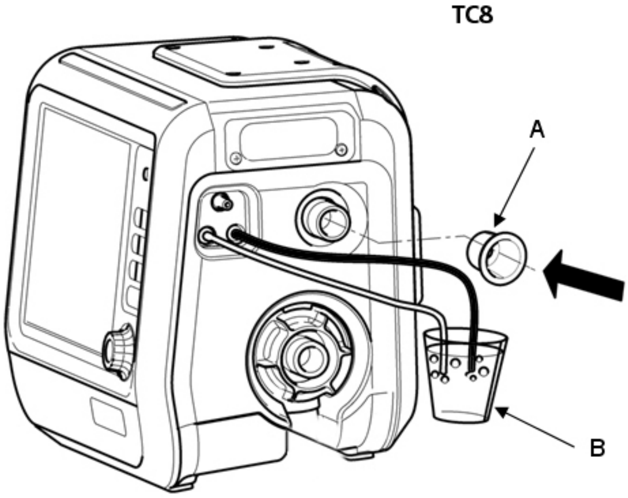


Fig. 127 Test configuration 8

Legend:

A) Stopper (PN 281717)

B) Glass of water

3. Close the inspiratory port with a stopper (A).

4. Attach 2 tubes of identical length to the flow sensor connectors, immerse the tubes in a glass of water (B).

5. Touch the **Start** button to start the rinse flow test .

6. Verify that the bubbles appear at both tube outlets and that the number of bubbles are approximately equal on each outlet and confirm with **OK/NOT OK.**

7. Set up test configuration 3.

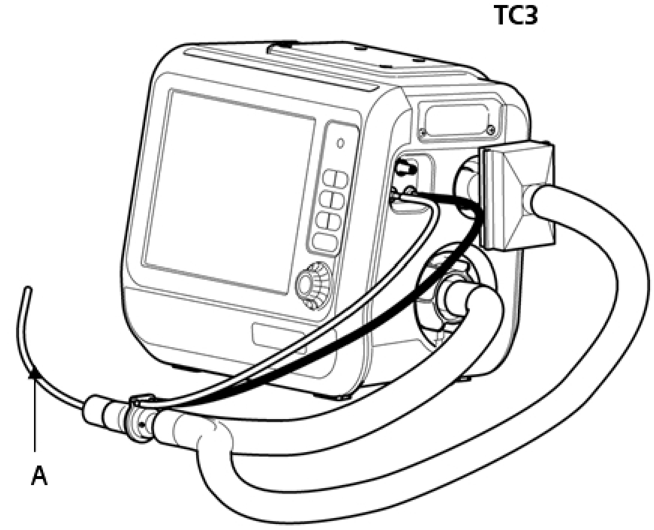


Fig. 128 Test configuration 3

Legend:

A) 7 mm ET-Tube, adult (PN 151813)

8. Touch **Start** button to start the proximal pressure test.

   The test runs automatically, indicated by **Proximal Pressure test is running...** on the screen. After the test completion the result is displayed with **OK/NOT OK.**

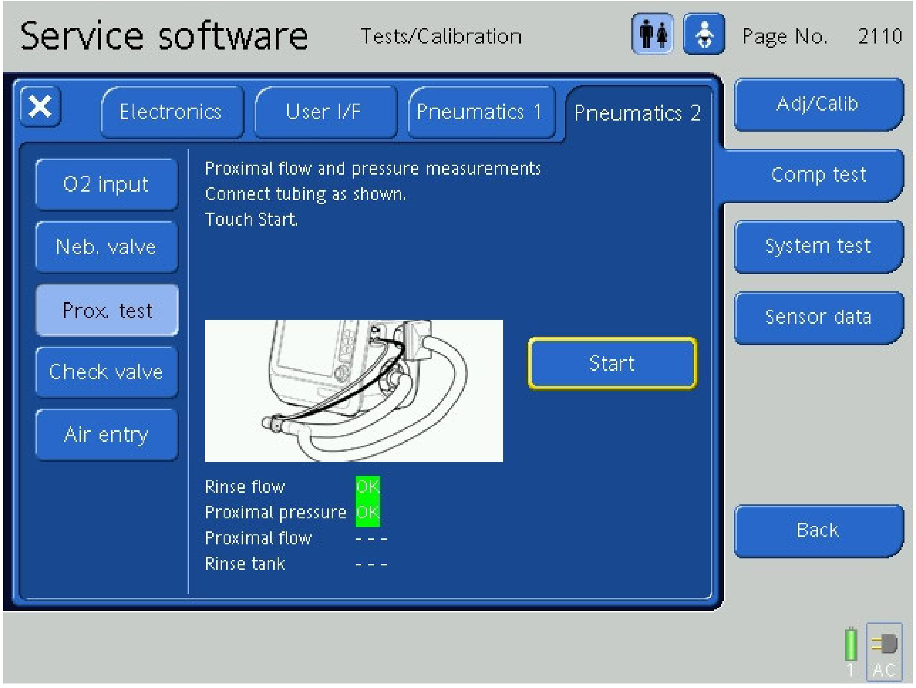


Fig. 129 Proximal test (Page No 2110), Proximal pressure

9. Set up test configuration 9.

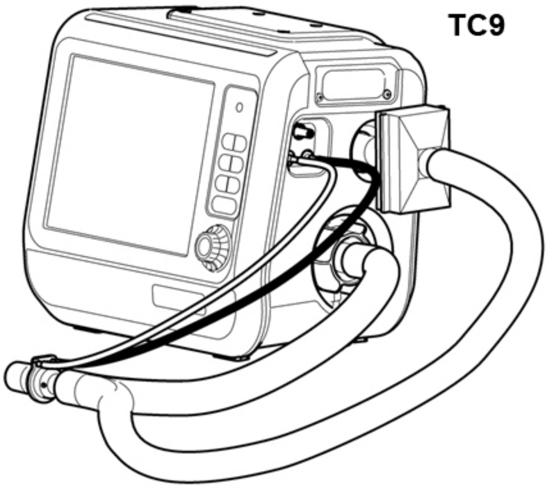


Fig. 130 Test configuration 9

10. Touch the **Start** button to start the proximal flow test.

    The test runs automatically, indicated by **Proximal Flow test in progress**... on the screen. After the test completion the result is displayed with **OK/NOT OK.**

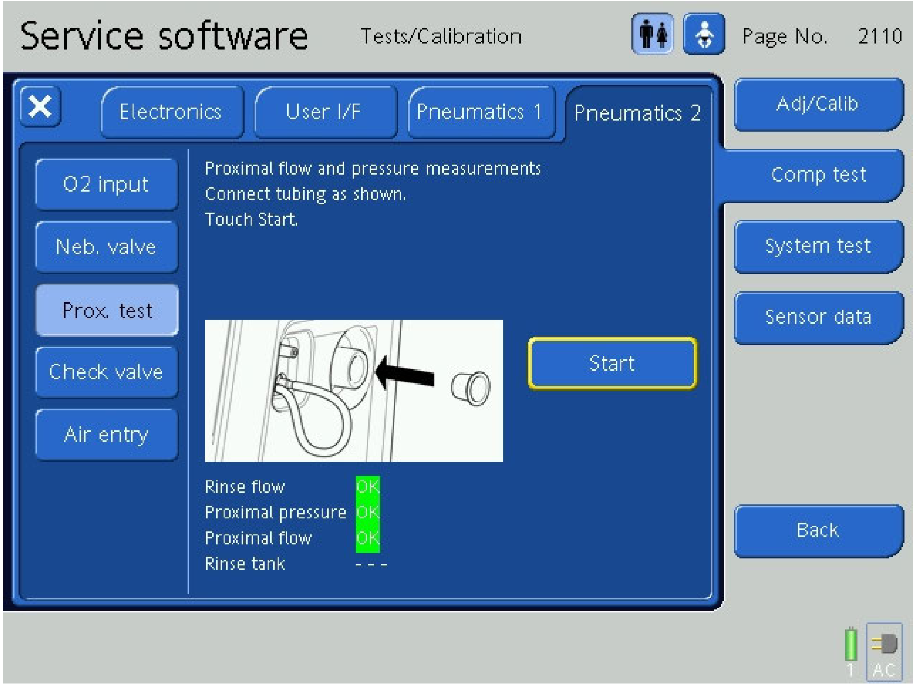


Fig. 131 Proximal Test (Page No 2110), Proximal flow

11. Set up test configuration 10.

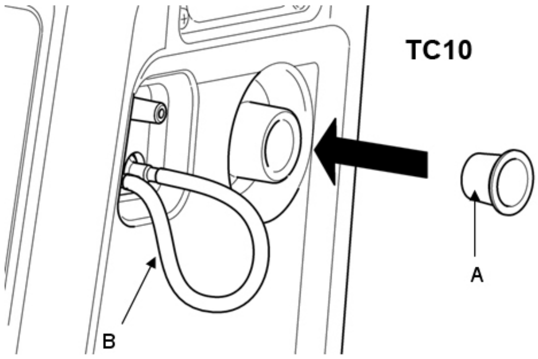


Fig. 132 Test configuration 10

Legend:

A Stopper (PN 281717)

B 4mm tube

12. Close the inspiratory port with a stopper (A).

13. Use a tube to connect both flow sensor connectors with each other.

14. Touch **Start** button to start the rinse tank tightness test.

The test runs automatically indicated by **Rinse tank test running**... on the screen. After the test completion the result is displayed with **OK/NOT OK**.

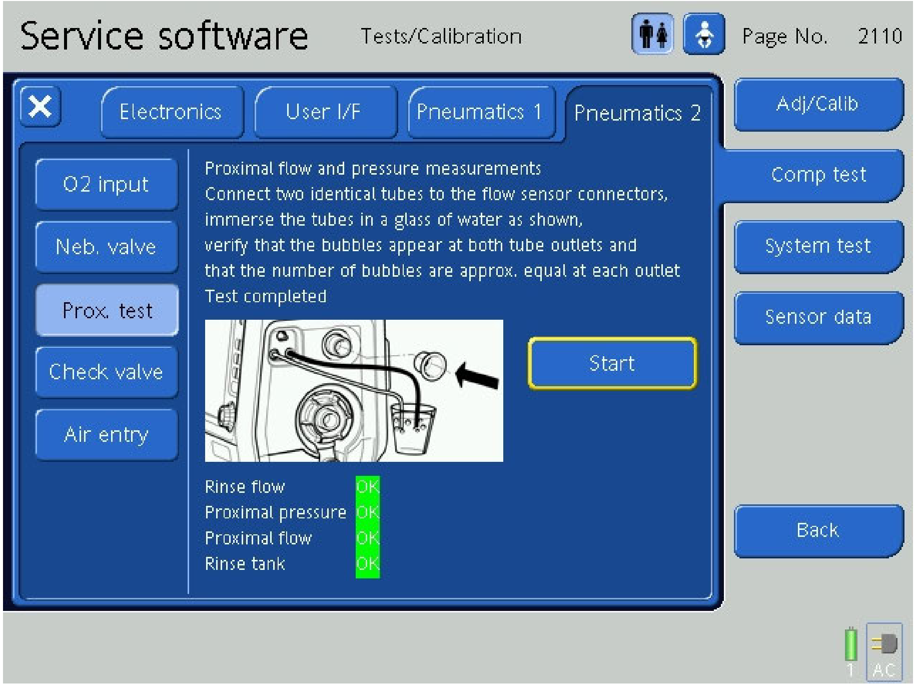


Fig. 133 Proximal Test (Page No 2110), Rinse tank

9.9.5.4 Check Valve (Page No 2118)

1. Touch the **Check valve** button to test the functionality of the check valve assembly.

Tab. 12 Overview check valve assembly

Available test(s)	Check valve assembly installed
—Check valve	PN 161243 (HAMILTON-C1 < SN6000)
—Tightness —Obstr. valve active	PN 161192 (HAMILTON-C1 ≥ SN6000)
Make sure the correct part number (PN) has been entered in the technial state. Refer to Chapter 9.7.4	

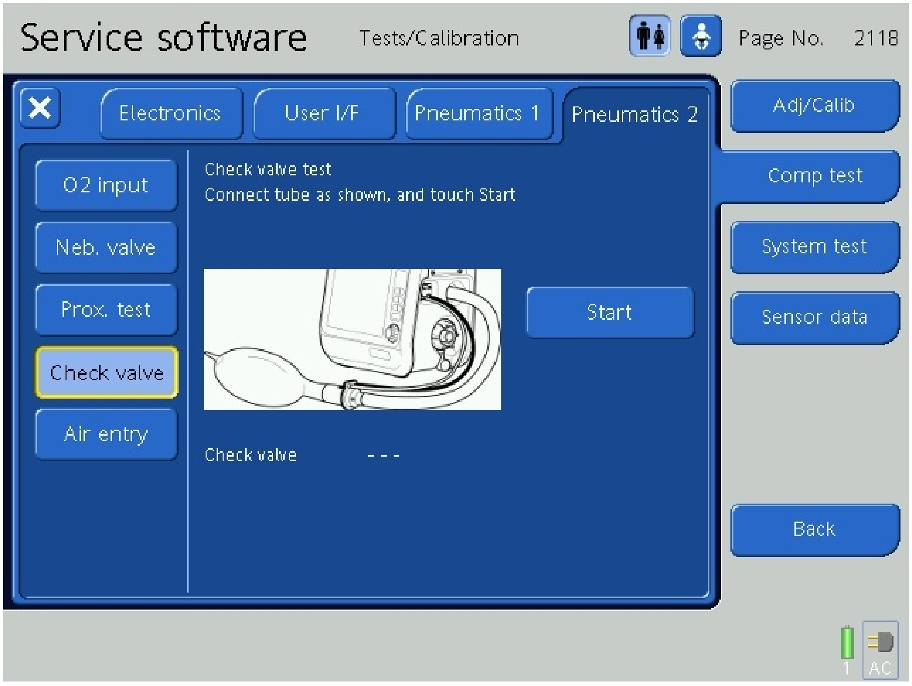


Fig. 134 Check valve (Page No 2118), with check valve assembly PN161243

2. Set up test configuration 11.

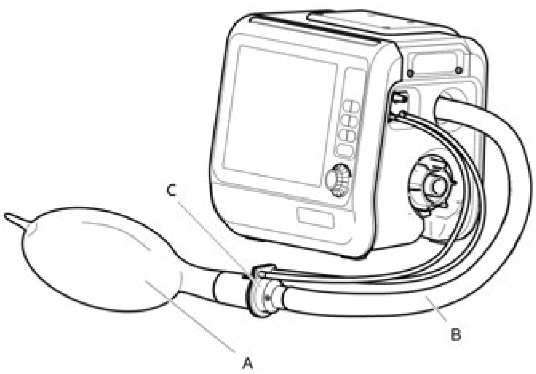


Fig. 135 Test Configuration 11

Legend:

A) Adult demo lung (PN 151815)

B) Silicone tube 35cm 22F (PN 260100)

C) Connector 22M/15F-22M/15F (PN 281420)

3. Touch the **Start** button to start the check valve test.

The test runs automatically, indicated by **One way check valve test running...** on the screen. After test completion the result is displayed with **OK/NOT OK**.

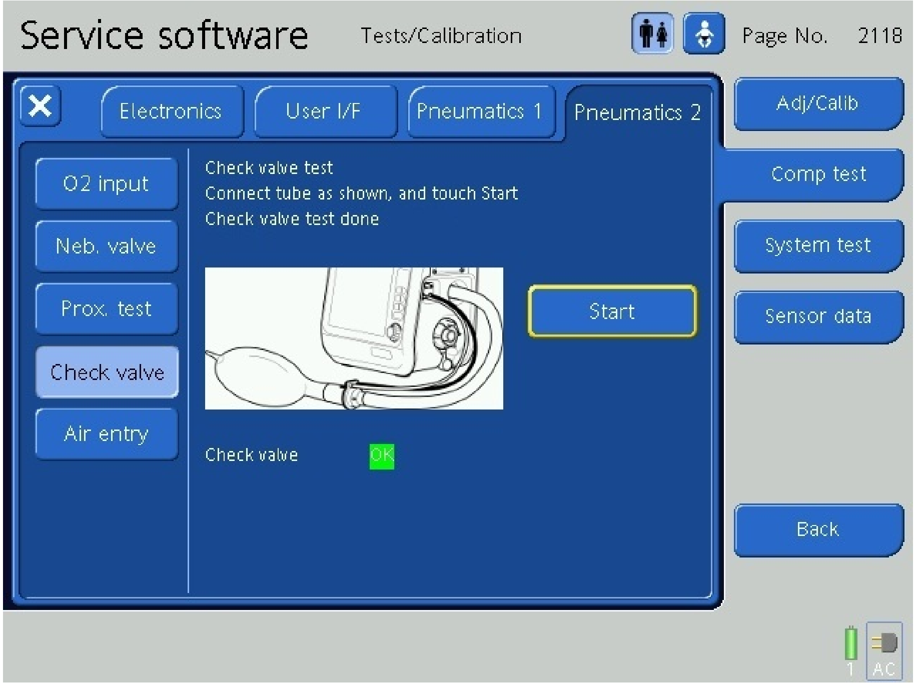


Fig. 136 Check valve (Page No 2118)

4. Set up test configuration 11. Fig 135.

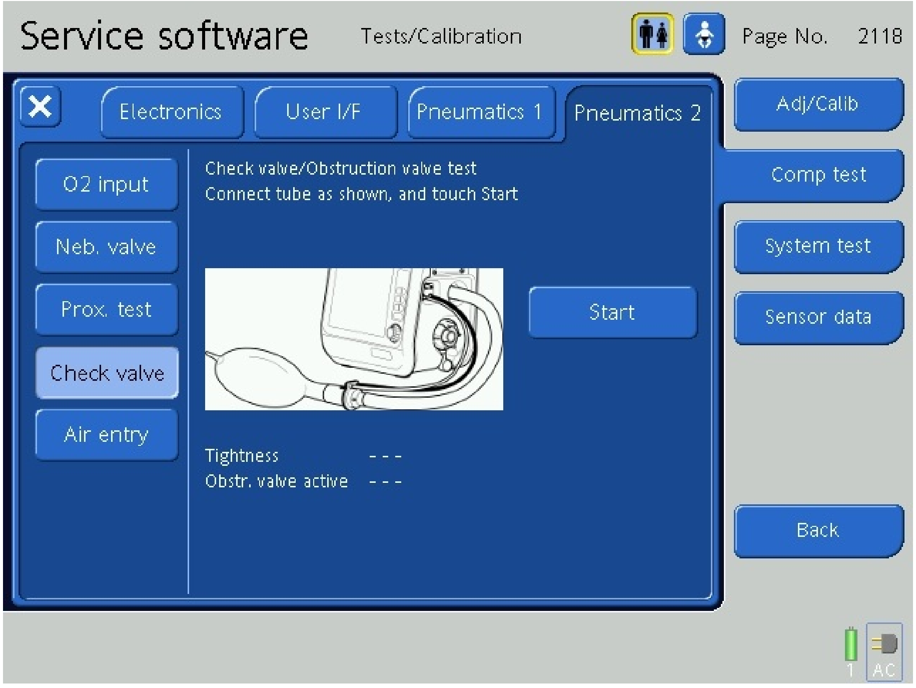


Fig. 137 Tightness (Page No 2118), with check valve assembly PN161192

5. Touch the **Start** button to start the tightness test of the check valve assembly.

6. The test runs automatically, indicated by **Check valve/Obstruction valve test running**... on the screen.

   After test completion, the result is displayed with **OK/NOT OK.**

   The **obstruction valve active** test starts automatically after the check valve tightness test.

   After test completion, the result is displayed with **OK/NOT OK.**

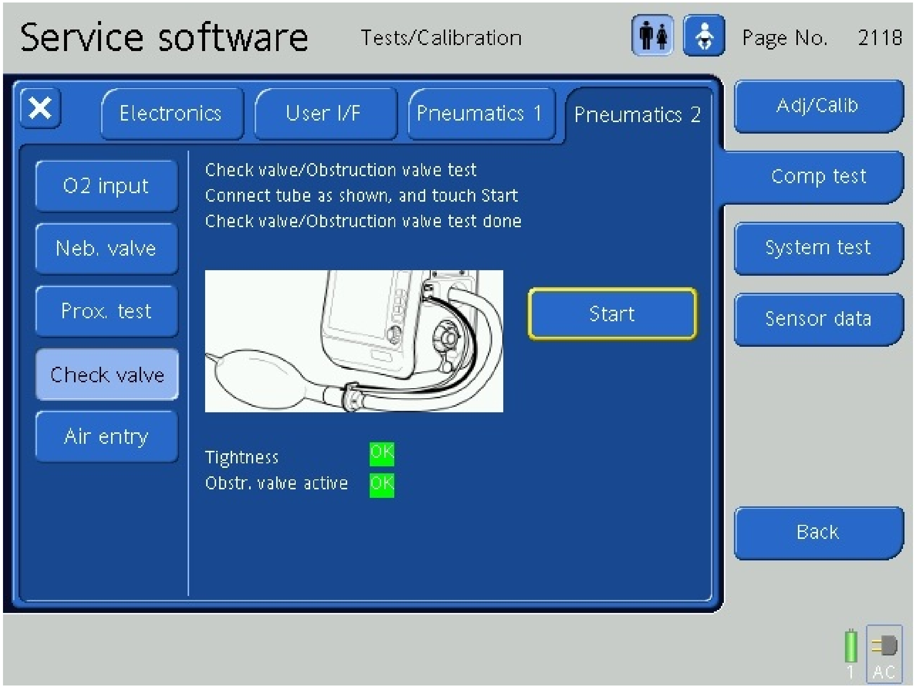


Fig. 138 Obstruction valve (Page No 2118), with check valve assembly PN161192

9.9.5.5 Air Entry Test (Page No 2117)

1. Touch the **Air entry button** to test the air entry (Pambient/ Pfilter)

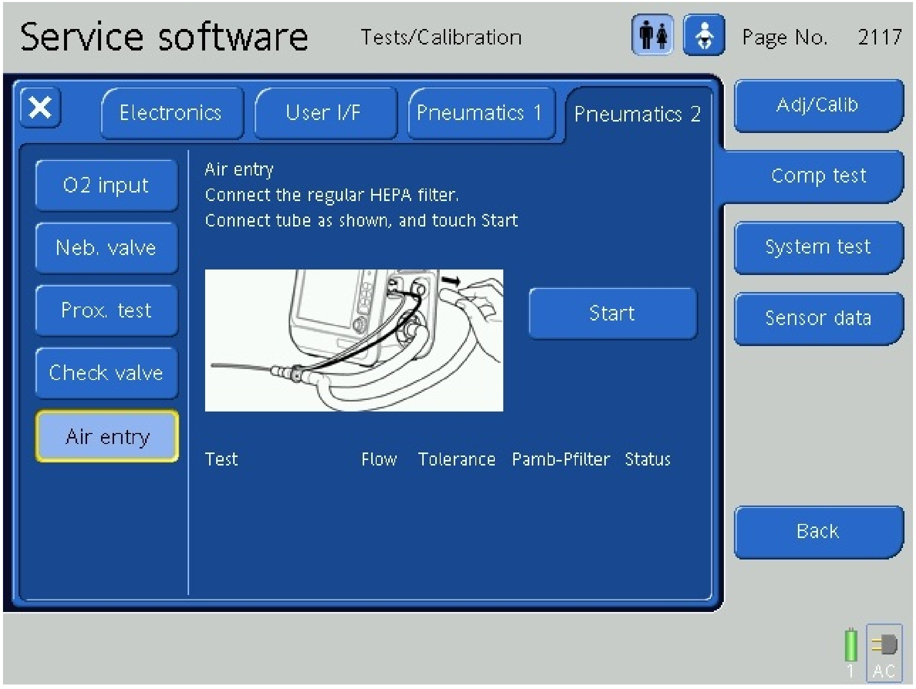


Fig. 139 Air Entry Test (Page No 2117)

2. Set up test configuration 5.

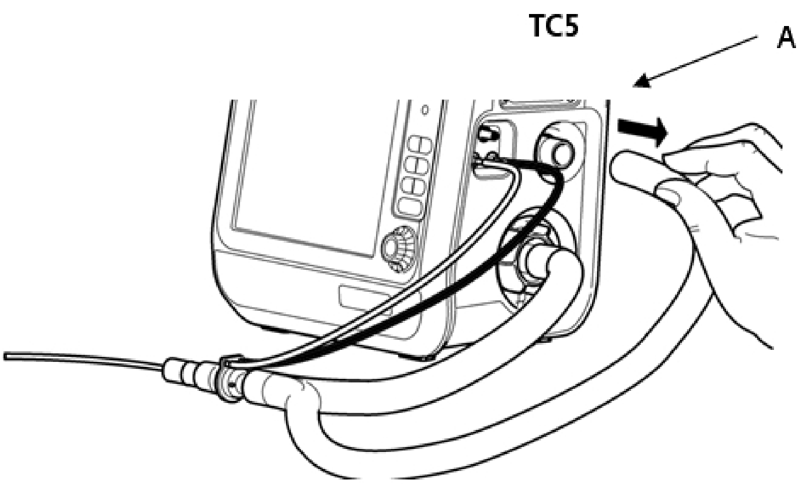


Fig. 140 Test Configuration 5

Legend:

A) Disconnect the inspiration tube

3. Ensure the HEPA filter is installed.

4. Touch the **Start** button to start the test's.

The HEPA filter **test** runs automatically, indicated by **Airway entry test is running**... on the screen. The result is displayed with **OK/NOT OK** when the pressure of the filter (Pfilter) is within the defined tolerance.

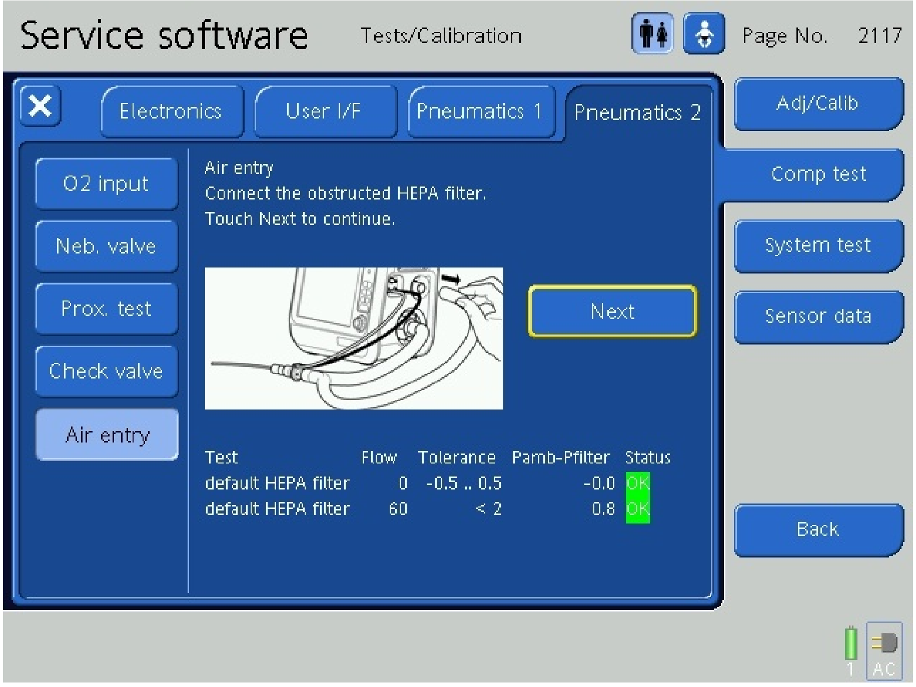


Fig. 141 Air Entry Test (Page No 2117)

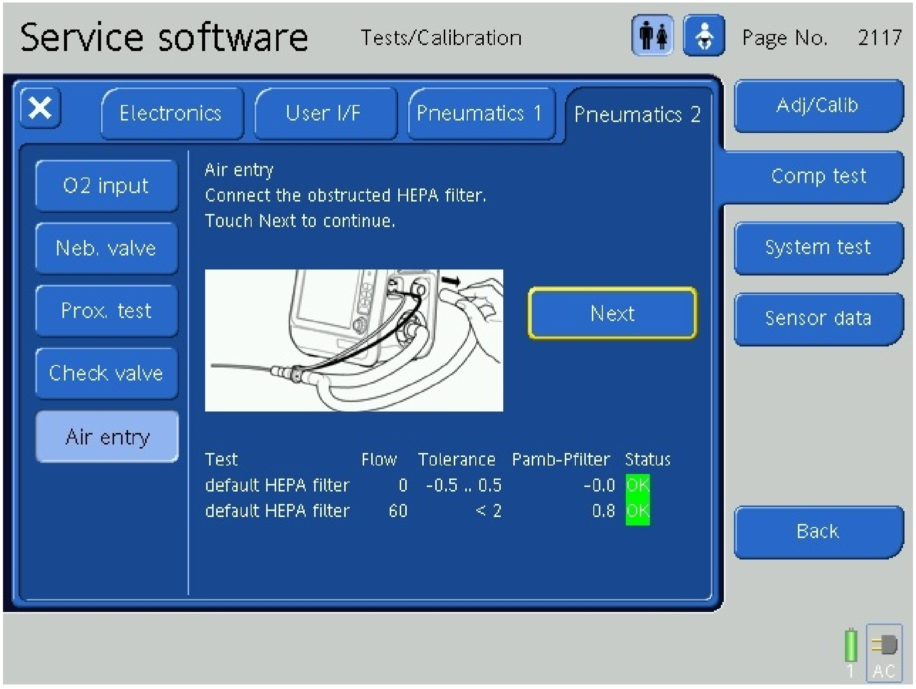


Fig. 142 Airway Entry Test (Page No 2117), with default HEPA filter

5. Touch the **Next** button to continue and to test with an obstructed HEPA filter.

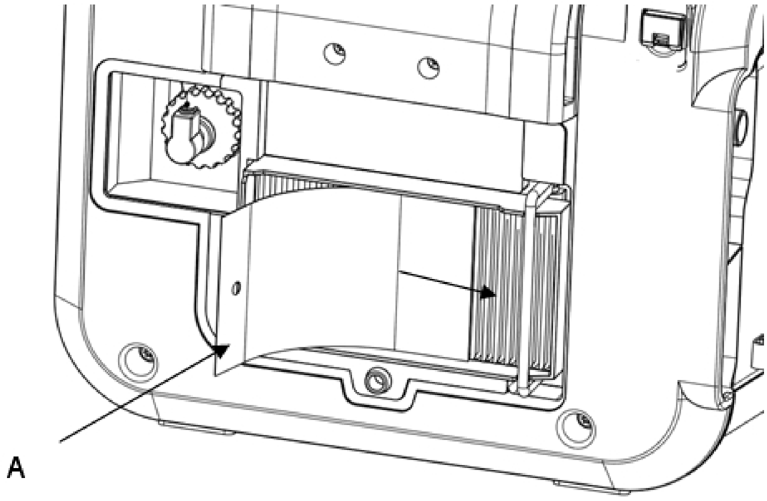


Fig. 143 Obstruction on air entry

Legend:

A) Piece of plastic foil (A) or paper 120x60mm with a small hole.

6. Create an obstruction on the HEPA filter by blocking it with a piece of plastic foil (A) or paper containing a small hole in order to achieve Pfilter >= 2mbar.

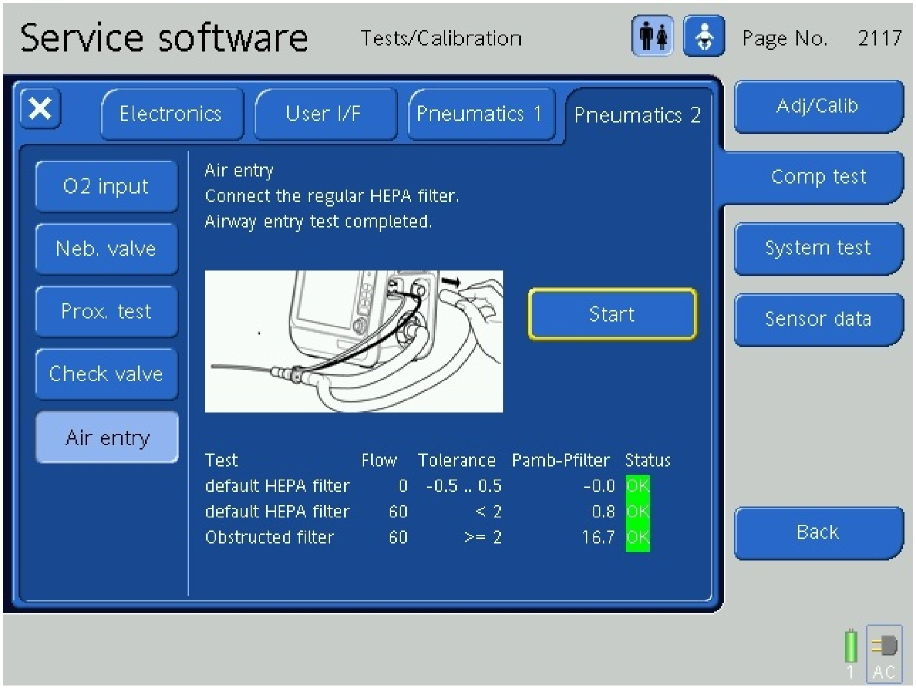


Fig. 144 Airway Entry Test (Page No 2117)

7. The test ends successfully when the pressure Pamb-Pfilter is within the given tolerance for an obstructed filter.

9.10 System Test (ADULT/PED.)

1. Touch the **System test** tab to enter the system test's of:

- Pressure
- Flow
- O2 mixer
- Tightness
- Alarming

9.10.1 Overview System Test

System Tests	Description	Component tested
Tests/Calib > System test > **Pressure** **(Page No 2201)** Chapter 9.10.2	This test requires three different pressures to be applied and to verify the values (Pvent_control, Pvent_monitor Paw and Pexp valve) are within the given tolerance range (shown in a green or red background).	– Pvent_control, – Pvent_monitor – Paw – Pexp valve
Tests/Calib > System test > **Flow** **(Page No 2202)** Chapter 9.10.3	This test requires a flow to be applied and to verify the internal flow sensor Qvent and the proximal flow sensor Qaw values are within the given tolerance range (shown in a green or red background). Additionally the flow has to be verified with an external flow analyzer.	– flow sensor Qvent, – flow sensor Qaw
Tests/Calib > System test > **O2 mixer** **(Page No 2203)** Chapter 9.10.4	This test requires a flow at different O2 concentrations to be applied to verify the internal flow sensor QO2, flow sensor Qvent, the proximal flow sensor and the O2 cell values are within the given tolerance range (shown in a green or red background).	– O2 mixer assembly – flow sensor QO2 – O2 cell
Tests/Calib > System test > **Tightness** **(Page No 2204)** Chapter 9.10.5	This test checks for leakage in the patient breathing circuit and determines the circuit's compliance compensation factor. The ventilator is pressurized to a certain pressure. The circuit is considered tight if this pressure can be maintained. If there is a leak, the pressure drops in proportion to the size of the leak.	Patient breathing circuit
Tests/Calib > System test > **Alarming** **(Page No 2205)** Chapter 9.10.6	This test allows activation of the 3 different alarm priorities and combinations by pressing the corresponding button and to verify the correct alarm lamp and sound has been generated. The test result needs to be confirmed manually.	Alarm priorities

9.10.2 Pressure Test (Page No 2201)

1. Touch the **Pressure** button to test the pressure measurement.
2. Set Pinsp=5 mbar and apply with the **On** button. Verify the values are within the given tolerance highlighted in green
3. Set Pinsp=25 mbar and verify the values are within the given tolerance highlighted in green
4. Set Pinsp=50 mbar and verify the values are within the given tolerance highlighted in green

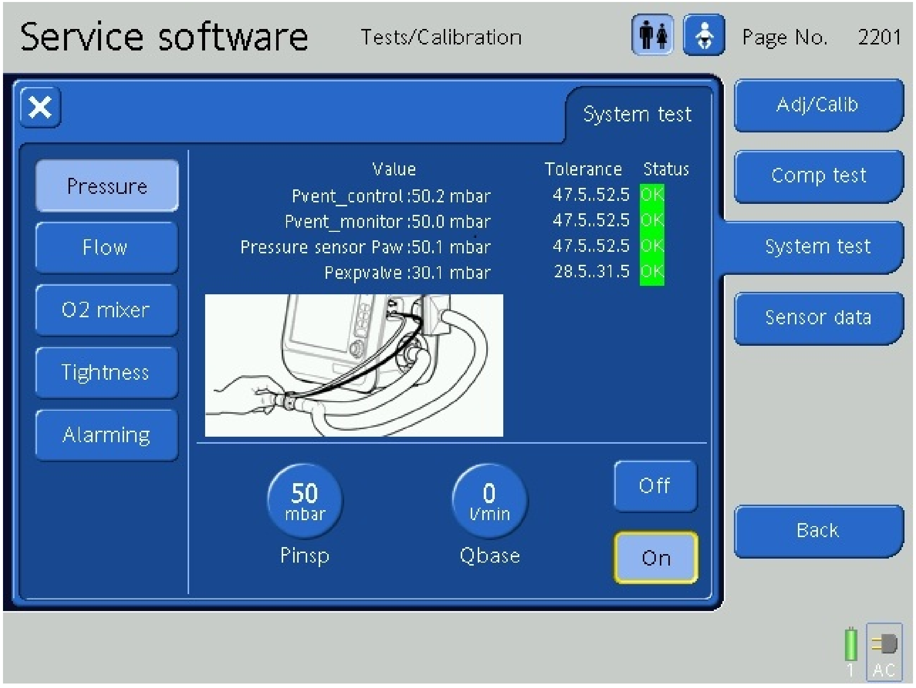


Fig. 145 Pressure Test (Page No 2201), all green

To finish the test press the **Off** button.

Remark: The Qbase button is for internal use only.

9.10.3 Flow Test (Page No 2202)

1. Touch the **Flow** button to verify the flow measurement of Qvent and Qaw with an external measurement.

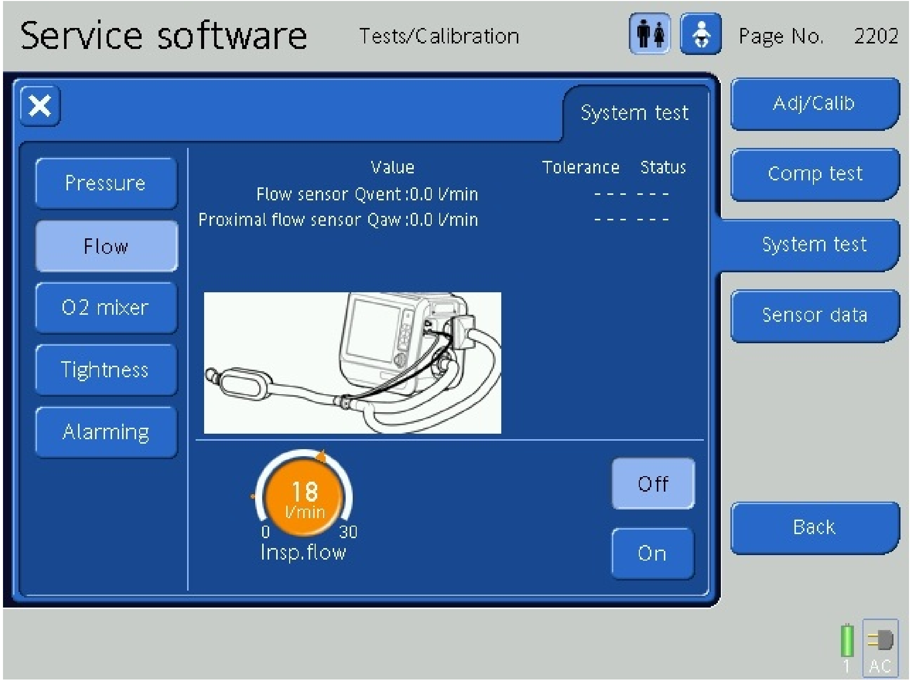


Fig. 146 Flow Test (Page No 2202)

2. Set up the test configuration 12.

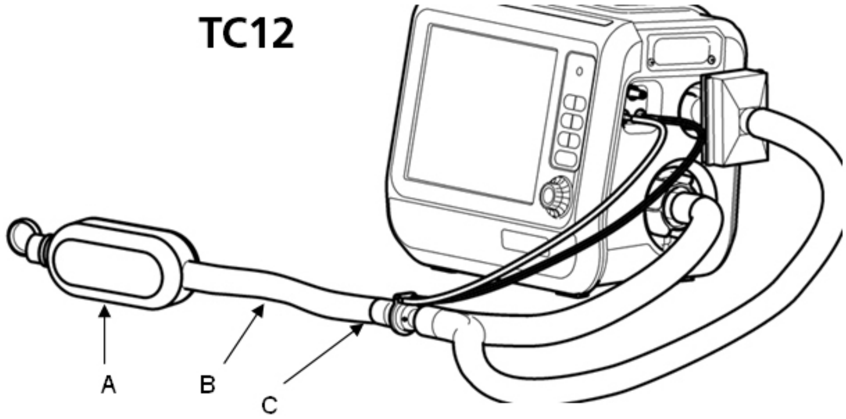


Fig. 147 Test Configuration 12

Legend:

A) TSI flowmeter (PN 500308)

B) Silicone tube adult 22MM 35CM (PN 260100)

C) Connector 22M/15F-22M/15F (PN 281420)

3. Set the flow sensor Qvent =9 l/min and apply with the **On** button.

Verify the values are in the defined tolerance (displayed with OK) and correspond to the external measurement (tolerance: +/- 5%)

4. Set the flow sensor Qvent =18 l/min

Verify the values are in the defined tolerance (displayed with OK) and correspond to the external measurement (tolerance: +/- 5%)

5. Set the flow sensor Qvent =27 l/min

Verify the values are in the defined tolerance (displayed with OK) and correspond to the external measurement (tolerance: +/- 5%)

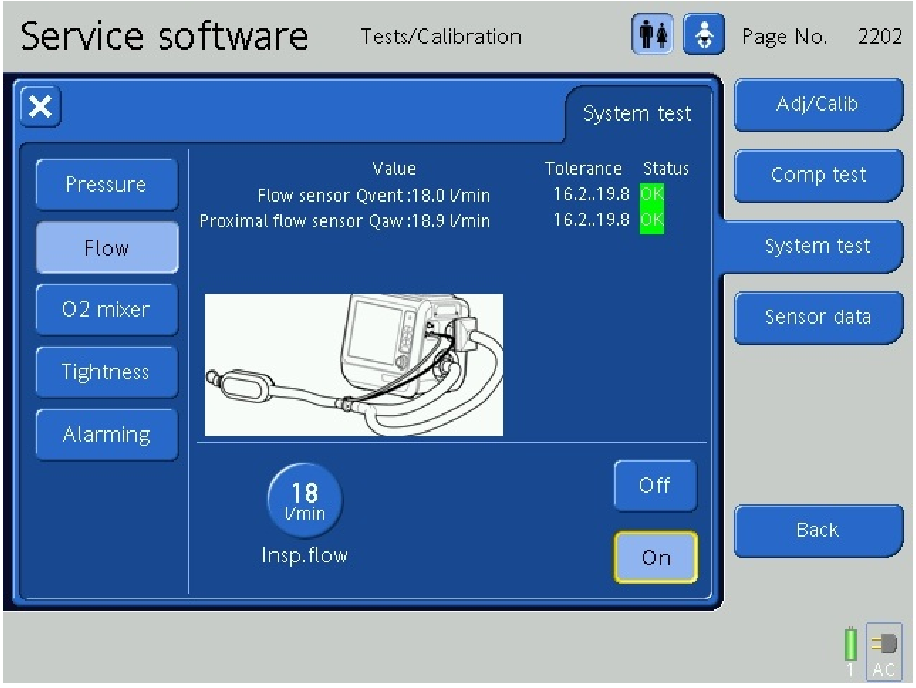


Fig. 148 Flow Test (Page No 2202), all green

6. To finish the test touch the **Off** button.

9.10.4 O2 Mixer Test (Page No 2203)

Note	At the FiO2 setting =61% the flow sensor QO2 should read 50% of the Qvent value.

1. Touch the **O2 mixer** button to test the O2 mixer with different FiO2 settings.

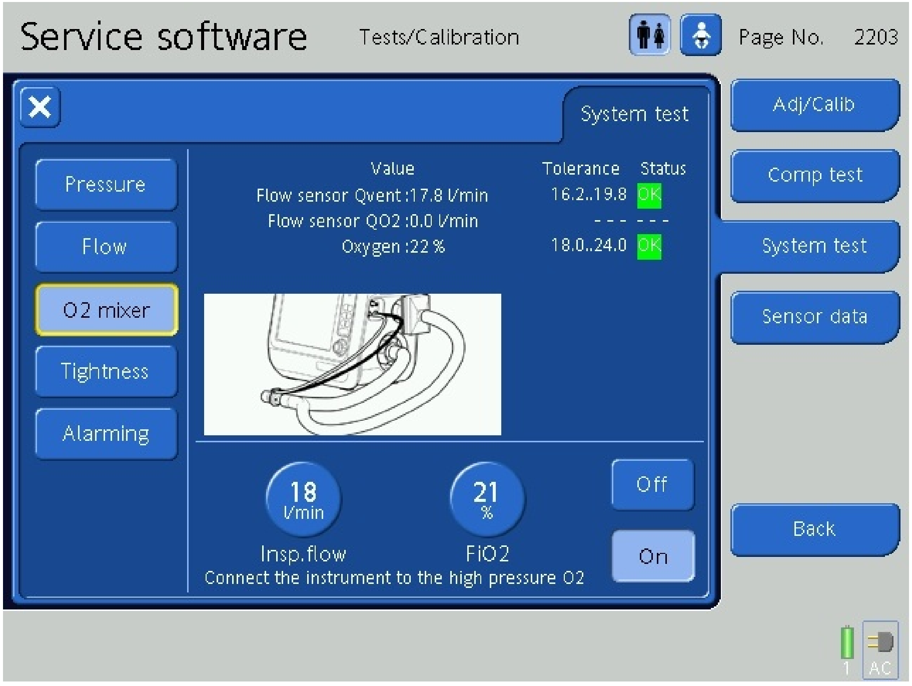


Fig. 149 O2 Mixer Test (Page No 2203)

2. Set up the test configuration 9.

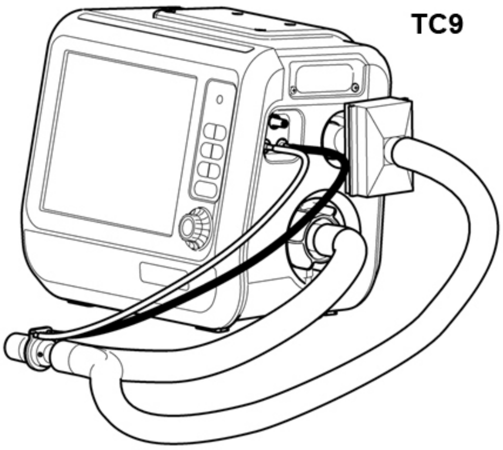


Fig. 150 Test Configuration 9

3. Connect the ventilator to high-pressure O2 (HPO).

4. Set the flow sensor Qvent =18 l/min and apply with the **On** button.

5. Set FiO2= 21% and wait (max. 2 minutes) until the values Qvent and Oxygen are within the defined range (indicated with OK).

6. Set FiO2 = 61% and wait (max. 2 minutes) until the values Qvent and Oxygen are within the defined range (indicated with OK).

7. Set FiO2 = 90% and and wait (max. 2 minutes) until the values Qvent and Oxygen are within the defined range (indicated with OK).

8. To finish the test press the **Off** button or proceed to the next test tab.

9.10.5 Tightness Test (Page No 2204)

1. Touch the **Tightness** button for the tightness test.

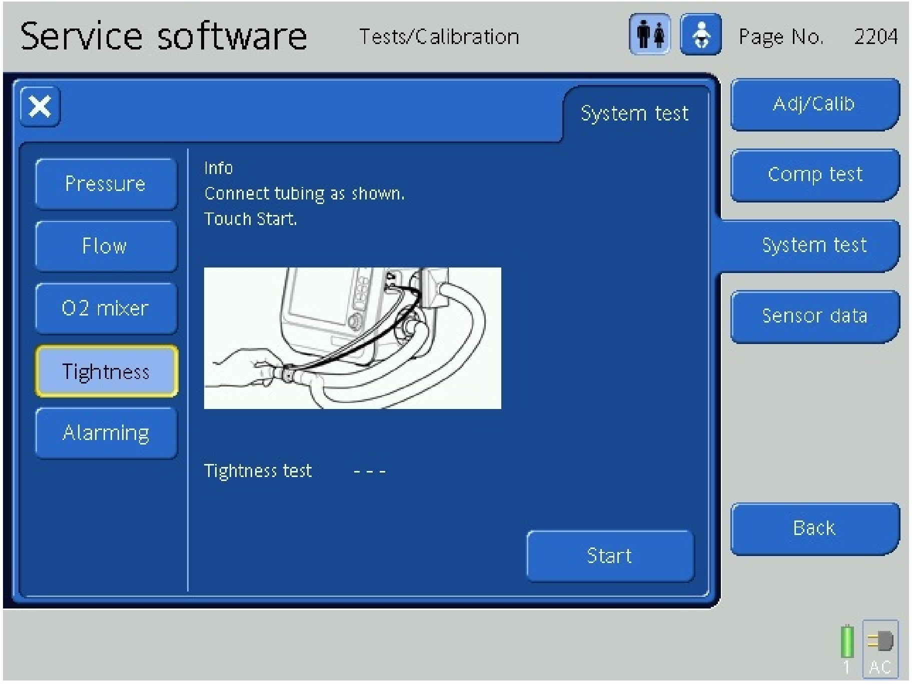


Fig. 151 Tightness Test (Page No 2204)

2. Set up the test configuration 4.

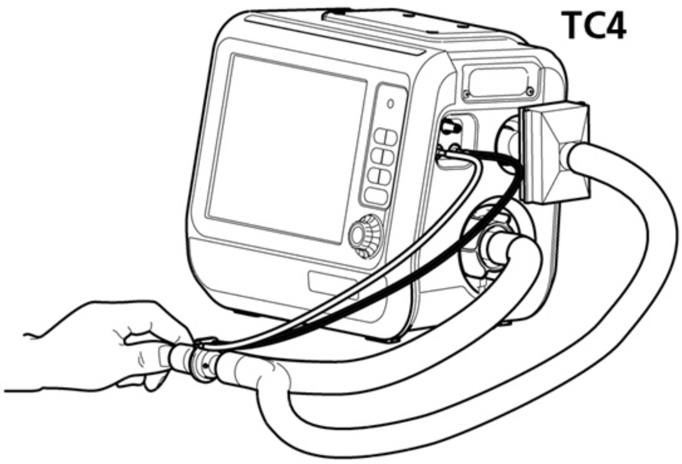


Fig. 152 Test Configuration 4

3. Touch the **Start** button to start the tightness test.

   The test runs automatically, indicated by **Tightness tubing test in progress**... on the screen.

4. After the test completion the result is displayed with **OK/NOT OK.**

9.10.6 Alarming Test (Page No 2205)

1. Touch the **Alarming** button for testing the different alarming priorities.

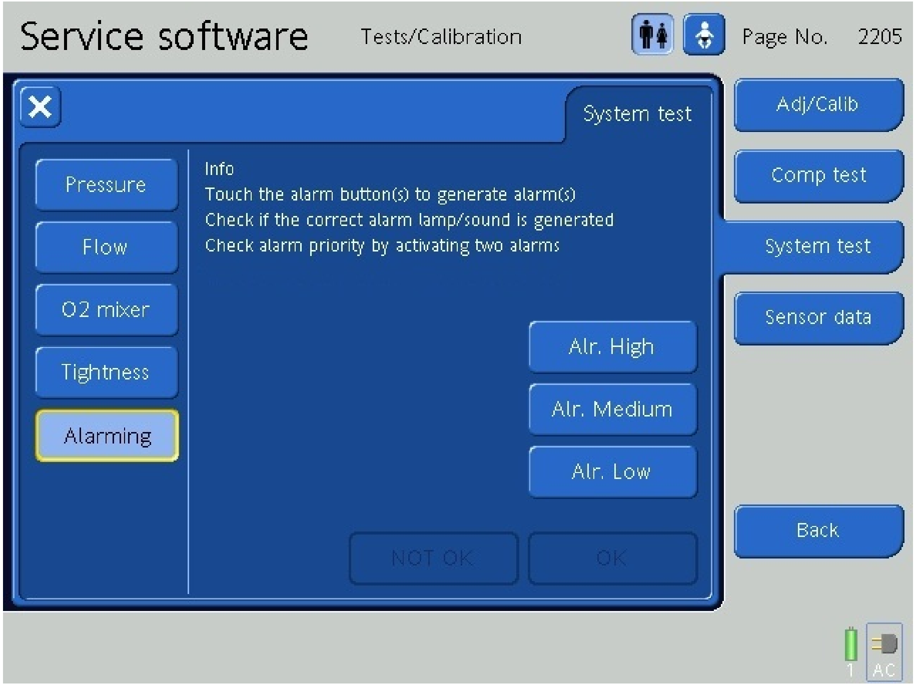


Fig. 153 Alarming Test (Page No 2205)

2. Touch the **Alr.High**, **Alr. Medium** and **Alr. Low** buttons to generate the corresponding alarm.

3. Check if the correct alarm lamp and alarm sound is generated.

4. Check the alarm priority by activating two alarms.

   To check the alarm sound on different loudness setting, set the loudness in Alarm system. Refer to Chapter 9.9.2.1

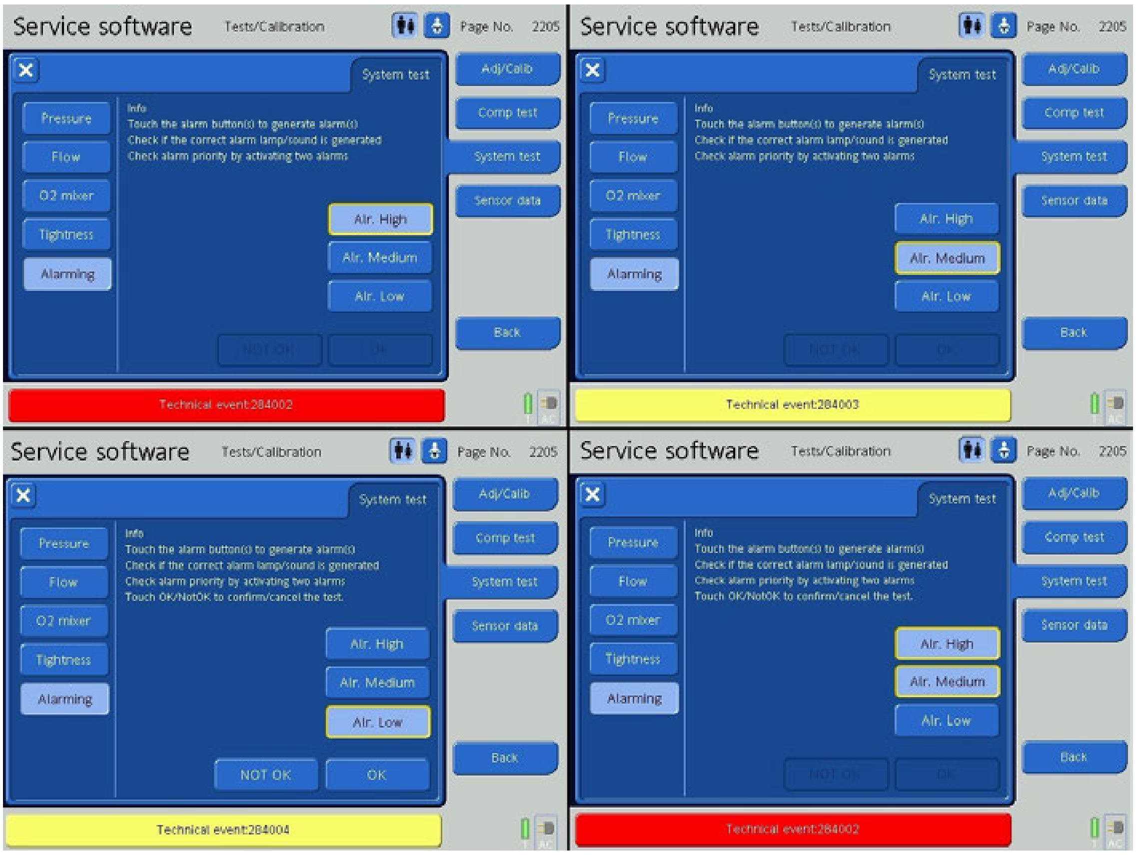


Fig. 154 Alarming Test (Page No 2205), combining the priorities

5. After the test completion the result needs to be confirmed manually with **OK/NOT OK.**

Note	To check the alarm sound on different loudness setting, set the loudness in Alarm system. Refer to Chapter 9.9.2.1

9.11 Adjustment / Calibration (NEONATAL)

9.11.1 Overview Adjustment/Calibration

for HAMILTON-C1 ≥ SN6000		
Adjustment/ Calibration	**Description**	**Component adjusted/calibrated**
Adj/Calib > Calibration> **Exp. valve** **(Page No 2343)** Chapter 9.8.9	The expiratory valve contains a voltage controlled linear valve (Expiratory proportional valve). The opening point of the valve depends on the contained spring. The goal of the expiratory valve calibration is to find the opening voltage of the valve, which we call Offset Voltage. Test sequence: A constant pressure is generated on the inspiration outlet. The voltage on the expiratory valve is adjusted until the flow through the expiratory valve is in the required range. The calibration is done with 2 different pressures. The calibration reaches an end as soon as both, the high and the low offset are within a defined tolerance. At the end the average value of Voltage Offset high and low is stored and used by the software.	– Expiratory valve Neonantal
Adj/Calib> Calibration> **flow sensor** **(Page No 2347)** Chapter 9.8.8	This calibration checks and resets the calibration point specific to the flow sensor in use. The flow sensor is calibrated in both directions.	– External flow sensor Qaw (Neonatal)

9.11.2 Expiratory valve calibration (Page No 2343)

1. Touch the **Exp. valve** button to enter the expiratory valve calibration.

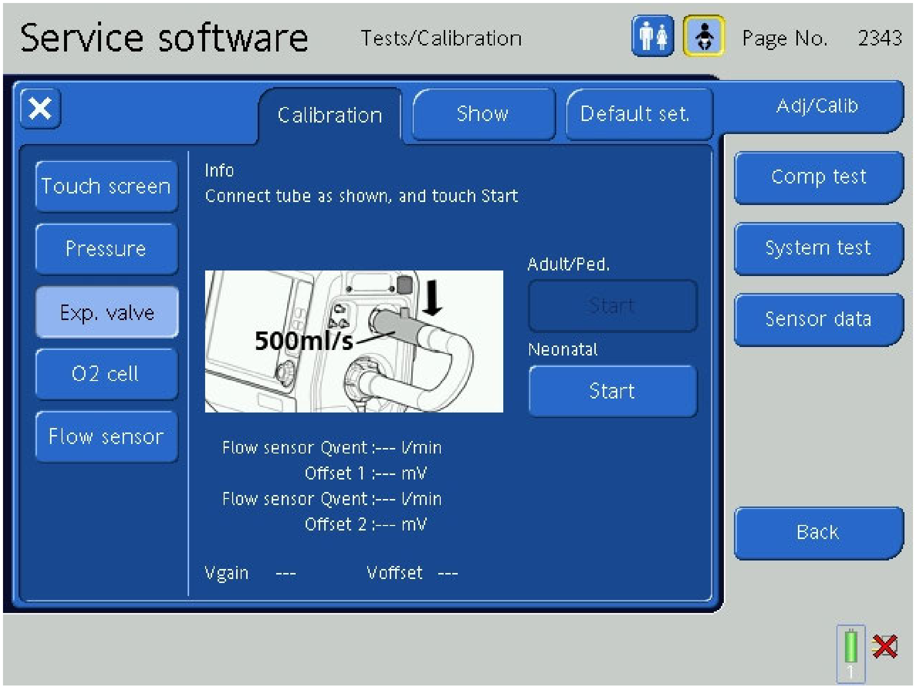


Fig. 155 Neonatal expiratory valve calibration (Page No 2343)

2. Select the neonatal mode by touching the adult button in the window header. 

3. Set up test configuration 2 and install the neonatal expiratory valve cover.

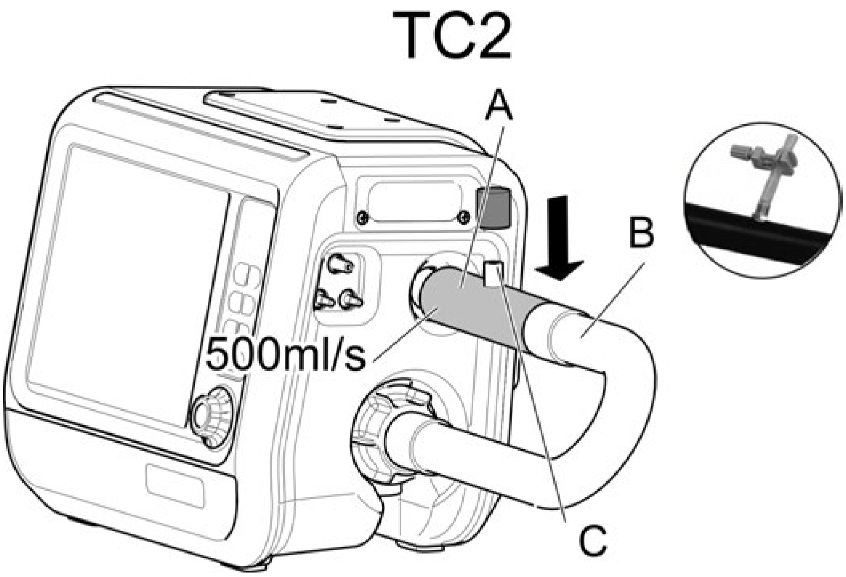


Fig. 156 Test configuration 2

Legend:

A Capillary tube 500ml/s (PN 500290)

B Silicone tube 22mm 35cm (PN 260100)

C Close the capillary tube connector (e.g. use a clamp PN 279812, Figure *Test configuration 2*)

4. Touch the **Start** button (Neonatal) to begin with the calibration. The calibration runs automatically, as indicated by the flow sensor Qvent, Offset 1 and Offset 2 values changing during the calibration process.

Note	Due to the sensitivity of the system the capillary tube 500ml/s is used in order to have a defined resistance. The calibration can take a few minutes. Vgain is not used and remains set to 1000.

Vgain and Voffset values are shown as soon as the calibration is successfully completed.

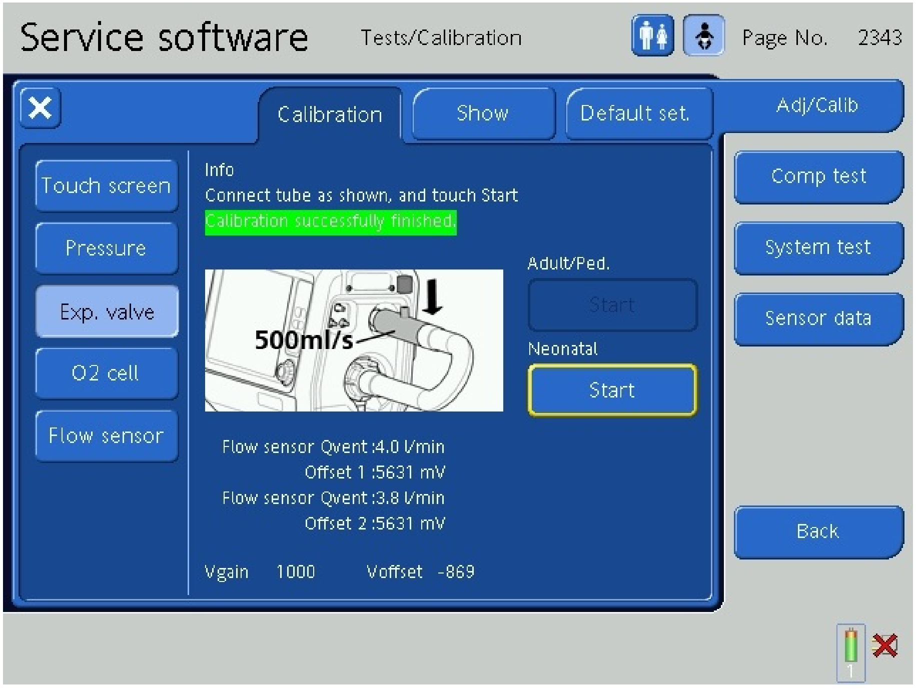


Fig. 157 Neo expiratory valve calibration

5. Record the Voffset value on the **HAMILTON Test Report**.

9.11.3 Neonatal flow sensor calibration (Page No 2347)

1. Touch the **Flow sensor** button to enter the flow sensor valve calibration

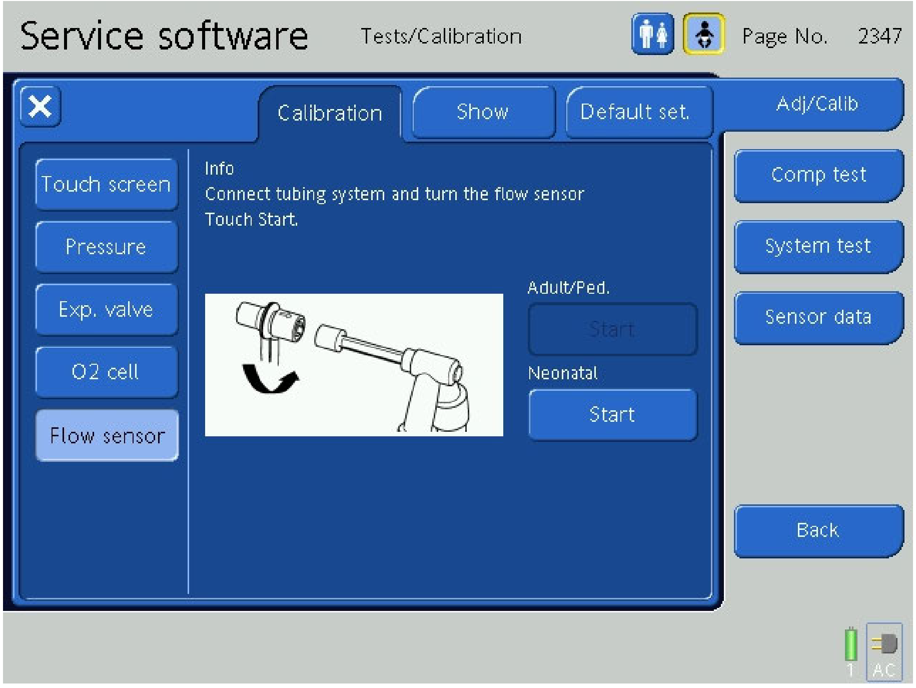
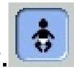


Fig. 158 Neonatal flow sensor calibration (Page No 2347)

2. Select the neonatal mode by touching the neonatal button in the window header. 

3. Connect the HAMILTON-C1 with the neonatal breathing circuit (Test configuration 9n).

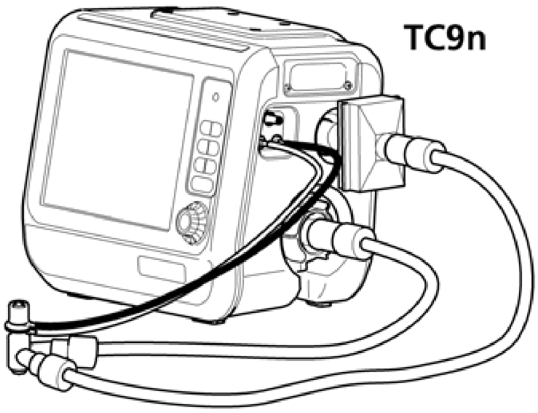
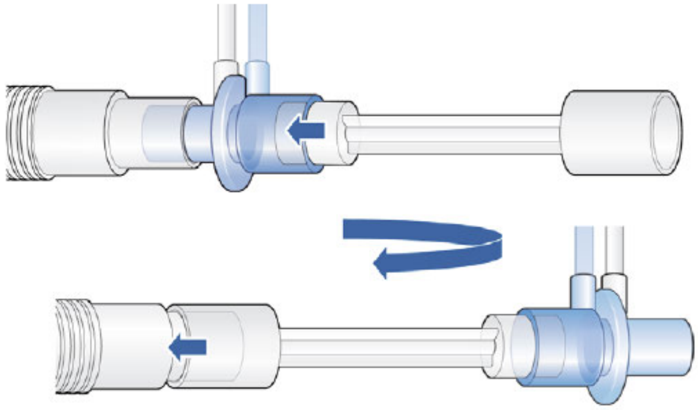


Fig. 159 Test configuration 9n

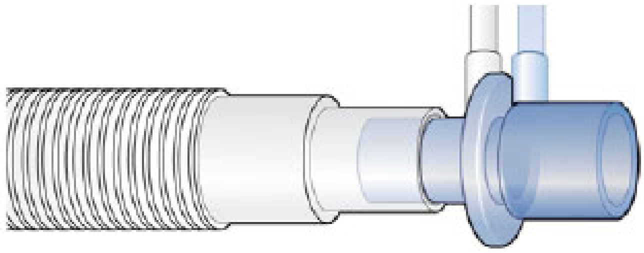
4. **Turn** the flow sensor prior to start and connect the flow sensor with the calibration adapter (PN 279962) as shown.



5. Start the Neonatal flow sensor calibration by touching the **Start** button.

6. **Flow Sensor calib started** will be displayed.

7. **Turn** back the flow sensor when instruction is given and remove the calibration adapter (PN 279962). Proceed by touching the **Next** button.



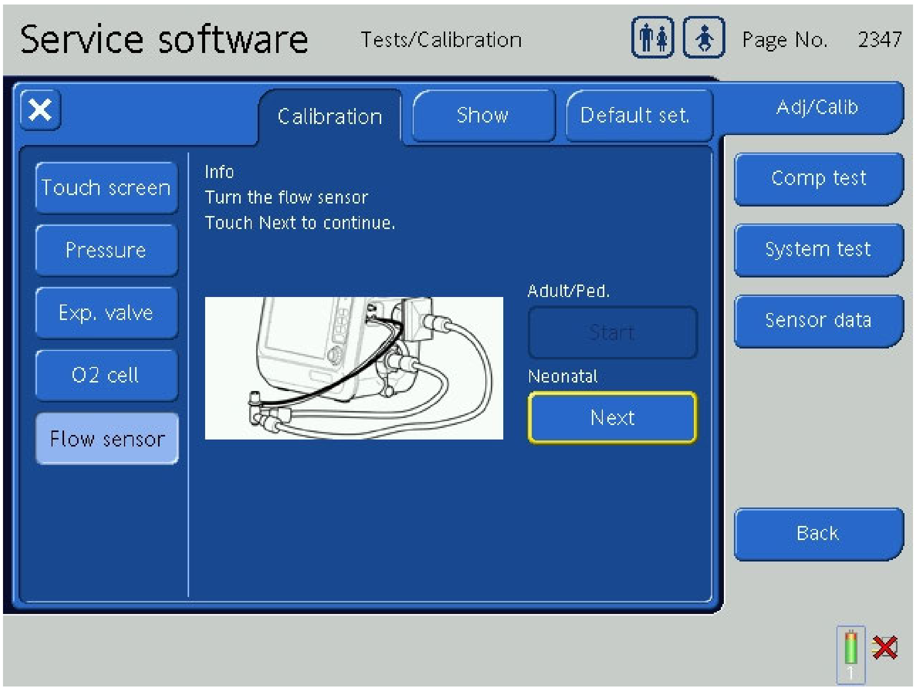


Fig. 160 Neonatal flow sensor calibration

8. **Flow Sensor calibration successful** will be displayed after completion.

9.12 Component test (NEONATAL)

9.12.1 Overview Component Test

for HAMILTON-C1 ≥ SN6000		
Component Tests	**Description**	**Component tested**
Tests/Calib > Comp test > Pneumatics 1> **Exp. valve** Chapter 9.9.4	This test consists of three parts: -Pexpvalve test: While the patient system is tightened and the expiratory proportional valve is fully closed, the Pressure Sensors Pexpvalve and Pvent_control will be compared and have to be equal. Afterwards the expiratory proportional valve will be opened and the pressure sensor Pexpvalve should measure zero. -Pressure test: Several pressures are set as target to the blower and expiratory valve with a defined base flow. The pressures are measured by Paw and have to be within the tolerance.	– Expiratory valve with neonatal cover – Pressure sensor Pexpvalve – Expiratory proportional valve

9.12.2 Expiratory valve (Page No 2111)

1. Touch the **Exp. valve** button to test the expiratory valve.
2. Select the neonatal mode by touching the neonatal button in the window header. 

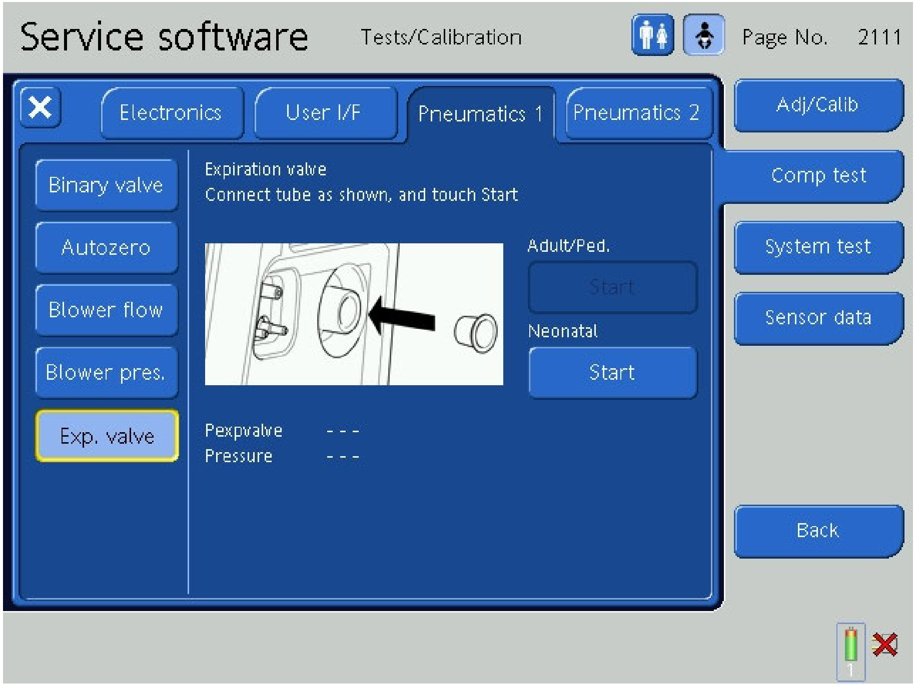


Fig. 161 Neonatal expiratory valve (Page No 2111)

3. Set up test configuration 6 and install the neonatal expiratory valve cover.

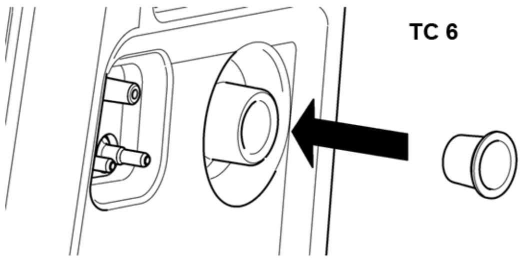


Fig. 162 Test configuration 6

4. Touch the **Start** button (Neonatal) to start the Pexpvalve test.

   The test runs automatically as indicated by **Pexpvalve pressure test in progress**... on the screen. After the test completion the result is displayed with **OK/NOT OK**.

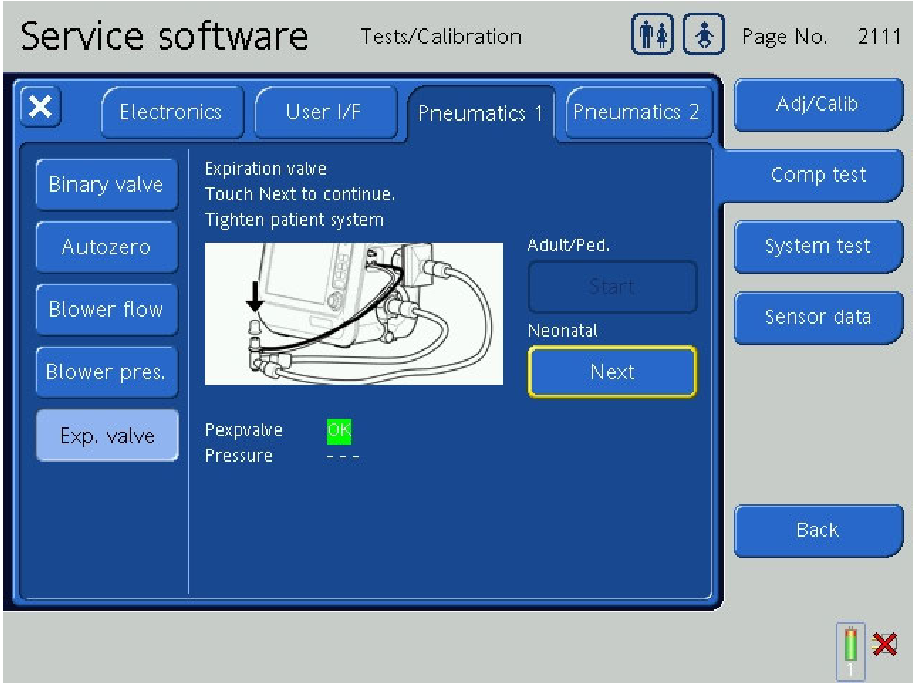


Fig. 163 Neonatal expiratory valve (Page No 2111), Pexpvalve

5. For pressure test set up test configuration 4n.

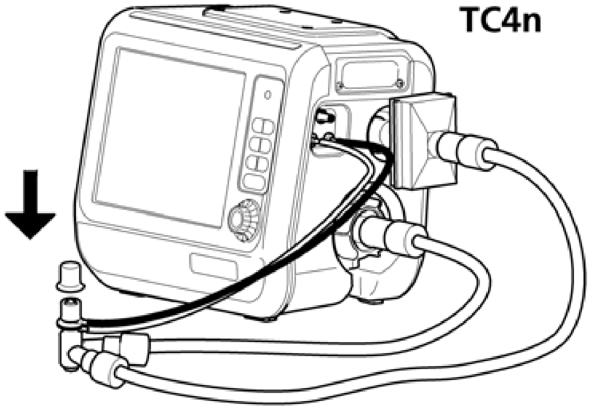


Fig. 164 Test configuration TC4n

6. Touch the **Next** button to start the pressure test.

7. The test runs automatically as indicated by **Expiration valve pressure test in progress**... on the screen. After the test completion the result is displayed with **OK/NOT OK**.

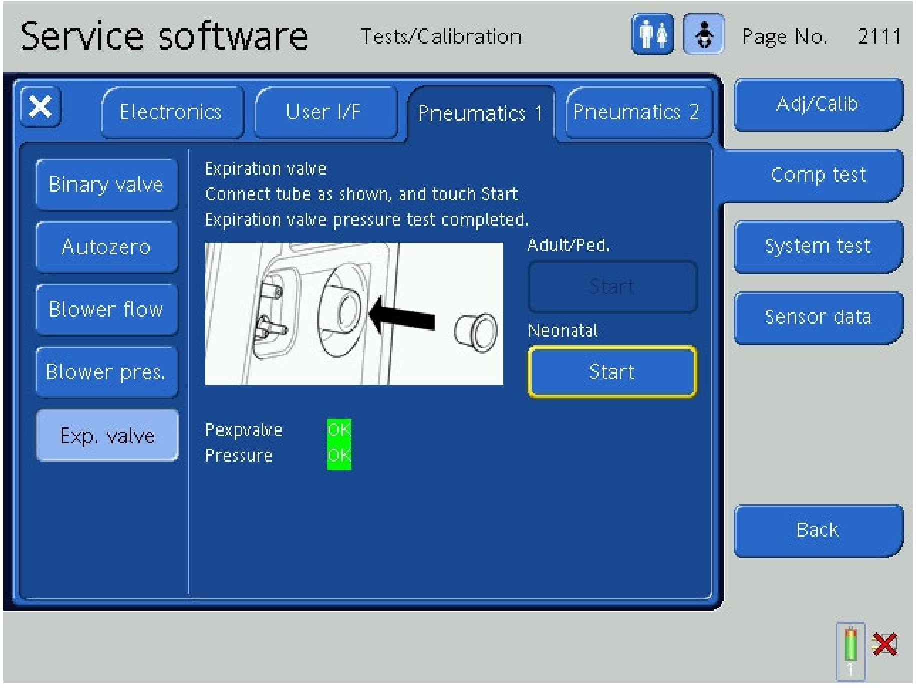


Fig. 165 Neonatal expiratory valve (Page No 2111), Pressure test

9.13 Sensor Data

The sensor data is intended for internal use only or if advised by the Technical Support for troubleshooting / analysis.

Touch the **Sensor data** tab to enter the sensor overview.

9.13.1 Sensor 1 (Page No 2401)

1. Touch the **Sensor 1** tab to display the value and status of several sensors.

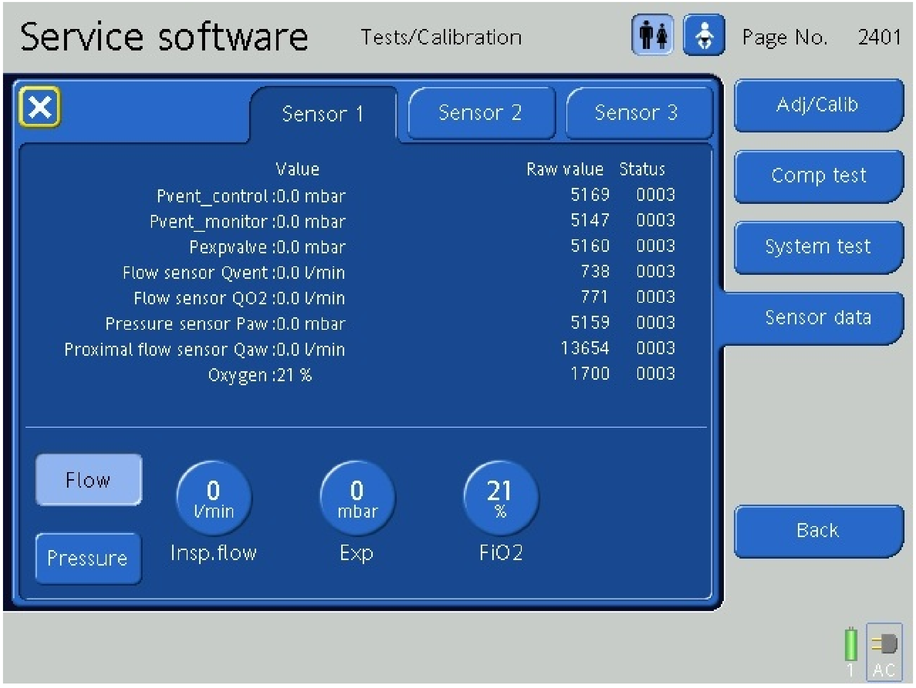


Fig. 166 Sensor 1 (Page No 2401)

9.13.2 Sensor 2 (Page No 2402)

1. Touch the **Sensor 2** tab to display the value and status of several sensors.

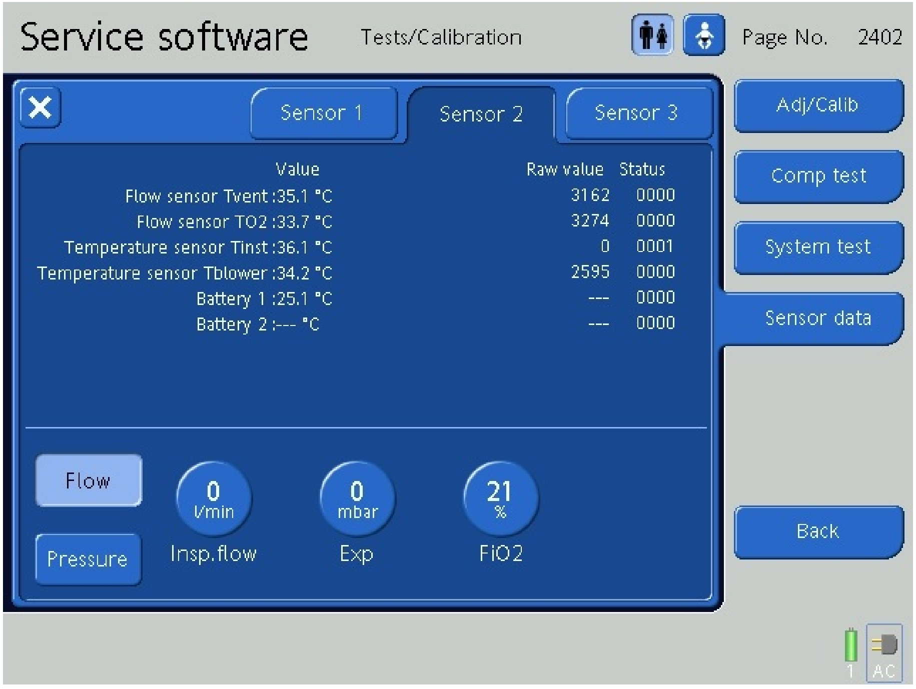


Fig. 167 Sensor 2 (Page No 2402)

9.13.3 Sensor 3 (Page No 2403)

1. Touch the **Sensor 3** tab to display the value and status of several sensors.

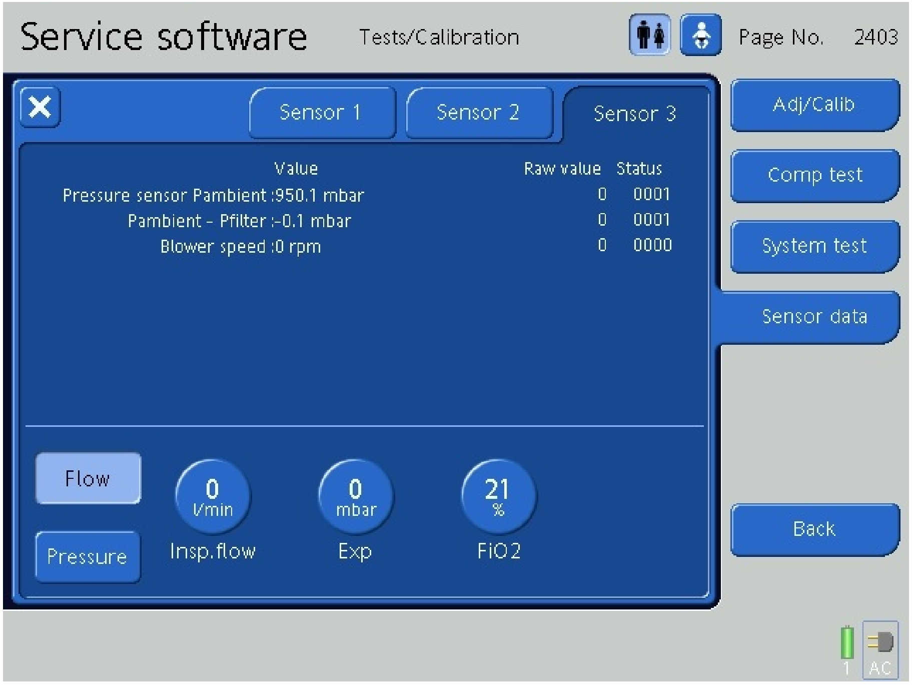


Fig. 168 Sensor 3 (Page No 2403)

9.13.4 Sensor Status (Page No 2401-2403)

1. The displayed sensor status (hex) is a value which consists of a combination of several status (bits)

   The table below shows possible sensor status. Not all status are applicable for every sensor.

Status	Description	Value (Hex)	Value (Bin) Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Cleared	Default value after startup	0																
Initialized	The sensor is initialized	1																1
Calibrated	The sensor has valid calibration data	2															1	
Defect	The sensor is defect	4														1		
Missing	The sensor is not connected	8													1			
Autozero	An autozero sequence is running	10												1				
Overflow	The measurement is out range (high)	20											1					
Underflow	The measurement is out range (low)	40										1						
Disabled	The sensor is disabled	80									1							
Undertemperature	The temperature is too low	100								1								
Overtemperature	The temperature is too high	200							1									
Invalid	The sensor is invalid	400						1										
Sidestream	The sensor is using a sidestream measurement	800					1											
Adapter	The sensor is not attached to its measurement adapter	1000				1												
Line	The sampling line is occluded	2000			1													
Simulated	Some of the sensors values are simulated	4000		1														
CalibrationRunning	The calibration sequence is running	8000	1															
Example:																		
Proximal Flow sensor Qaw shows Status= 00003(Hex)=0000000000011(Bin)																	1	1
means that Qaw was initialized and calibrated																		

Fig. 169 Sensor Statuses (Page No 2401-2403)

9.14 Log/Config Files

1. From the Main Service Software Screen, touch the **Log/Config Files** button.

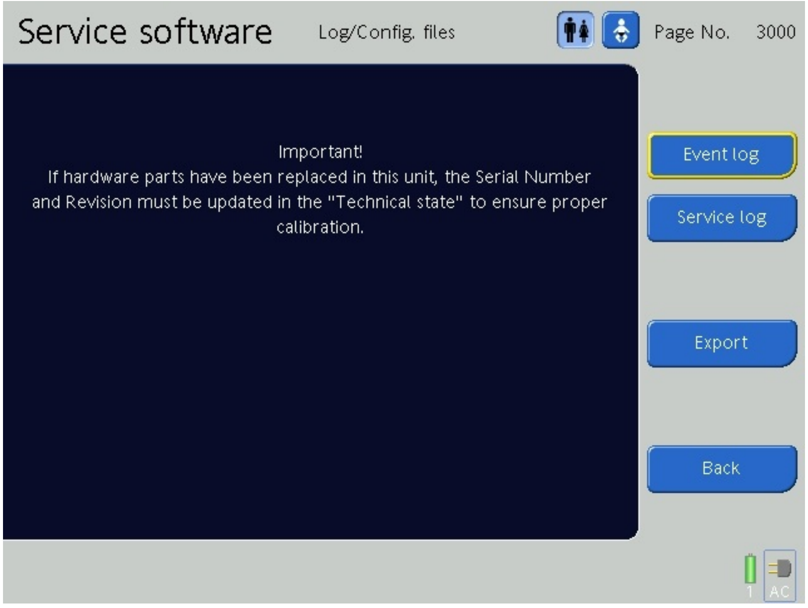


Fig. 170 Log/Config Files (Page No 3000)

9.14.1 Event Log

1. Touch the **Event log** button to open the Event Log.

   Use the P+T knob to scroll.

   The Event Log displays the technical events, which have occurred with the date, time, device affected, and a description of the technical event.

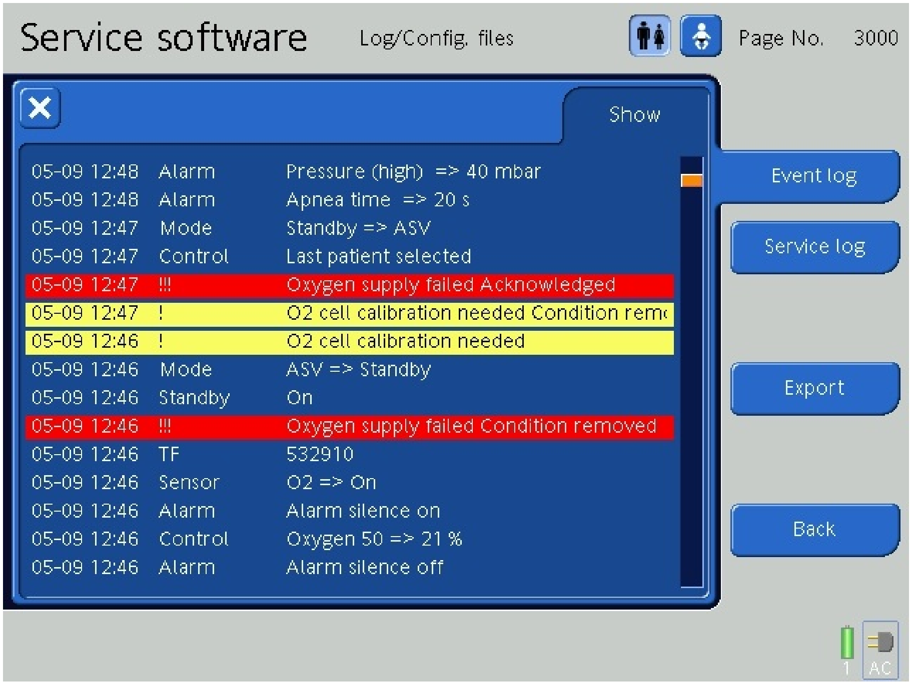


Fig. 171 Event Log

9.14.2 Service Log

1. Touch the **Service Log** button to display the service log.

   Use the P+T knob to scroll.

   The Service Log displays the test and calibration results with the date, times and a description of the event.

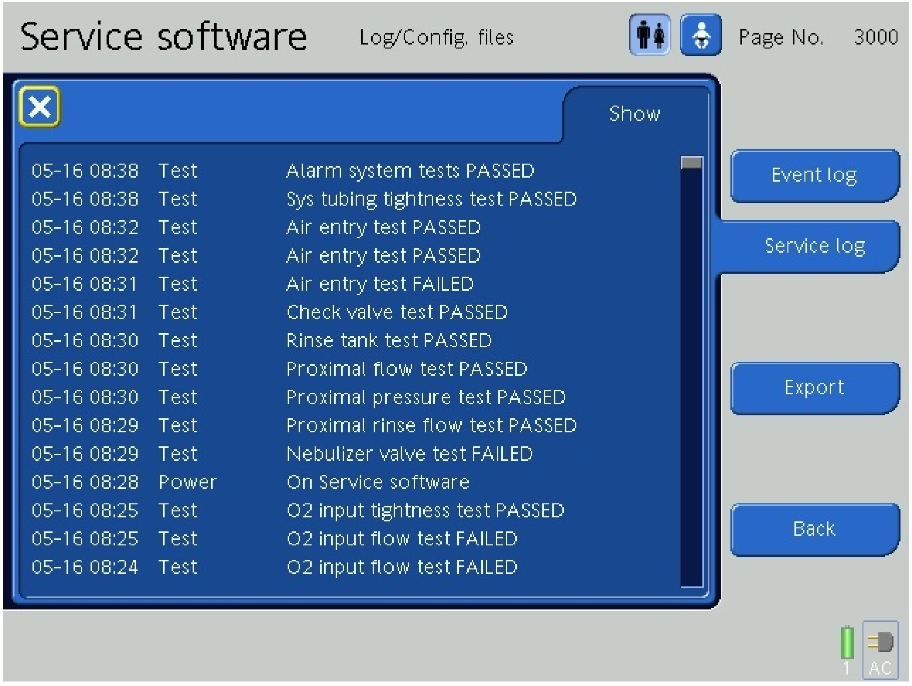


Fig. 172 Service Log

9.14.3 Export (Instrument Report and Events)

1. Touch the **Export** button to enter the export section, which allows downloading the Service log / Instrument Report to USB memory stick.

9.14.3.1 Events (Page No 3302)

1. To download the events touch the **Events** tab.

2. Insert the USB memory stick and touch the **Start** button for the download.

   The status of the download is displayed.

   The completion is displayed with **Export successful**.

   The USB memory stick can be removed as soon as the LED is OFF.

   The Event log files will be downloaded in a folder named as:

   C1-sn#### (#### device serial number) which will be created first if not already exists.

   The main files are:

   -year-month-day_hour-minute-second_eventLog_enGB.txt containing the Event log

   -year-month-day_hour-minute-second_serviceLog_enGB.txt containing the Service log

   The remaining files are intended for internal use only.

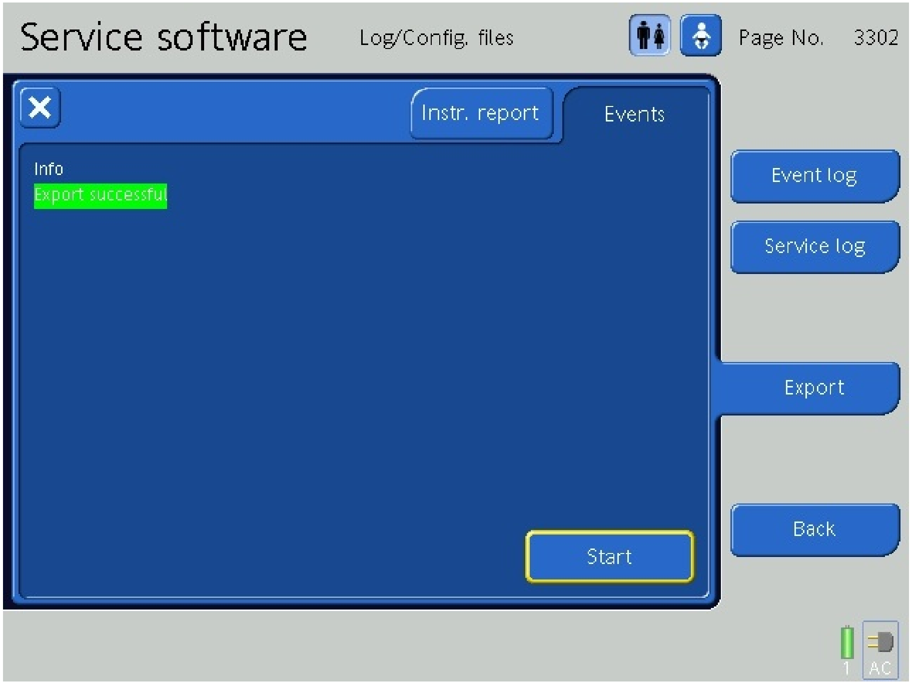


Fig. 173 Operation

9.14.3.2 Instrument report (Page No 5502)

1. To download the instrument report touch the **Instr. Report** tab.

2. Insert the USB memory stick and touch the **Start** button for the download.

   The Instrument report contains all the following ventilator informations, technical state and the calibration values.

   The status of the download is displayed with **Generating instrument report....** and the completion with **Export successful.**

   The Instrument report file will be downloaded in a folder named as:

   C1-sn#### (#### device serial number) which will be created first if not already exists.

   The file is named:

   -year-month-day_hour-minute-second **InstrumentReport.txt**

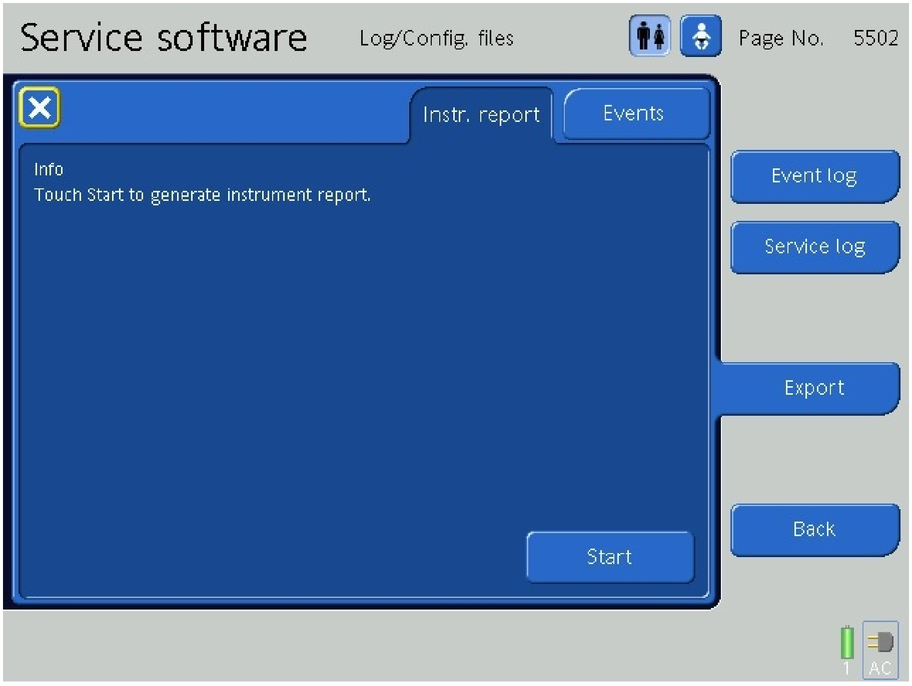


Fig. 174 Instrument report

9.15 Software Update (Page No 5101)

WARNING	After the software update the ventilator must be restarted and the complete service software calibration/test's must be performed. The adults and the neonatal tests must be performed. Perform the calibration and tests in neonatal mode as described in addition to adult/ped. mode. Even if the neonatal option is not installed (for HAMILTON-C1 units ≥ SN 6000 only).

1. Touch the **SW update** button in the main service software screen to the enter the **SW update** page, which allows updating or upgrading of the ventilator software.

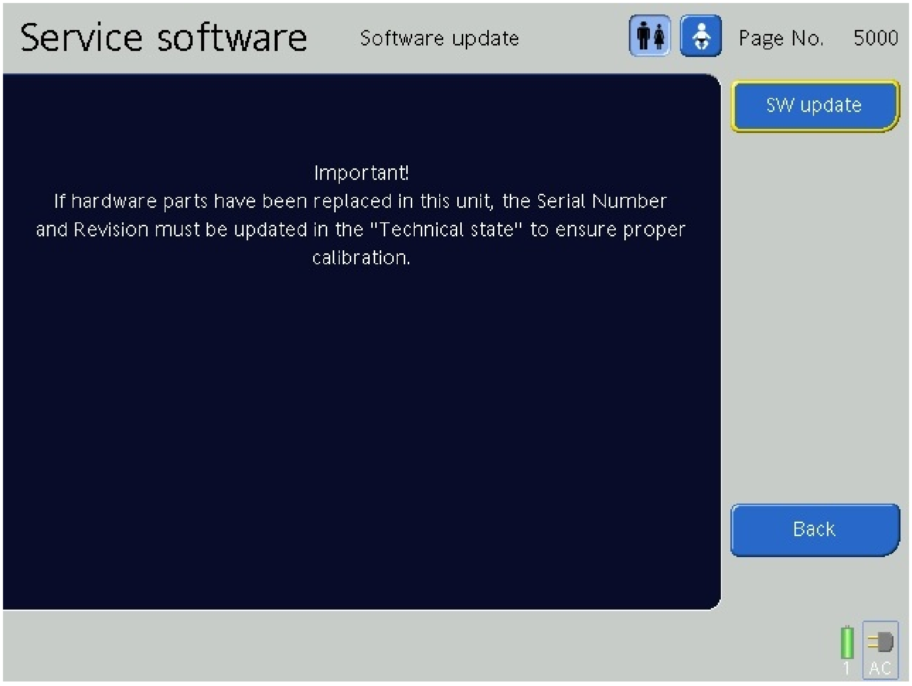


Fig. 175 Software Update (Page No 5000)

9.15.1 SW upgrade from version 1.x.x to 2.x.x (HAMILTON-C1 <SN6000)

1. For upgrading the HAMILTON-C1 (<SN6000) from SW version 1.x.x to SW version 2.1.x a migration step is necessary.

   The following files are required :

- C1_V2.1.1-Migration.tar	This is required as migration step from 1.x.x to 2.x.x since the software structure has been changed.
- C1_EM01A_V2.1.1.tar	This is the final SW to be installed after the migration SW.

2. Touch the **SW update** button to enter the update page.

3. Insert the USB memory stick containing the migration and upgrade version as listed in table above.

   If a correct file is available on the USB memory stick,a message indicating the update version appears. Otherwise the message **No Update Tarball File is available...** is displayed. In case there are more than one SW updates stored on the USB memory stick please ensure to choose the latest version.

   When the update is complete, go back one step and check the update was successful.

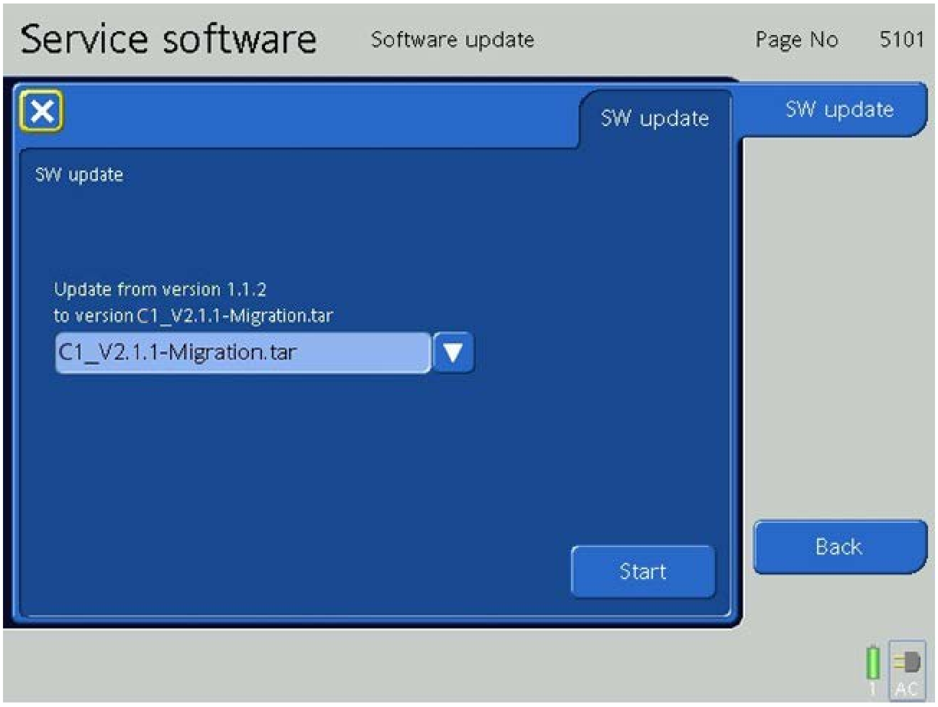


Fig. 176 SW update (Page No 5101)

4. Select the SW file to be installed (C1_V2.1.1-Migration.tar)

5. Touch the **Start** button to start the SW update which consists of extracting, verifying, and installing.

6. A progress bar shown indicates the current status of the SW update.

9.15.2 SW update from version 2.x.x to higher version

1. Touch the **SW update** button to enter the update page.

2. Insert the USB memory stick containing the update / upgrade version (see table below).

   If a correct file is available on the USB memory stick, the message appears indicating the update version otherwise the message **No Update Tarball File is available...** will be displayed. In case there are more than one SW updates stored to the USB memory stick please ensure to choose the correct version.

   When the update is complete, go back one step and check the update was successful.

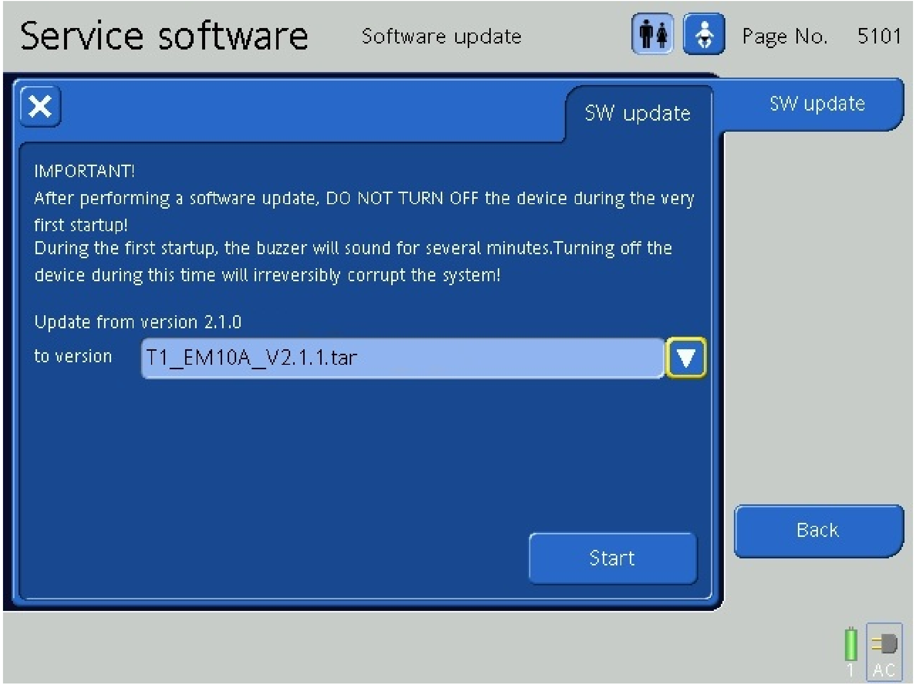


Fig. 178 SW update (Page No 5101)

3. Select the correct file for updating:

HAMILTON-C1 units	< SN6000	≥SN6000
Installation file:	C1_EM**01**A_V2.x.x.tar	C1_EM**10**A_V2.x.x.tar

4. Touch the **Start** button to start the SW update which consists of extracting, verifying and installing.

5. A progress bar shown indicates the current status of the SW update.

6. The completion is stated with **done**.

7. Restart the HAMILTON-C1 and perform the complete service software calibration and test's.

Note	A downgrade to a lower SW version is not possible

9.16 General Tests

Note	All devices connected to the HAMILTON-C1 must meet the requirements of standard IEC 60601-1.

1. Connect the HAMILTON-C1 to the mains AC power supply.
2. Turn the HAMILTON-C1 on, and keep the unit in standby mode.
3. Perform following test's:

3.1. AC-Battery Test

Disconnect the AC mains power supply. Verify that the unit runs continuously on battery and that the battery symbol is framed and the AC symbol is crossed out.

3.2. Power Loss Test

Now remove the batteries. Verify that the unit alarms. Connect the batteries again and verify the unit starts up again.

3.3. Fan Check

In order to check the fan for proper assembly, put a piece of paper over the fan inlet. If the paper sticks while the ventilator is on, the fan functions properly.

3.4. Nebulizer tightness check

This test has to be performed in addition to the preventive maintenance, or after a repair since the service software cannot detect small leaks of the nebulizer internal connection. Do the following steps:

Tubing/connection tightness check

1) Connect the ventilator to HPO (2.8..6bar).
2) Connect the hand pump (PN 500330) to the nebulizer port with a tube (Di=4mm /L=150mm) as show in Fig. 179.
3) Apply a pressure of 60mbar with the hand pump.
4) Watch the pressure indicator of the hand pump for a potential pressure loss.
5) In case of pressure loss, check tubing for proper connection or replace if necessary.

Nebulizer valve tightness check

1) Connect the hand pump (PN 500330) to the nebulizer port with a tube (Di=4mm /L=150mm) as shown in Fig.179.
2) Connect the ventilator to HPO (2.8...6bar)
3) Apply a pressure of 4mbar with the hand pump.

4) Watch the pressure indicator of the hand pump for a potential pressure rise.

5) In case of pressure rise of more than 5mbar in 30s, replace the nebulizer valve or the O2 mixer assembly if necessary.

Fig. 179 Nebulizer tightness check

3.5. Expiratory valve bleed port tubing check

In case the expiratory proportional valve exhaust is not connected with the expiratory valve bleed port (bottom cover), the expiratory valve will work properly, but O2 enrichment inside the ventilator can occur.

In order to avoid O2 enrichment inside the ventilator, the tubing of the expiratory proportional valve exhaust must be connected properly to the expiratory valve bleed port (outlet underneath the bottom cover)

1 Block the expiratory valve bleed port A) at the bottom cover and start the HAMILTON-C1 in ventilation mode (e.g. ASV).

2 he alarm "**Exhalation obstructed**" should appear after a few breaths.

If test fails, check the tubing (Chapter 9.10.5).

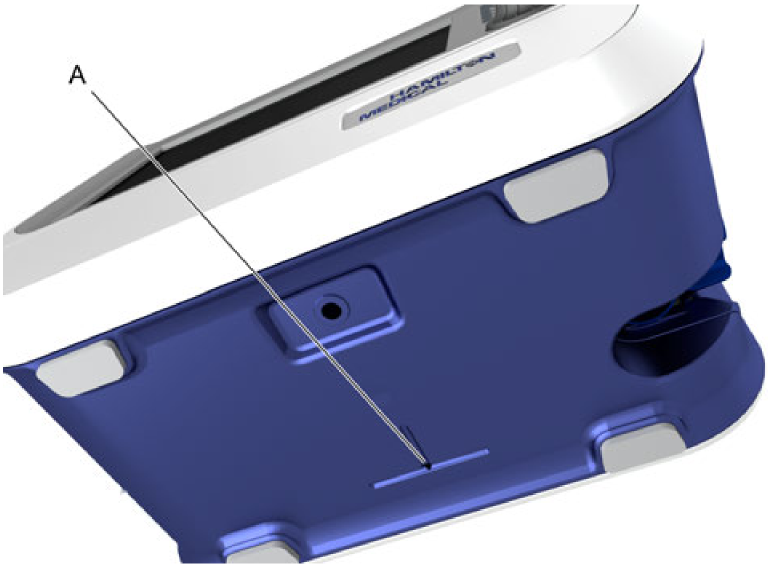


Fig. 180 Expiratory valve bleed port (Bottom View HAMILTON-C1)

9.17 CO2 Sensor Accuracy Check

Follow these steps to check the accuracy of the CO2 monitor, if installed.

In addition to the HAMILTON-C1 ventilator with CO2 monitor installed, this check requires:

- Patient breathing circuit (*not required*: humidifier, water traps, or inspiratory filter)
- Test lung
- PN 281718, CO2 sensor
- PN 281719, CO2 adult airway adapter, single use, 10/box
- PN 281803, adapters (x3), (one Box contains 25 pieces)
- Barometric pressure gauge (mbar) or TSI
- PN 159173, CO2 calibration gas cylinder or equivalent (CO2 5% ± 0.03; O2 0% ± 0.03; N2 Balance)
- PN 159172, CO2 gas regulator

1 Enter Service Software-> **Tests/calibration, Sensor data, Sensor 2**

2 Note the displayed barometric pressure (Pressure sensor Pambient) and verify that it is within +/- 20mbar of actual barometric pressure (measured with second gauge or device e.g. the TSI flow meter).

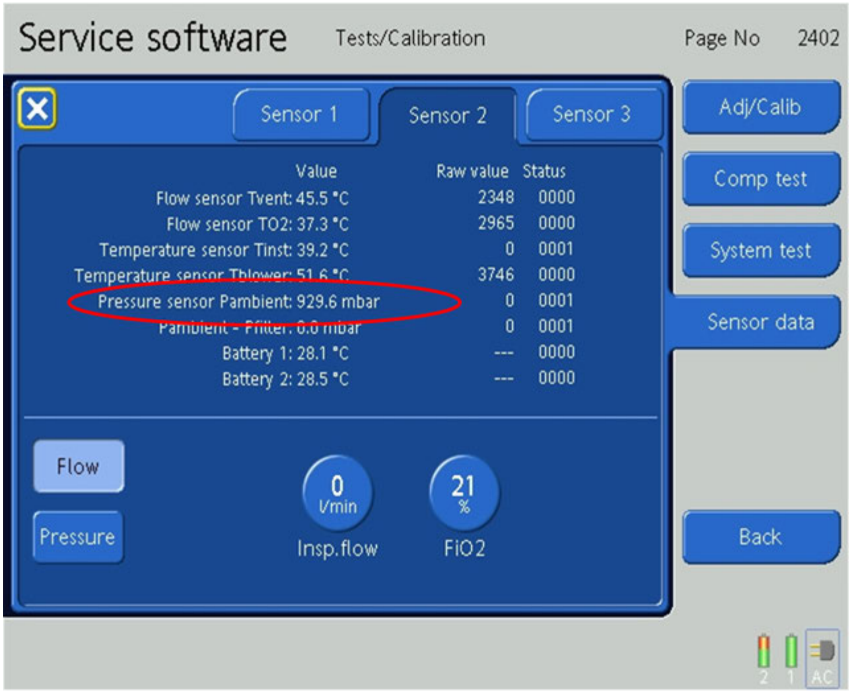


Fig. 181 Pressure sensor Pambient

Fig. 182 TSI flow meter

3 Restart the ventilator in operational mode.

4 Enter the configuration menu: Utilities->Configuration.

Fig. 183 Utilities Configuration

5 Activate the CO2 Hardware Option: Utilities->Configuration->Options->HW options

Fig. 184 HW Options

6 Connect the CO2 sensor with the CO2 communication Board.

7 Activate the CO2 sensor and deactivate the O2 cell: System->Sensors on/off. Set oxygen (FiO2) =21%.

8 Wait 3 minutes in order for the sensor to reach working temperature

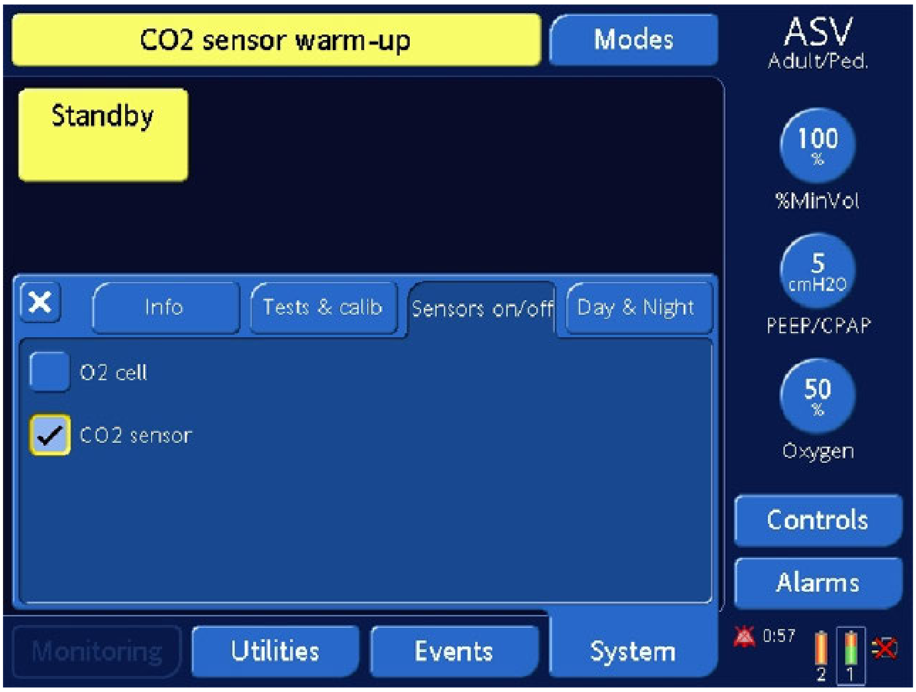


Fig. 185 Sensor Update

9 Connect patient breathing circuit, test lung, CO2 sensor, adapters, CO2 calibration gas and CO2 gas regulator as shown.

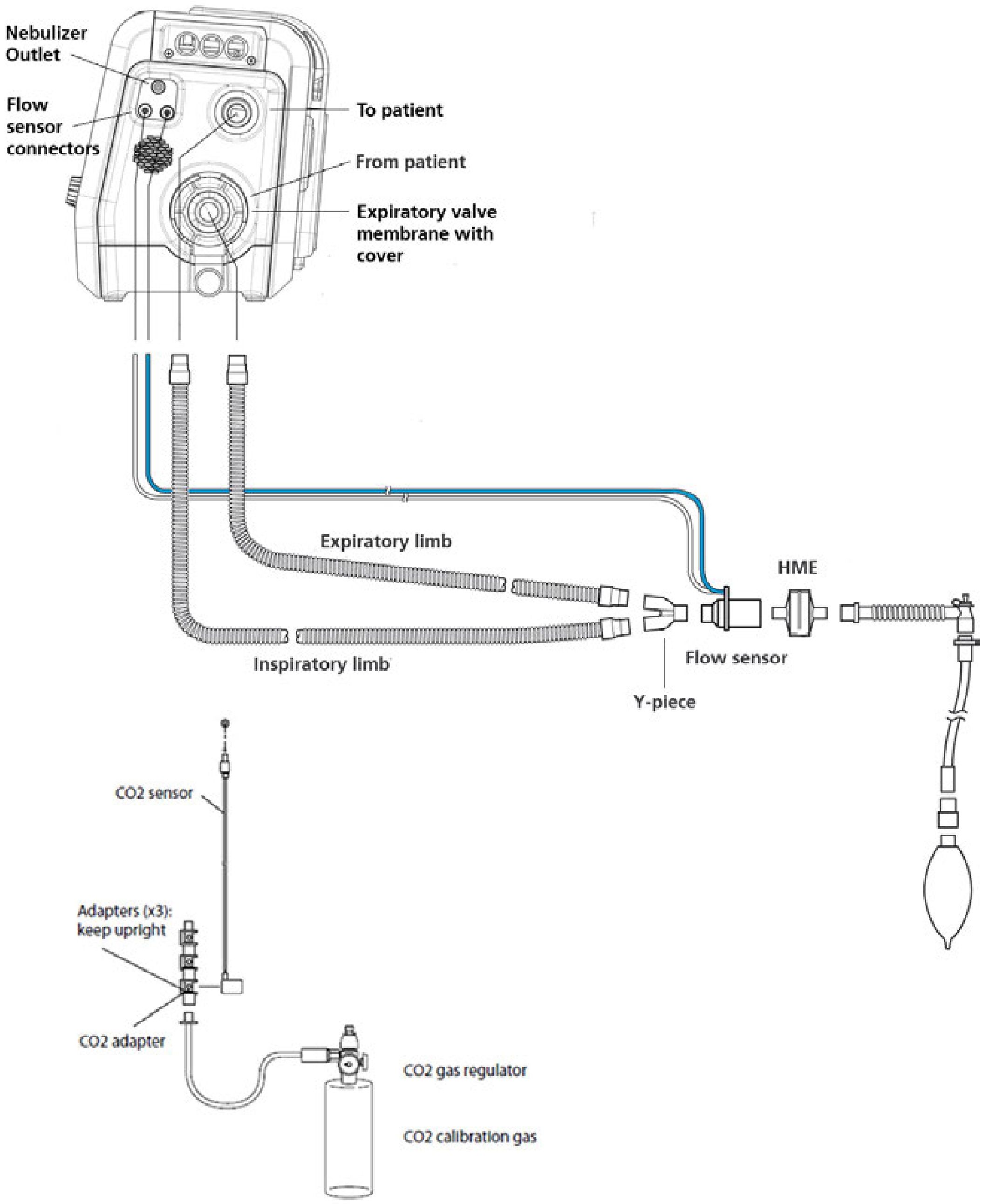


Fig. 186 CO2 Accuracy Check Setup

10 Select the System tab, Tests calib, then CO2 Sensor to start the zero calibration.

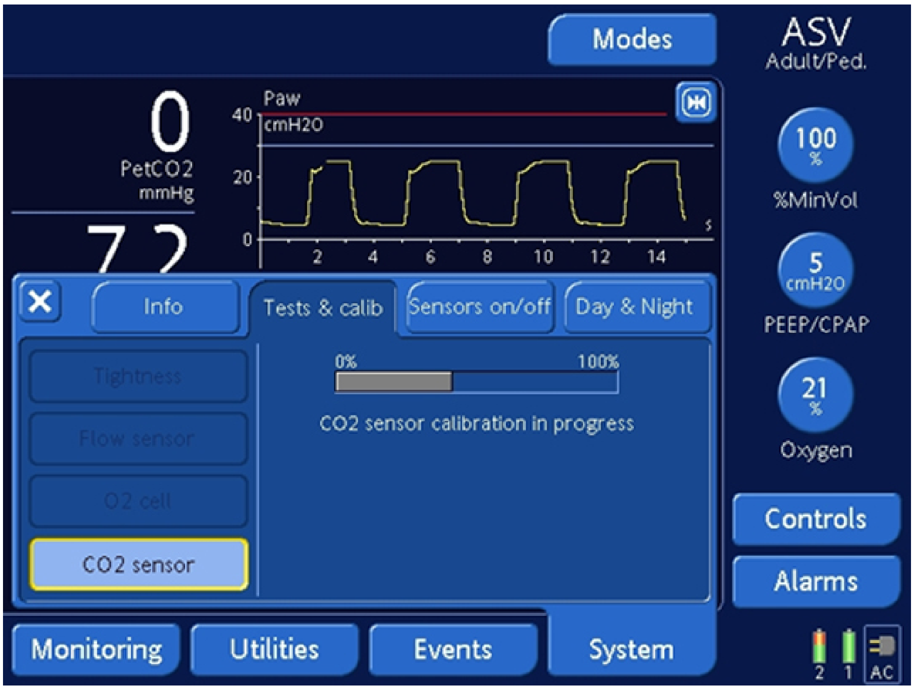


Fig. 187 CO2 sensor calibration

11 Start ventilation with standard settings. Select the PCO2 curve for displaying on screen.

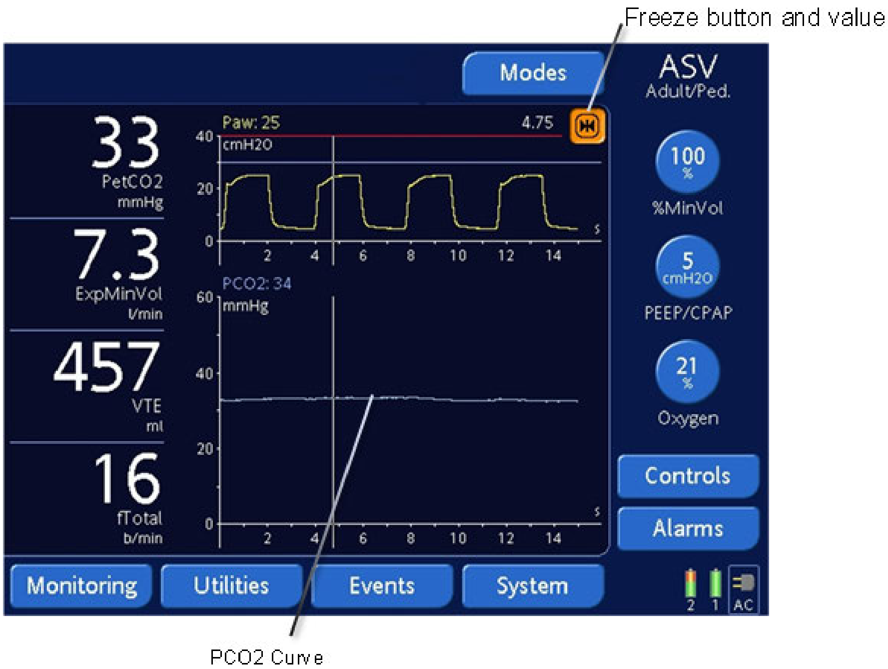


Fig. 188 CO2 Sensor Accuracy Check

12 Fill up the test volume - created by the three adapters - with CO2. Open the CO2 regulator only slightly, so the pressure does not push the CO2 out of the test volume.

13 Close the CO2 regulator once the test volume is filled and a stable curve is displayed. Hold the test volume steady and upright. Should the curve not be stable, repeat step 12 and 13.

14 To get the PCO2 value in mmHg, press the freeze button. (e.g. 34mmHg as shown).

Example: if the ambient temperature is 20 °C, barometric pressure is 900 mbar, and displayed PCO2 reading is 34 mmHg, the displayed PCO2 value is at the low end, but still within the range.

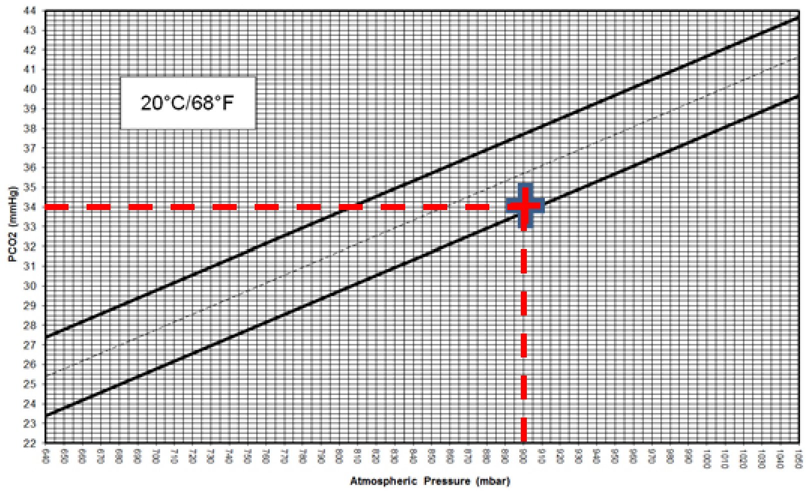


Fig. 189 Graph based on ambient temperature

15 See the following graphs based on ambient temperature:

- Ambient temperature 20 °C (17.5 to 22.5 °C): Fig 190
- Ambient temperature 25 °C (22.5 to 27.5 °C): Fig 191
- Ambient temperature 30 °C (27.5 to 32.5 °C): Fig 192
- Ambient temperature 35 °C (32.5 to 37.5 °C): Fig 193

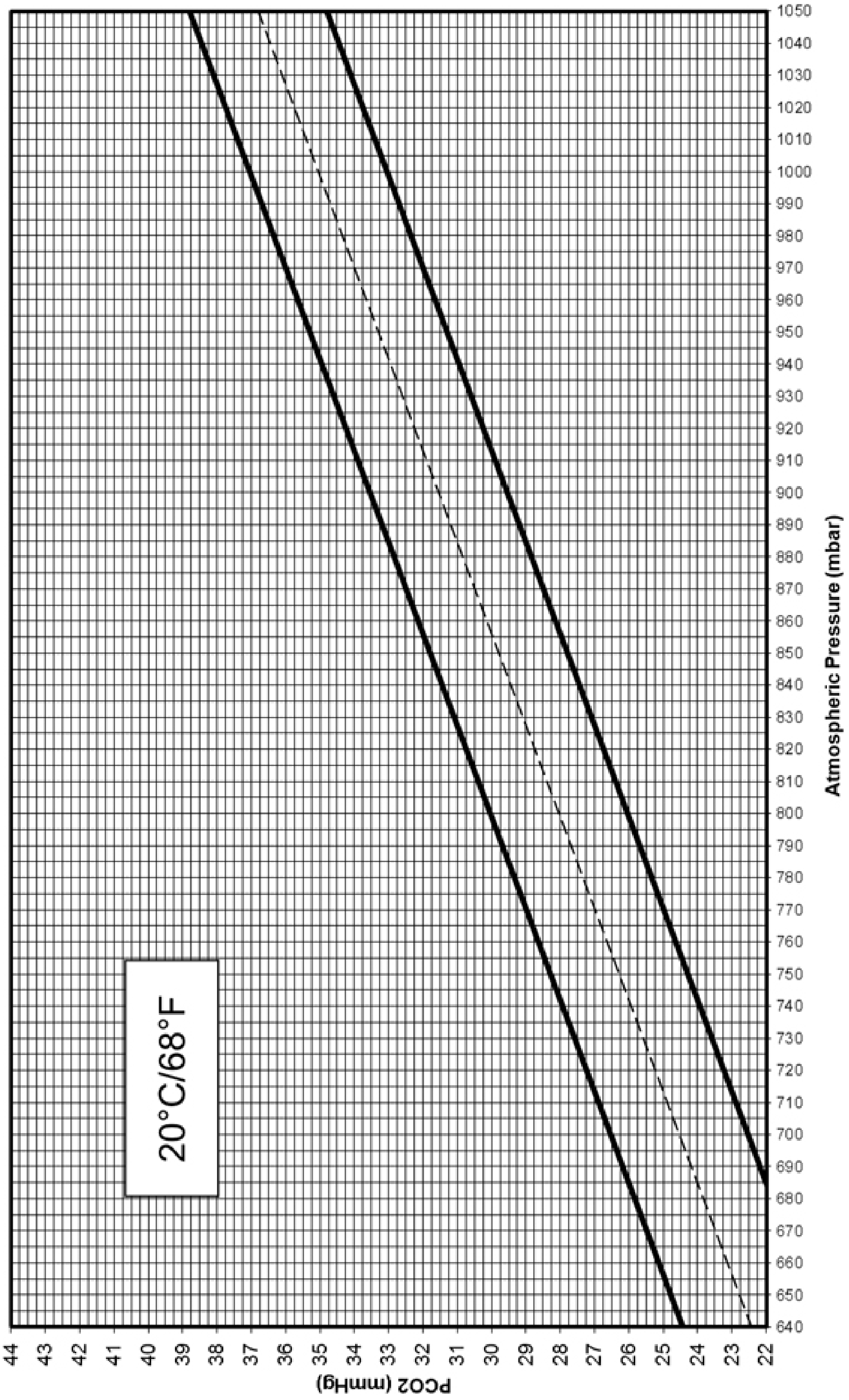


Fig. 190 Acceptable Range for PCO2 at Atmospheric Pressure (17.5 to 22.5 °C)

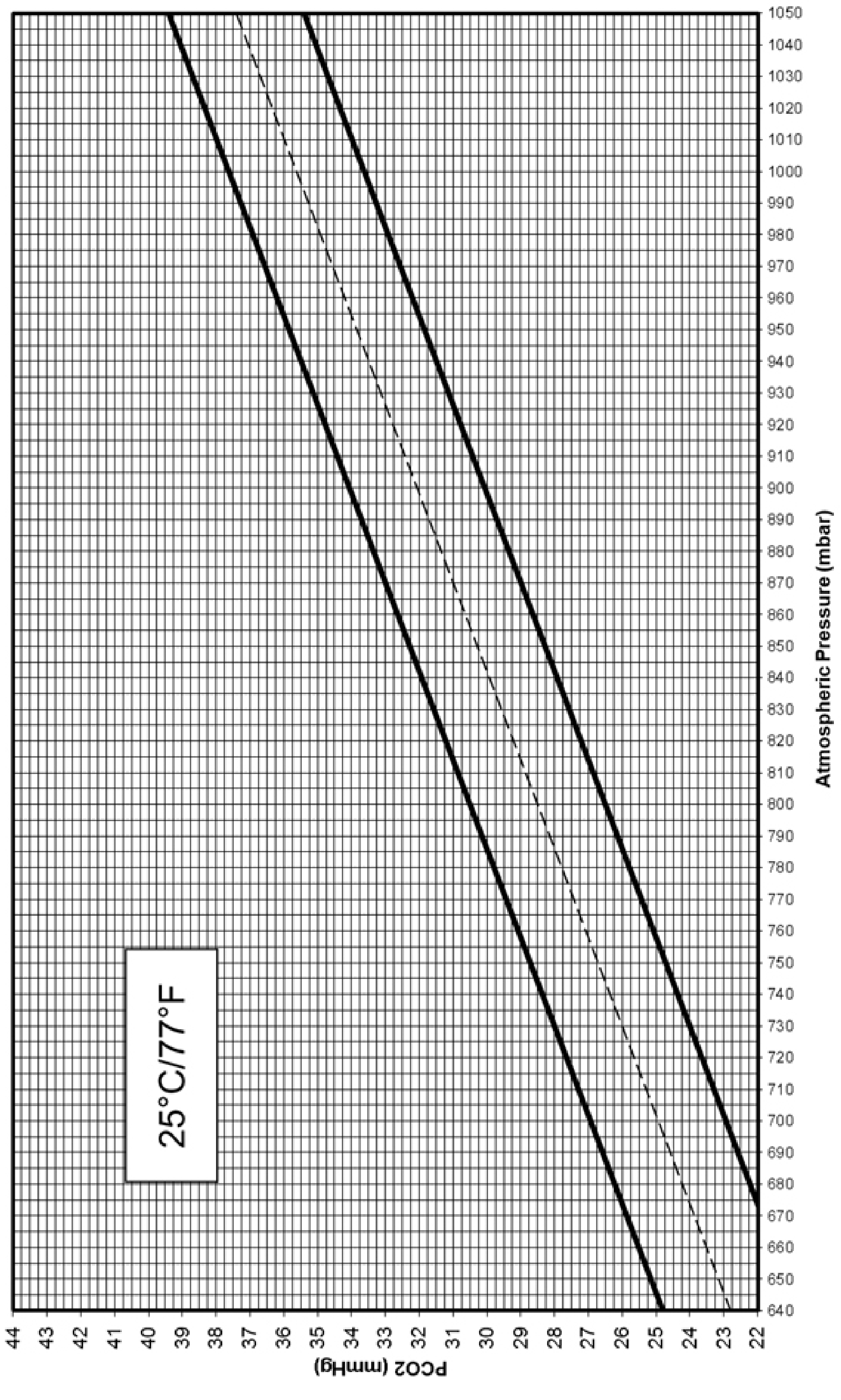


Fig. 191 Acceptable Range for PCO2 at Atmospheric Pressure (22.5 to 27.5 °C)

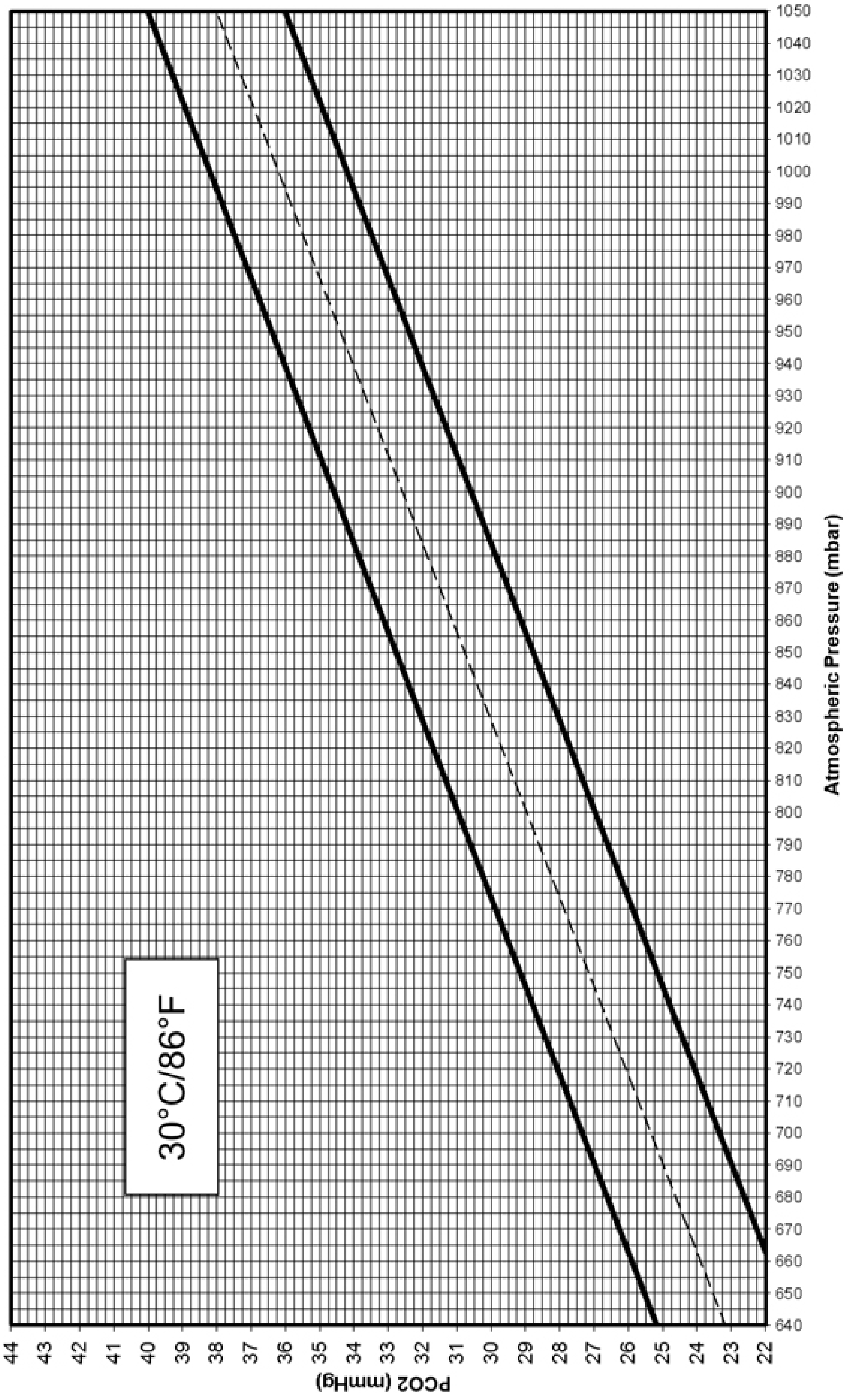


Fig. 192 Acceptable Range for PCO2 at Atmospheric Pressure (27.5 to 32.5 °C)

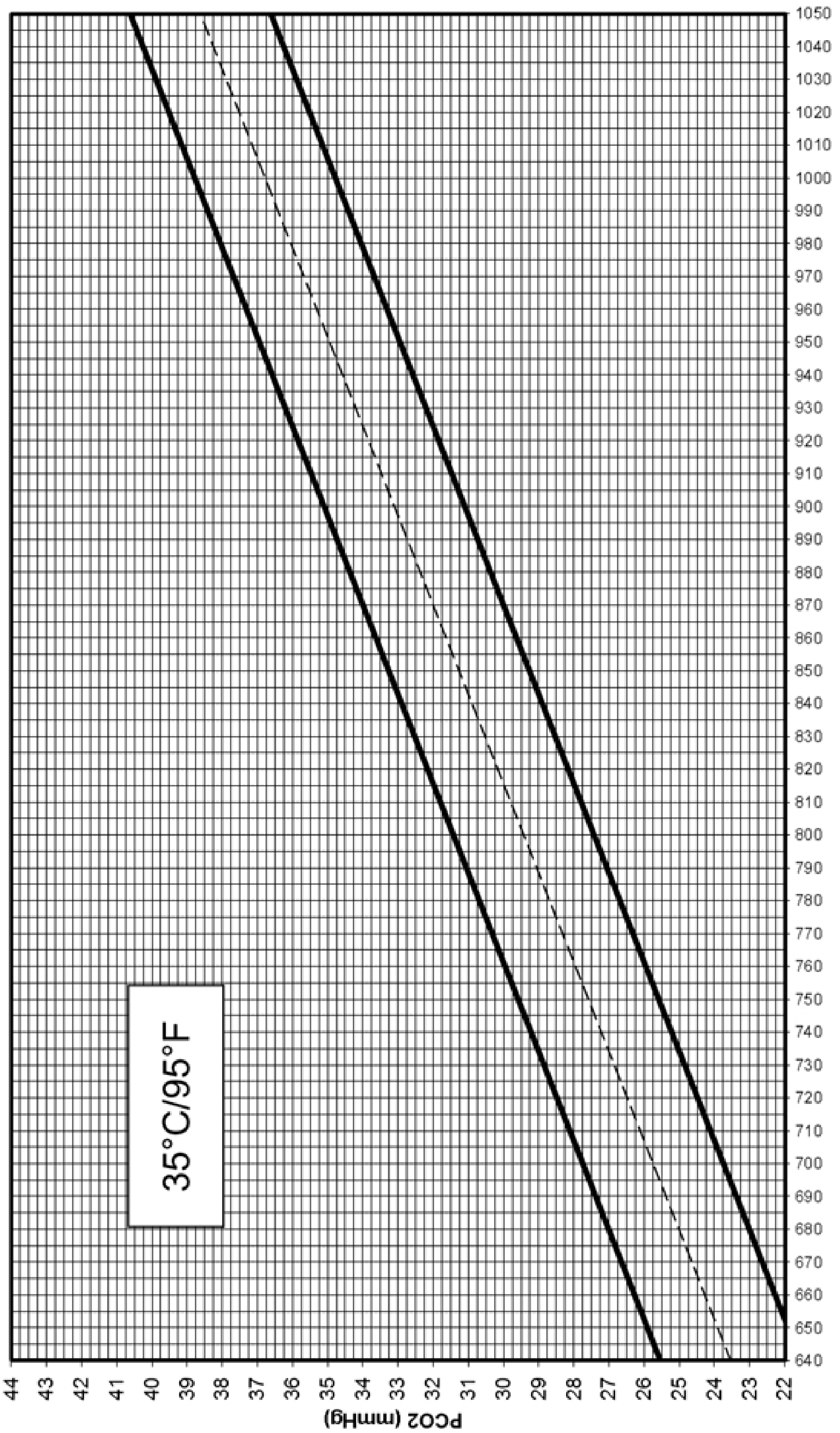


Fig. 193 Acceptable Range for PCO2 at Atmospheric Pressure (32.5 to 37.5 °C)

9.18 SpO2 measurerment check

Follow these steps to check the SpO2 measurement, if installed.

In addition to the ventilator with SpO2 option board installed, this check requires:

- Patient breathing circuit (*not required*: humidifier, water traps, or inspiratory filter)
- Test lung
- PN 281718, SpO2 sensor Masimo

1 Enter System->**Info**

2 Verify the SpO2 option board is displayed in the Info Tab.

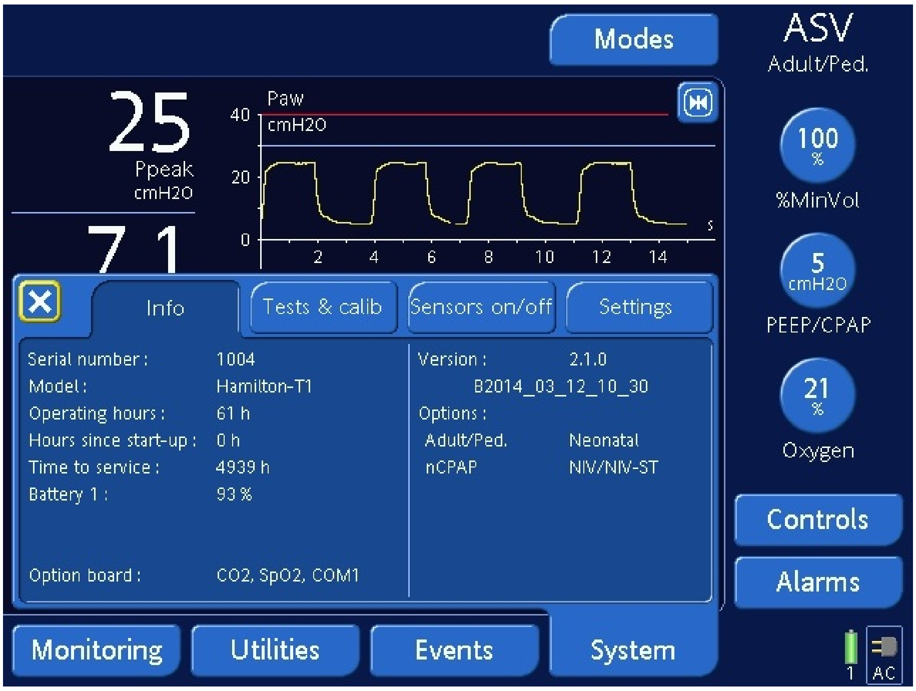


Fig. 194 Installed SpO2 option board

3 Activate the SpO2 Hardware Option: Utilities->Configuration->Options->HW options

Fig. 195 HW Option SpO2

4 Connect the SpO2 sensor with the SpO2 option board.
5 Activate the SpO2 sensor: System->Sensors on/off.

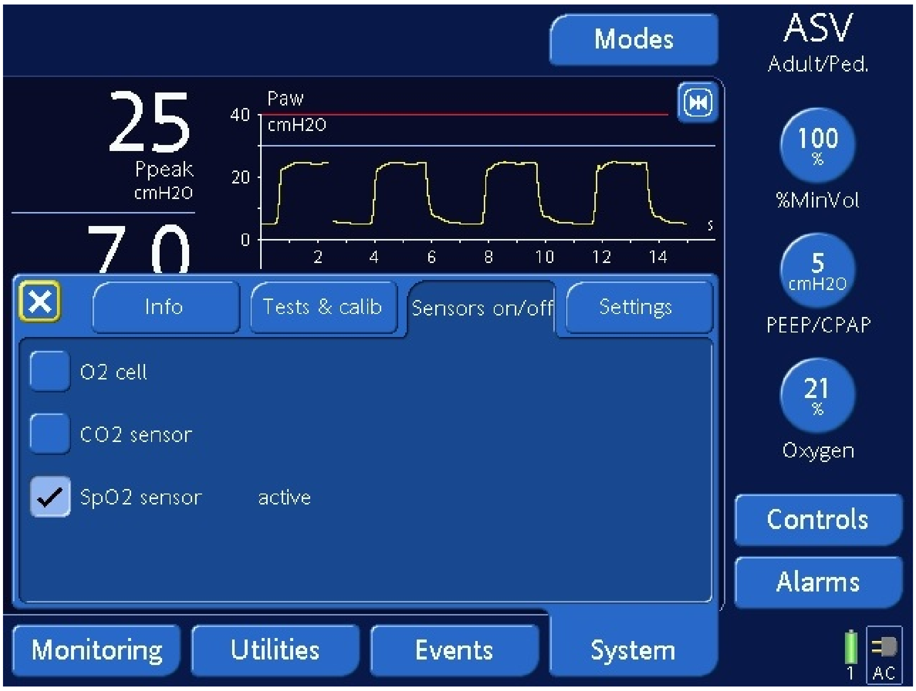


Fig. 196 SpO2 sensor active

6 Start the ventilator in ventilation mode (e.g.. in ASV mode).

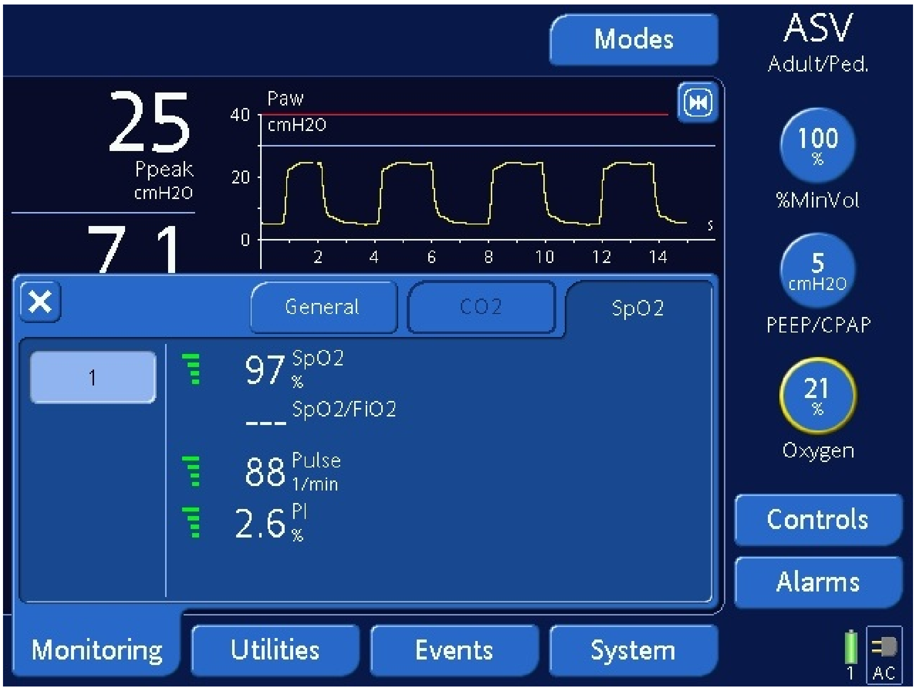


Fig. 197 SpO2 monitoring

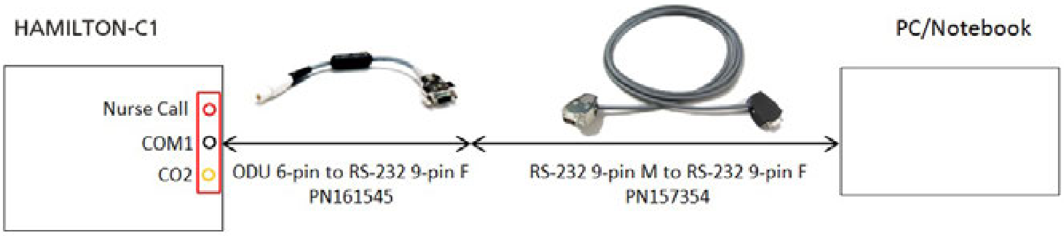
7 Attach the SpO2 sensor to the finger and verify for valid values in the SpO2 monitoring tab or in the dynamic lung view.

9.19 Communication interface RS232 functional test

Connect a patient monitoring system. Verify that the communication with the patient monitoring system works properly.

Alternatively, check the signal availability using the Datalogger software, as described next.

1 Connect the ventilator to an IEC 60601-1 standard-compliant computer via RS-232, as shown.



2 Download the Datalogger software from the HAMILTON Partner-net: http://www.hamilton-medical.com/clinical-resources/datalogger.html
Set the RS232 Protocol as follows:

2.1 In Standby mode, touch **Utilities**, and type the configuration code *7132*.

2.2 In the Configuration > General window, touch the **More** tab.

2.3 In the RS232 Protocol list, select HAMILTON.

Running the test:

3 Run *HAMILTON-Datalogger.exe.*

The Welcome window appears.

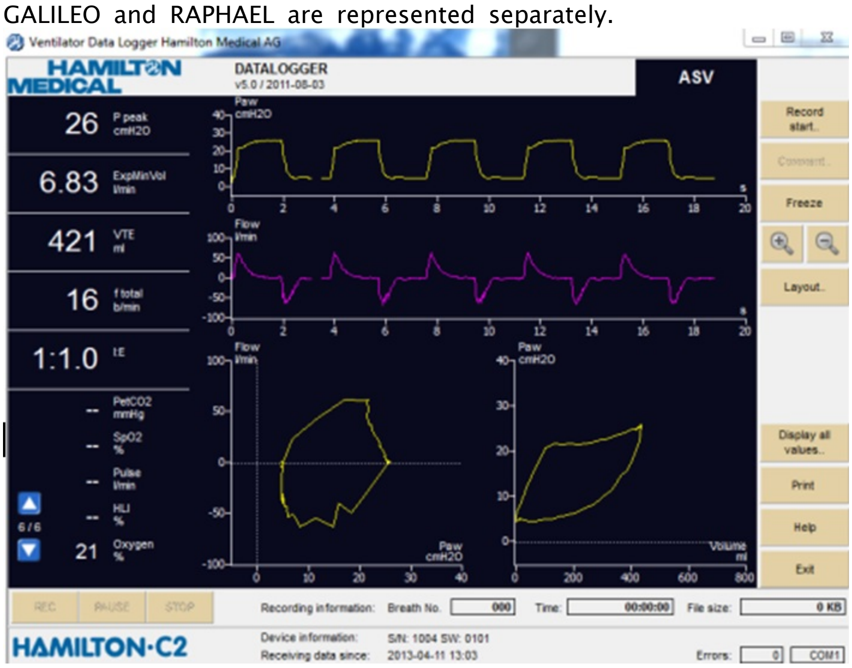
4 Click >ENTER.

5 The software automatically recognizes the connected device's software:

– For HAMILTON-C1 / T1 /C2/C3 ventilators, the Datalogger displays *HAMILTON-C2*.

– For HAMILTON-S1 and HAMILTON-G5 ventilators, the Datalogger displays *HAMILTON-G5*.

– GALILEO and RAPHAEL are represented separately.



6 To check whether the connection is working properly, start ventilation.

If the Datalogger is working properly, the display shows ventilation values as well as the device serial number (S/N at Device information).

Also check the Errors counter on the right lower corner.

9.20 Nurse call functional check

1 Connect the nurse call connector (PN 160166) with the HAMILTON-C1 option board.

2 Check the three relays with a multimeter by measuring the resistance during ventilation, alarm off and alarm on between the following wires:

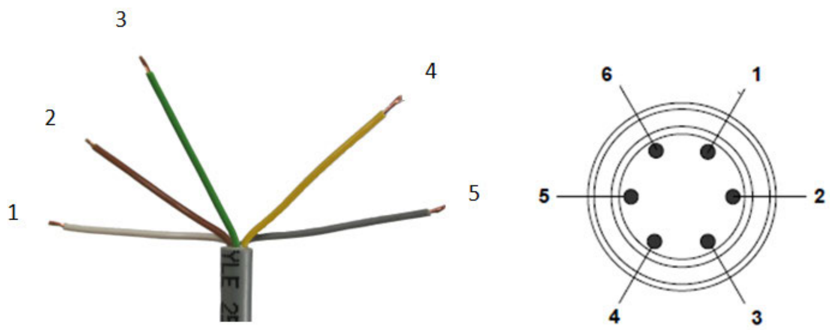


Fig. 198 Plug

Connector	Description	Colour
1	Alarm return normally closed	white
2	Alarm return normally open	brown
3	Alarm common	green
4	I:E Contact 2	yellow
5	I:E Contact 1	grey
6	—	-

Status	green — white	green — brown	yellow — grey
Alarm on	closed	open	depending
Alarm off	open	closed	depending
Inspiration	depending	depending	closed
Expiration	depending	depending	open

3 Check the three relays with a multimeter by measuring the resistance during ventilation, alarm off and alarm on between the following wires:

Enter Service software-> Tests/Calibration-> System test->Alarming (Page No 2205).

Activate/deactivate alarm (eg. Alr. High)

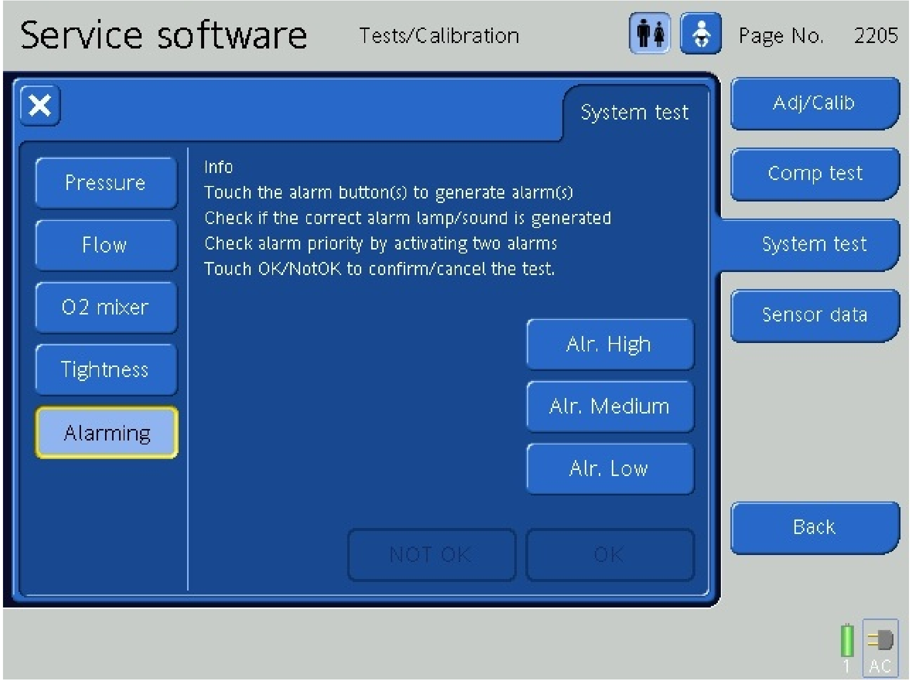


Fig. 199 Alarm on/off relay check

4 I:E relay check:

Restart the HAMILTON-C1 in operational mode. Start ventilation. Check I:E contact with the multimeter.

9.21 Preoperational Check

Refer to the ventilator operator's manual.

Perform the preoperational checks:

- Tightness test
- flow sensor calibration
- O2 cell calibration
- Alarm test's:
  - High pressure alarm
  - Low minute alarm
  - Low oxygen alarm / oxygen supply failed alarm
  - Disconnection on patient side
  - Loss of external power
  - Exhalation obstructed
  - Apnea

10 Technical Faults

10.1 Technical Faults

Alarm Indications

Tab. 13 Alarm Indications in the Ventilator

Alarm type	Message bar[a]	Alarm lamp	Audio	Action required
High-priority alarm	Red, with alarm message	Red	A sequence of 5 beeps, repeated until the alarm is reset. If the audible alarm is not silenced during the first minute, the continuous-tone buzzer also sounds.	The patient's safety is compromised. The patient needs immediate attention.
Medium-priority alarm	Yellow, with alarm message	Yellow	A sequence of 3 beeps, repeated periodically. If the audible alarm is not silenced during the first minute, the continuous-tone buzzer also sounds.	The patient needs prompt attention.
Low-priority alarm	Yellow, with alarm message	Yellow	Two sequences of beeps. This is not repeated.	Operator awareness is required.
Technical fault	Red, with **Safety ventilation**: xxxxxx or **Technical fault**: xxxxxx	Red	Same as for high-priority alarm, if technically possible. At the minimum a continuous buzzer tone. The buzzer cannot be silenced.	The ventilator enters safety mode, or, if it cannot safely ventilate, the ambient state. Provide alternative ventilation. Turn off the ventilator. Have the ventilator serviced.

a. If more than one alarm is active, the associated alarm messages alternate in the message bar.

Alarm Class

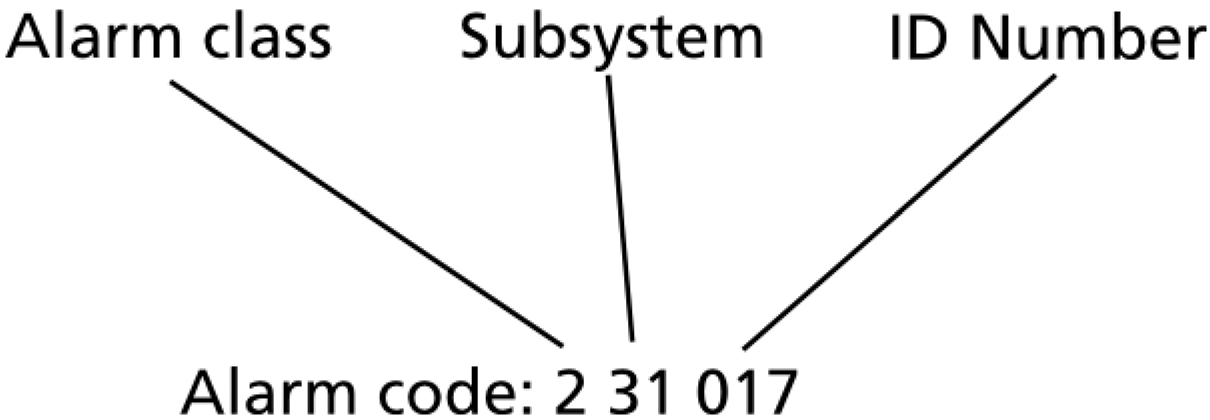


Fig. 200 Alarm class

Alarm Codes	Alarm Class
100000 Chapter 19.2	Patient alarms
200000 Chapter 19.3	Technical events
300000 Chapter 19.4	Technical failures resulting in the ventilator switching to the safety mode
400000 Chapter 19.5	Technical failures resulting in the ventilator switching to the ambient mode
500000	System failures; invisible TF for user, no action required. For internal use.

Patient alarms: (Alarm code 100000)

- High-priority alarms
- Medium priority alarms
- Low priority alarms

Alarms related to : Pressure, flow, volume, apnea

Technical alarms: (Alarm code 200000)

- High priority alarms
- Medium priority alarms
- Low priority alarms

Alarms related to: Temperature, battery, valves, sensors

Technical Faults

Technical faults end up in one of the following states:

Fatal -> safety mode: (Alarm code 300000)

In case of some technical failure the ventilator switches to SAFETY mode. This gives the user time for corrective actions, such as organizing a replacement ventilator. The turbine runs constant to create Pinsp. The expiratory valve switches system pressure levels between PEEP and inspiratory pressure. Patient monitoring is nonfunctional during safety ventilation. You must turn off ventilator power to exit safety ventilation.

Fatal -> ambient mode: (Alarm code 400000)

If the technical fault alarm is serious enough to possibly compromise safe ventilation, the ventilator enters the ambient state. The inspiratory channel and expiratory valve are opened, letting the patient breathe room air unassisted. You must switch off ventilator power to exit the ambient state.

Invisible technical faults (Alarm code 500000)

These are classed as “invisible technical faults” and are not shown on the LCD display during operation. They refer to exception handling performed by ventilator during operation, and are for HAMILTON MEDICAL AG internal use. Do not consult HAMILTON MEDICAL AG technical support concerning these technical faults. They have no significance for hospital workers or field engineers.

For detail description go to Glossary - Alarm overview Chapter 19.3.

10.1.1 Troubleshooting

For troubleshooting refer to document no 624485 "Troubleshooting Platform C" available for download from the Hamilton Medical Partner Net www.hamilton-medical.com.

Follow suggested troubleshooting steps in order as described.

Follow these steps when troubleshooting:

1. Confirm that test configuration is correct.
2. When replacing components, repeat the applicable test following each replacement. If the test passes successfully, repeat all test's in order (see Section Service Software).
3. If a problem cannot be resolved, enter a customer event report (CER) on the HAMILTON MEDICAL AG online help desk (https://hamilton.ky2help.com). Export event log and instrument report for failure analysis. Check regularly the knowledge base of the ky2help for latest information and troubleshooting.

11 Components Removal/Assembly

11.1 Notes on Maintenance and Replacement

WARNING

You must perform the repairs detailed in this section only as instructed in Preventive Maintenance and Testing Overview, refer to Chapter 7.1.

Service the HAMILTON-C1 only as described in this manual, using only parts approved or supplied by HAMILTON MEDICAL AG. Incorrect parts, components or assemblies could result in patient injury. See available spare parts starting in chapter Chapter 13.1.

- Always switch the HAMILTON-C1 off and disconnect the HAMILTON-C1 from the external mains power and as well as remove the battery, before opening the cover.
- Never use any kind of lubrication on any part of the HAMILTON-C1.
- Some parts may be hot after operational use (blower module, rinse flow valve, power supply, etc.).

CAUTION

After performing Maintenance or Replacement of a component or module, perform the necessary calibrations, Service Software checks and Safety Tests to ensure the HAMILTON-C1 is performing properly.

HAMILTON MEDICAL AG does not permit repairs to parts that are supplied as an assembly. For example:

- You have to replace the blower module as a complete assembly.
- You have to replace the expiratory valve as a complete assembly.
- You have to replace the mixer as complete assemblies.
- You have to replace HAMILTON MEDICAL AG printed circuit boards only.

Make sure to take full ESD (electrostatic discharge) precautions before opening the HAMILTON-C1. Refer to Chapter 12.3 (electrostatic discharge protection).

When the HAMILTON-C1 is switched ON, even when not connected to the external mains power, the battery pack(s) supply power. Therefore, a short circuit is possible when the HAMILTON-C1 is switched ON.

Note

Always send defective parts, components or assemblies to HAMILTON MEDICAL AG with a completed return good authorization (RGA) request.

Before making any repairs, remove from the HAMILTON-C1:

- External mains power supply and batties
- Oxygen supply
- Patient breathing circuit (if not needed)
- Flow sensor tubing (if not needed)
- Batteries

Update the technical state if necessary after exchanging the parts and restart the machine. This must be done before performing the service software.

11.2 Main Tools

	Torx screwdriver TX 8, TX 10 and TX 20	
	Slotted screw driver size 2	
	Tool set	
	Needle nose pliers	
PN 500077	ESD wristband	
	Socket wrench 11	

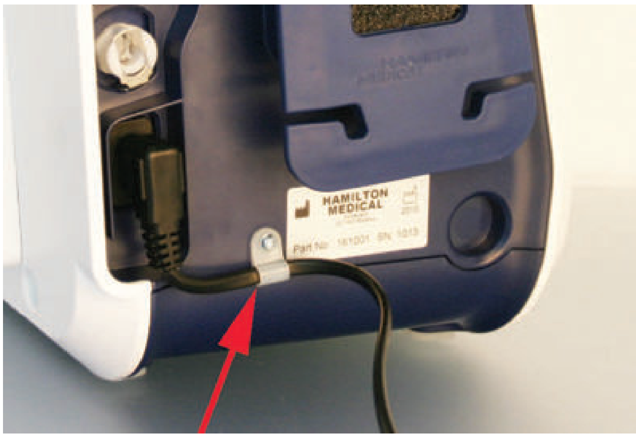
11.3 Securing the power cord

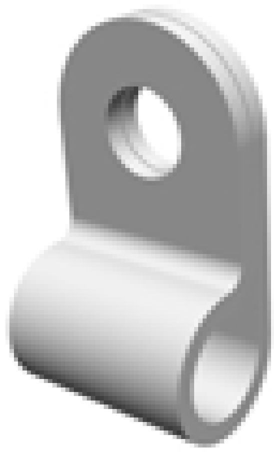
Note	To prevent unintentional disconnection of the power cord, make sure it is well seated into the ventilator's socket and secured with the power cord retaining clip. The HAMILTON-C1 does not require protective earth grounding, because it is a class II device, as classified according to IEC 60601-1.

Securing the power cord with the suitable retaining clip.

Secure the power cord with the retaining clip as shown in the picture below.

Two different retaining clips available. Use the suitable retaining clip as listed in the table below.



361061	Cable security clamp D=5.0 for power cords: -PN 355199 GB -PN 355200 EU	
361097	Cable security clamp D=6.2 for power cords: -PN 355198 USA -PN 355308 CN	

Replacing the power cord

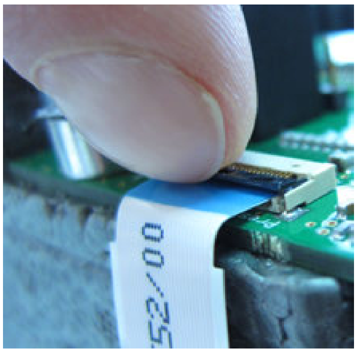
To replace the power cord release the screw (PN 420724) of the retaining clip.

When reconnecting the power cord make sure it is well seated into the ventilator's socket and secured with the power cord retaining clip.

11.4 Disconnecting Flexible Flat Cable (FFC)

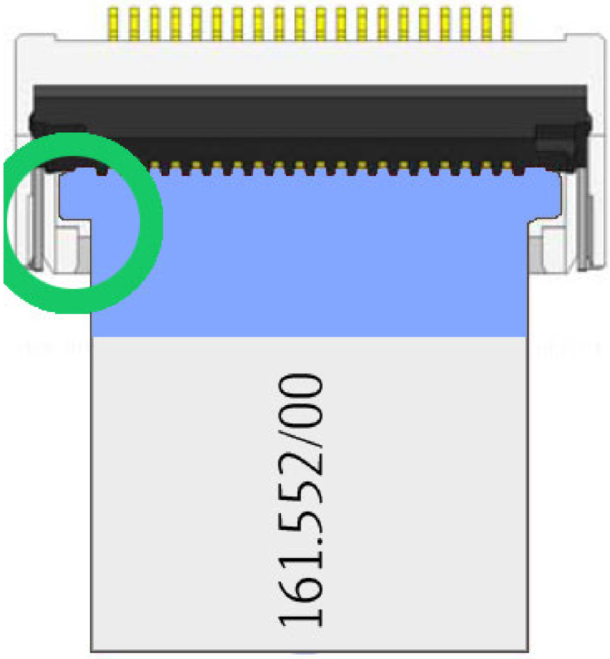
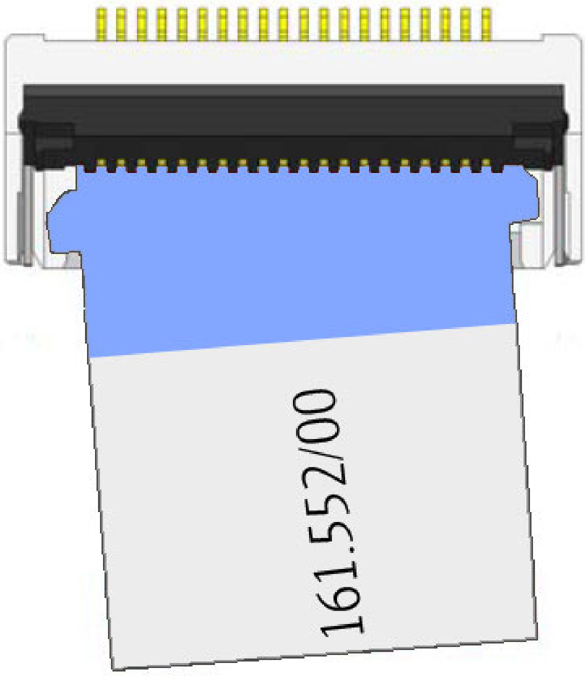
Flexible flat cable, or FFC, refers to any variety of electrical cable that is both flat and flexible.

Disconnection procedure of FFC

	Lift the slider. Use thumb or index finger.

Insertion procedure of FFC

	Fully insert the FFC in the connector parallel to mounting surface, with the exposed conductive traces facing down. While connecting the FFC the blue part must be visible from above.

Proper insertion flexible flat cable (FFC)	Oblique insertion flexible flat cable (FFC)
	

11.5 Tube Connector

1. Press the release bush (A) in direction to the connector for tube removal and reinsertion.

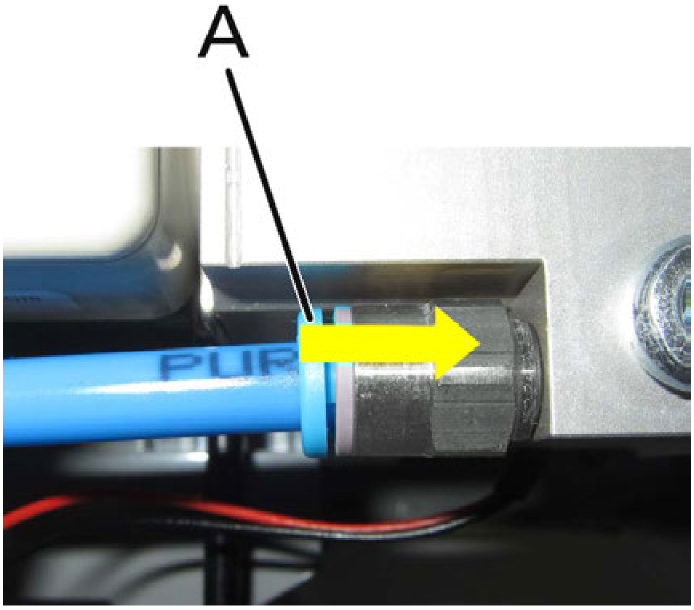


Fig. 201 Open Tube Connector

2. When reinserting the tube, push the tube all the way to the stop.
3. Lock the release bush in direction of the tube.
4. Check the tube for proper connection by pulling at the tube a little.
5. For tightness check, also refer to Nebulizer Tube / Connection Tightness Chapter 9.16.

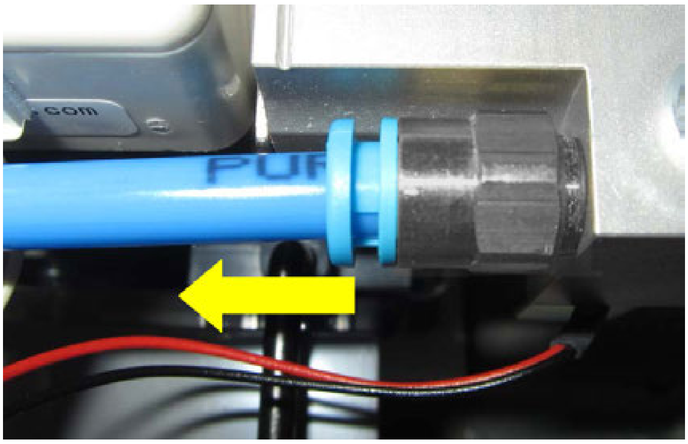


Fig. 202 Lock Tube Connector

11.6 Battery Removal/Assembly

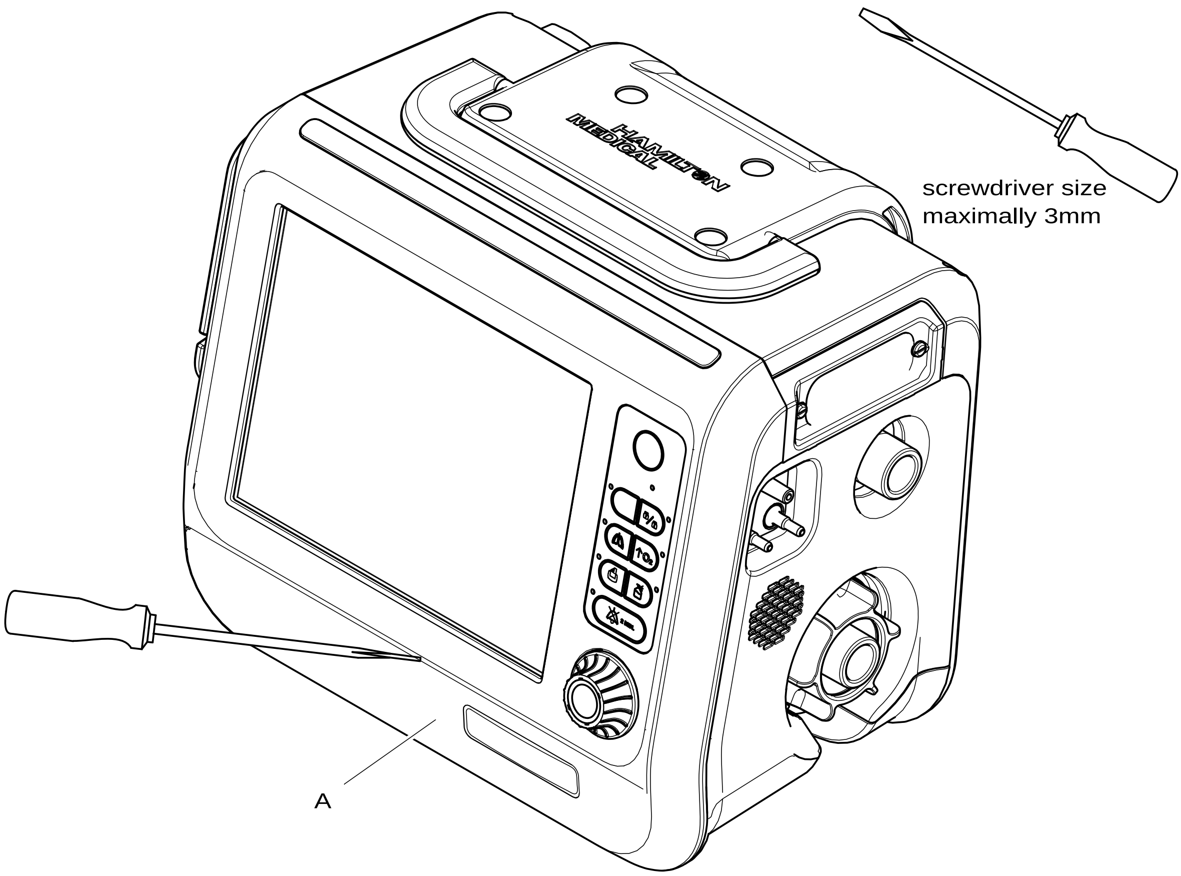


Fig. 203 Battery Cover Opening

Legend:

1. To remove the battery carefully open battery door (A) with your fingernails or a screwdriver.

2. Release the two screws (B, 2x PN 161274)).

3. Remove the battery cap (C).

4. Pull out the battery (D).

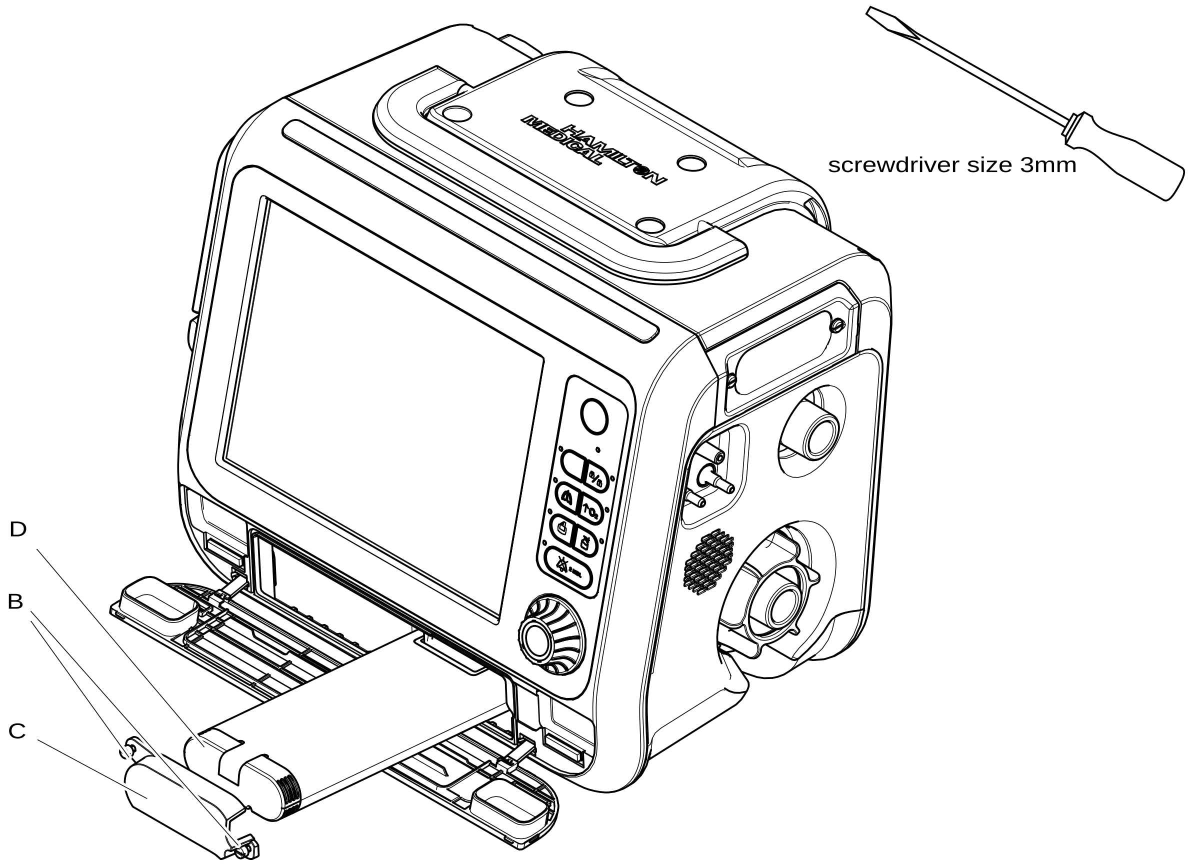


Fig. 204 Battery Removal/Assembly

11.7 Option Board Cover Removal/Assembly

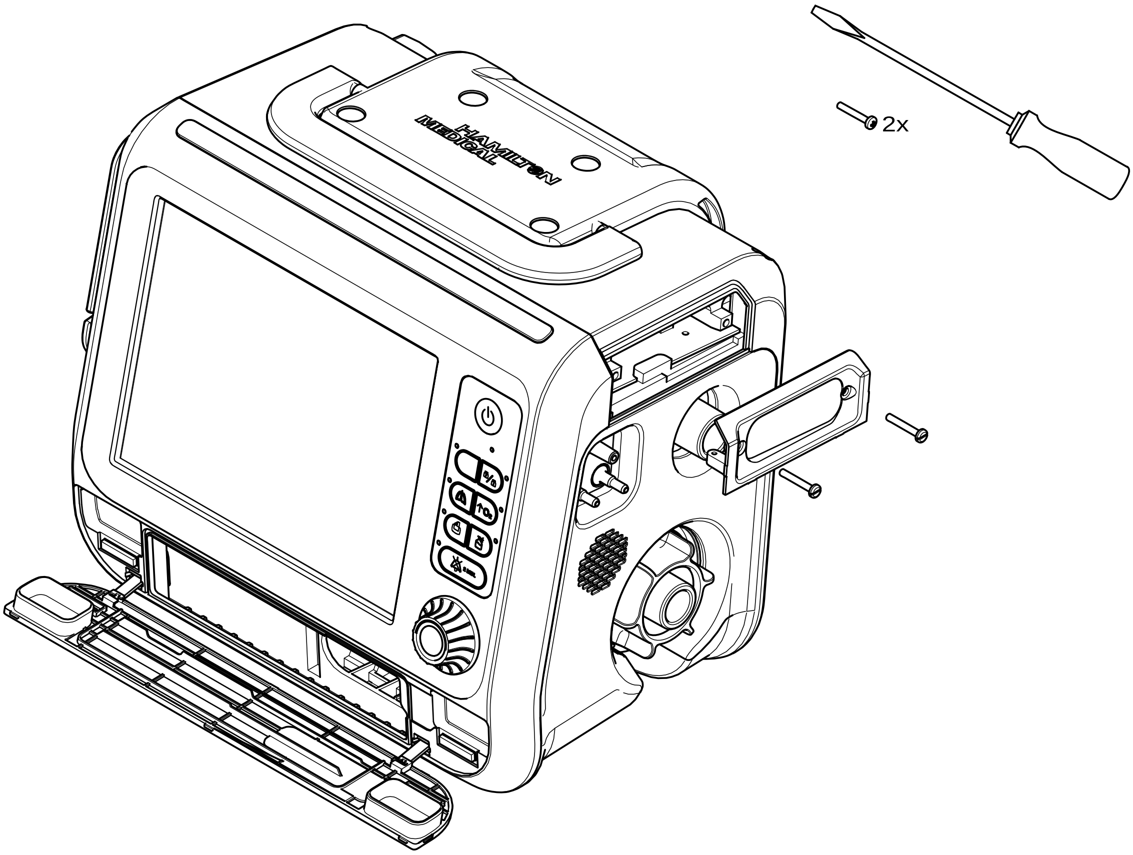


Fig. 205 Option Board Cover Removal/Assembly

Legend:

1	Remove the two screws (2x PN 420796).
2	Remove the option board cover.

11.8 Filter Cover

1. Remove the filter cover.

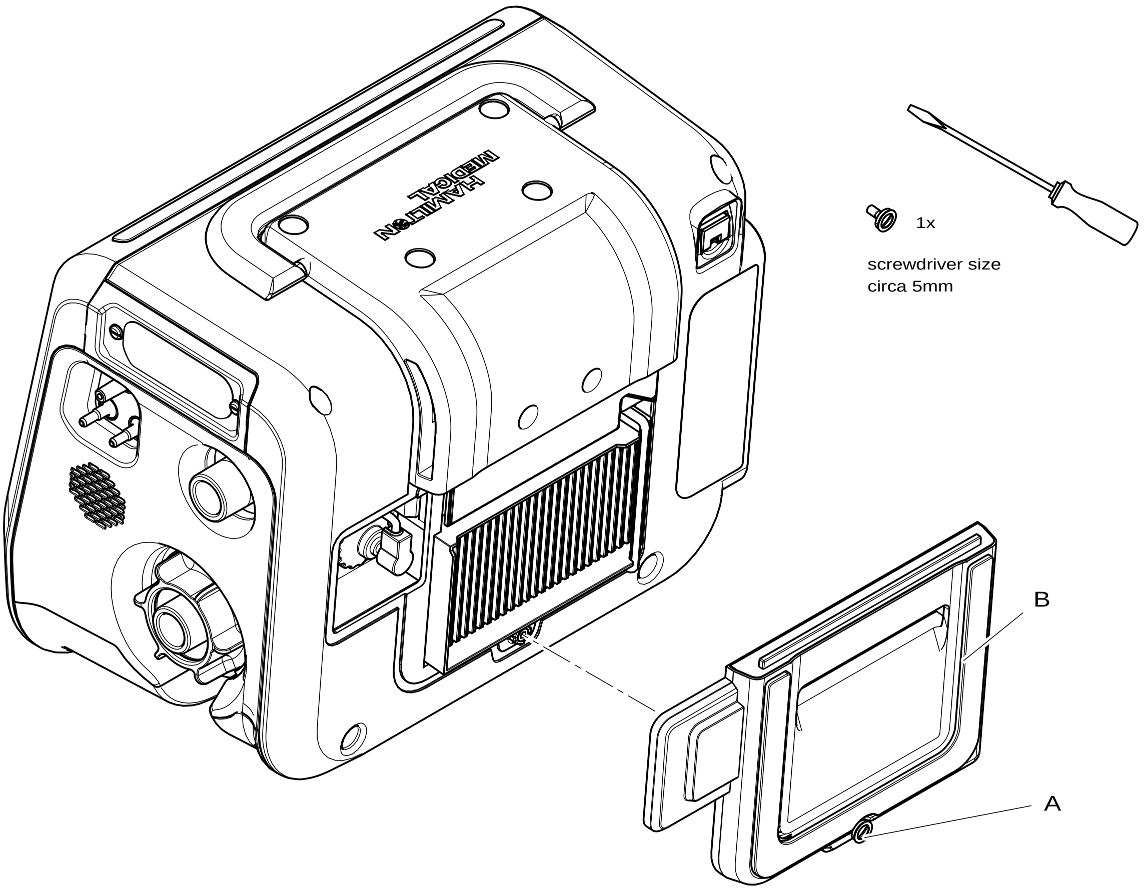


Fig. 206 Rear Cover Removal/Assembly

11.9 O2 Cell Removal/Assembly

1. Pull out the O2 cell plug (A).
2. Remove the O2 cell by turning it counterclockwise (B).

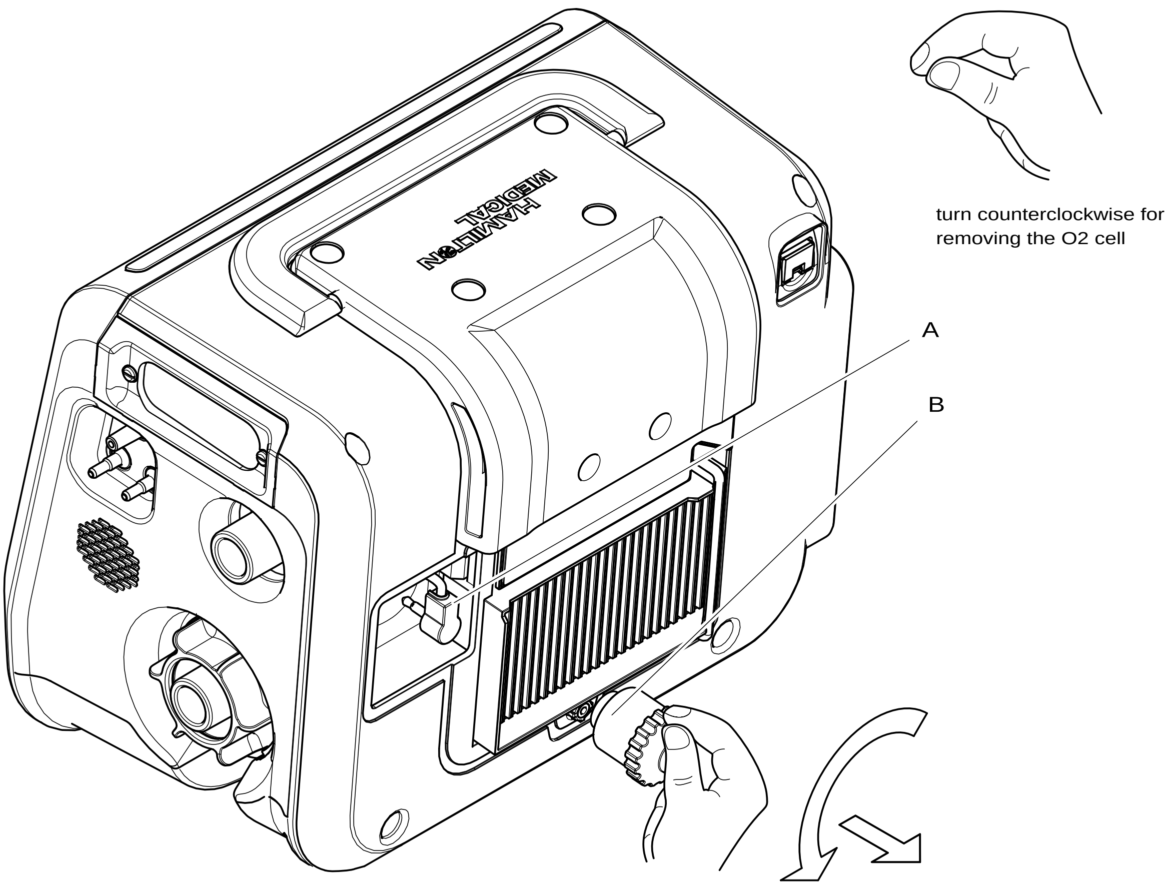


Fig. 207 O2 Cell Removal/Assembly

11.10 HEPA Filter Removal/Assembly

1. Turn the filter holder (A) to the right.
2. Pull out the HEPA filter (B).

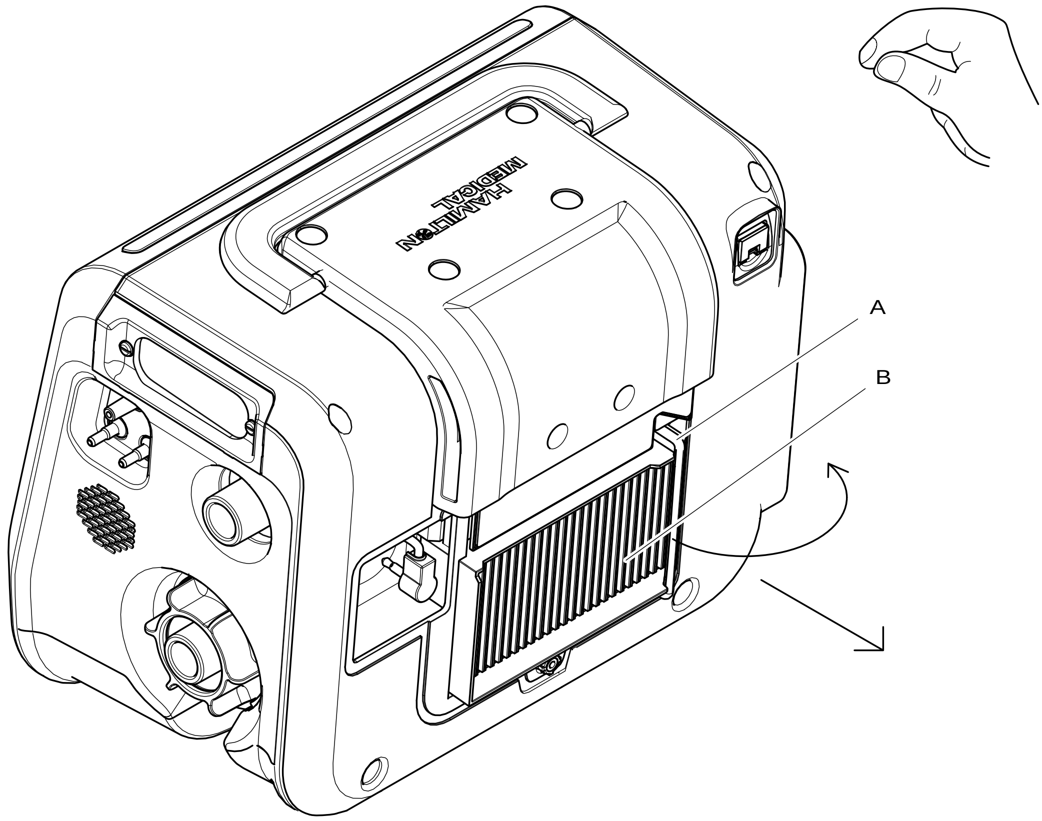


Fig. 208 Remove The HEPA Filter

11.11 Cover Removal/Assembly

1. Remove the 4 screws (4x PN 420667) on the back of the device.
2. Pull away the rear cover.

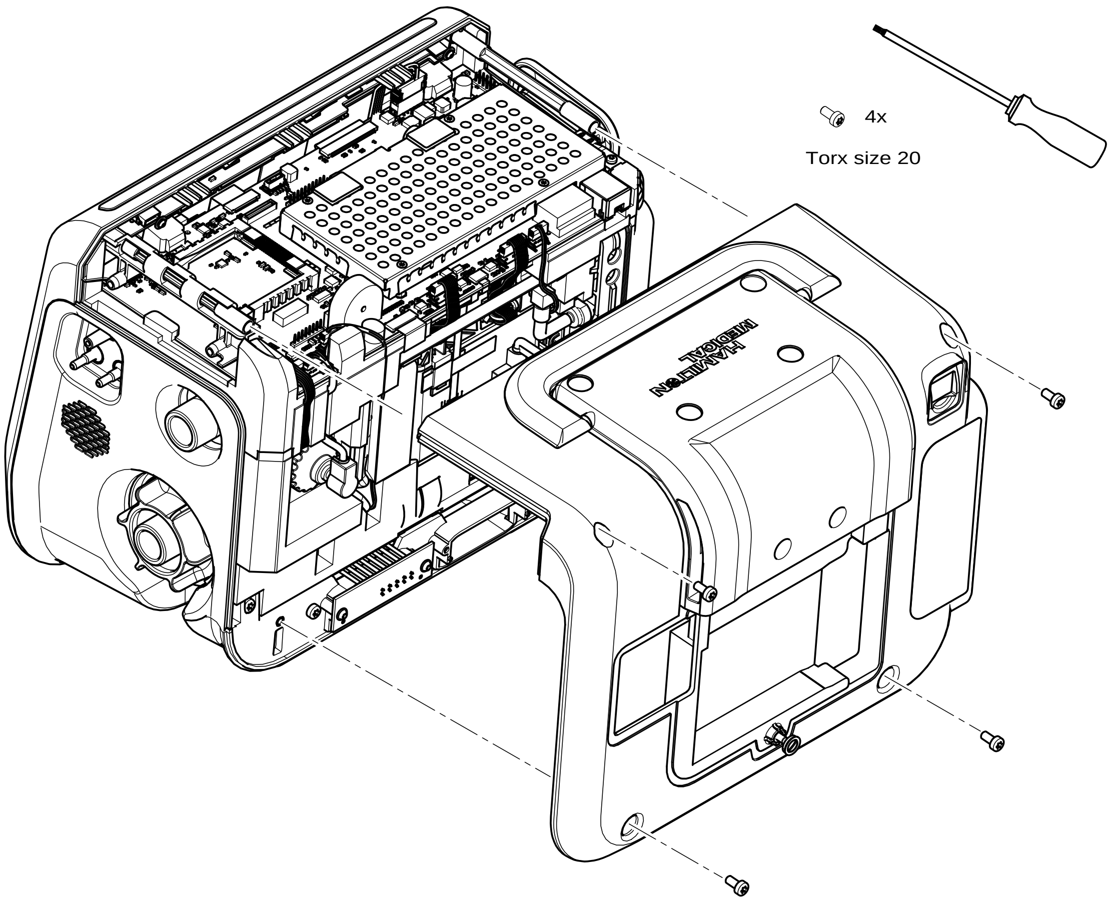


Fig. 209 Rear Cover Removal

11.12 Front Panel

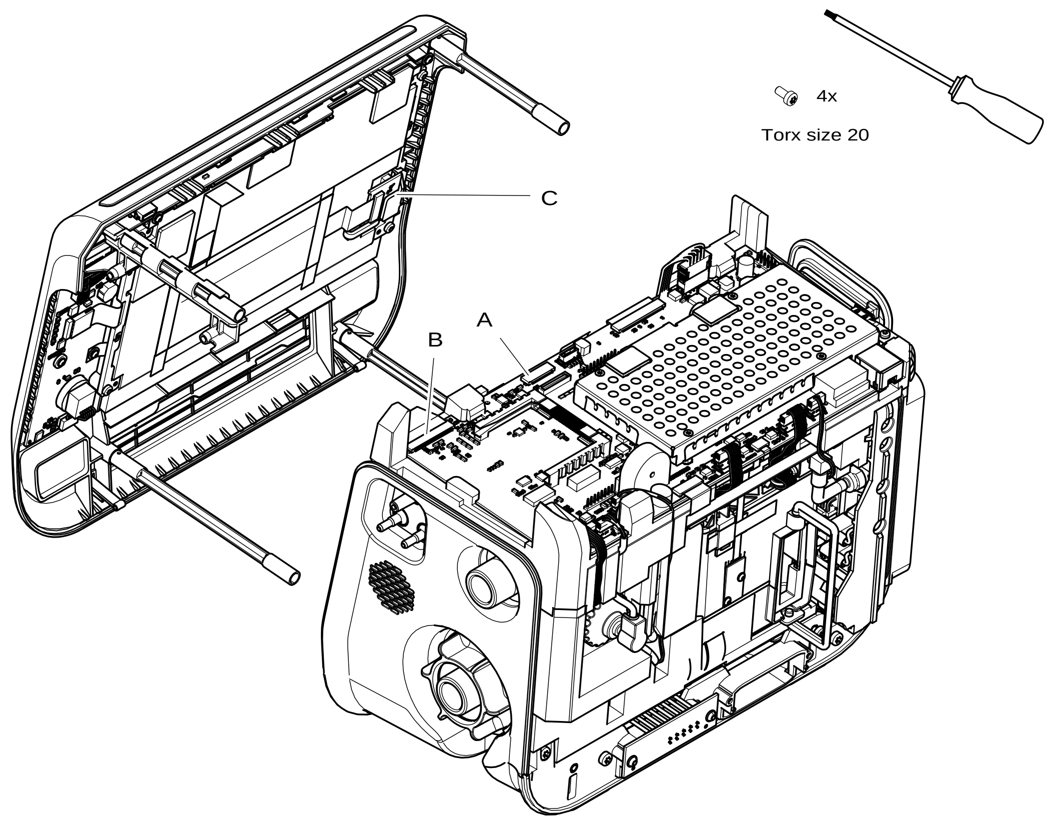


Fig. 210 Front Panel Removal/Assembly

1. Remove two screws at bottom back of the device (2x PN 420667).
2. Disconnect the two flat cables (A, B).
3. Remove the front panel (C) carefully.
4. Remove the option board bracket (Fig.211).

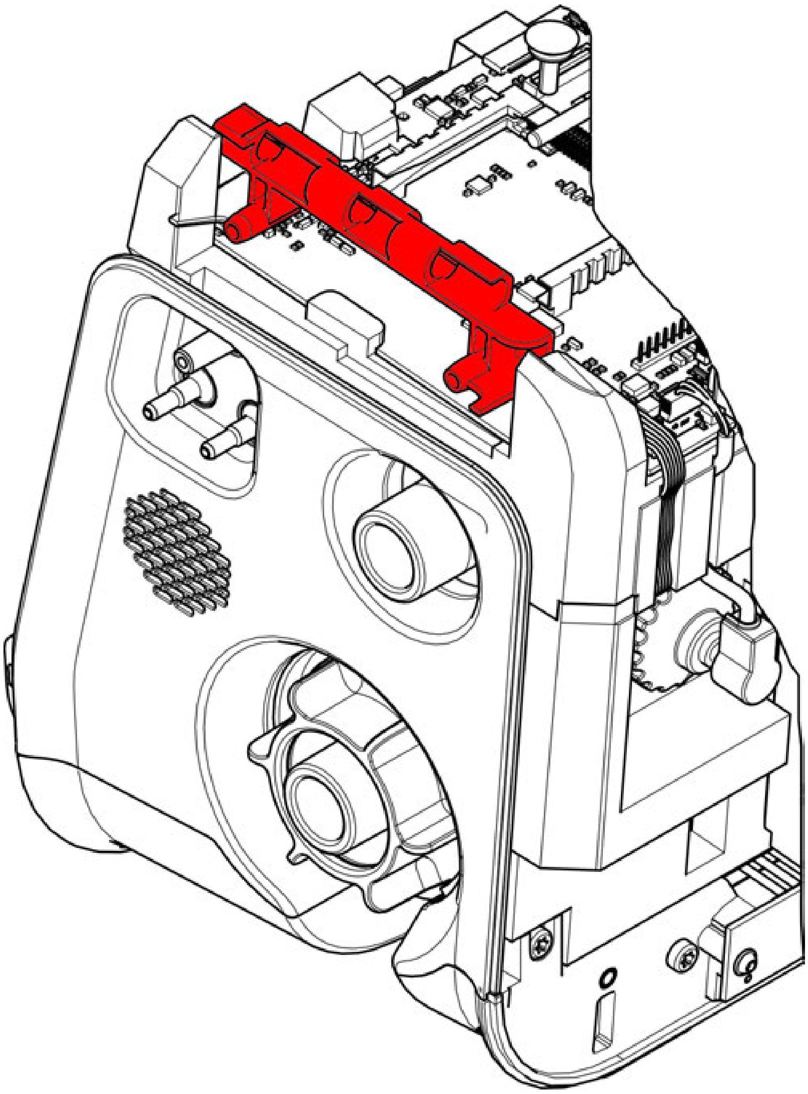


Fig. 211 Option board bracket

11.13 Expiratory valve cover

1. Remove the expiratory valve by turning the valve.

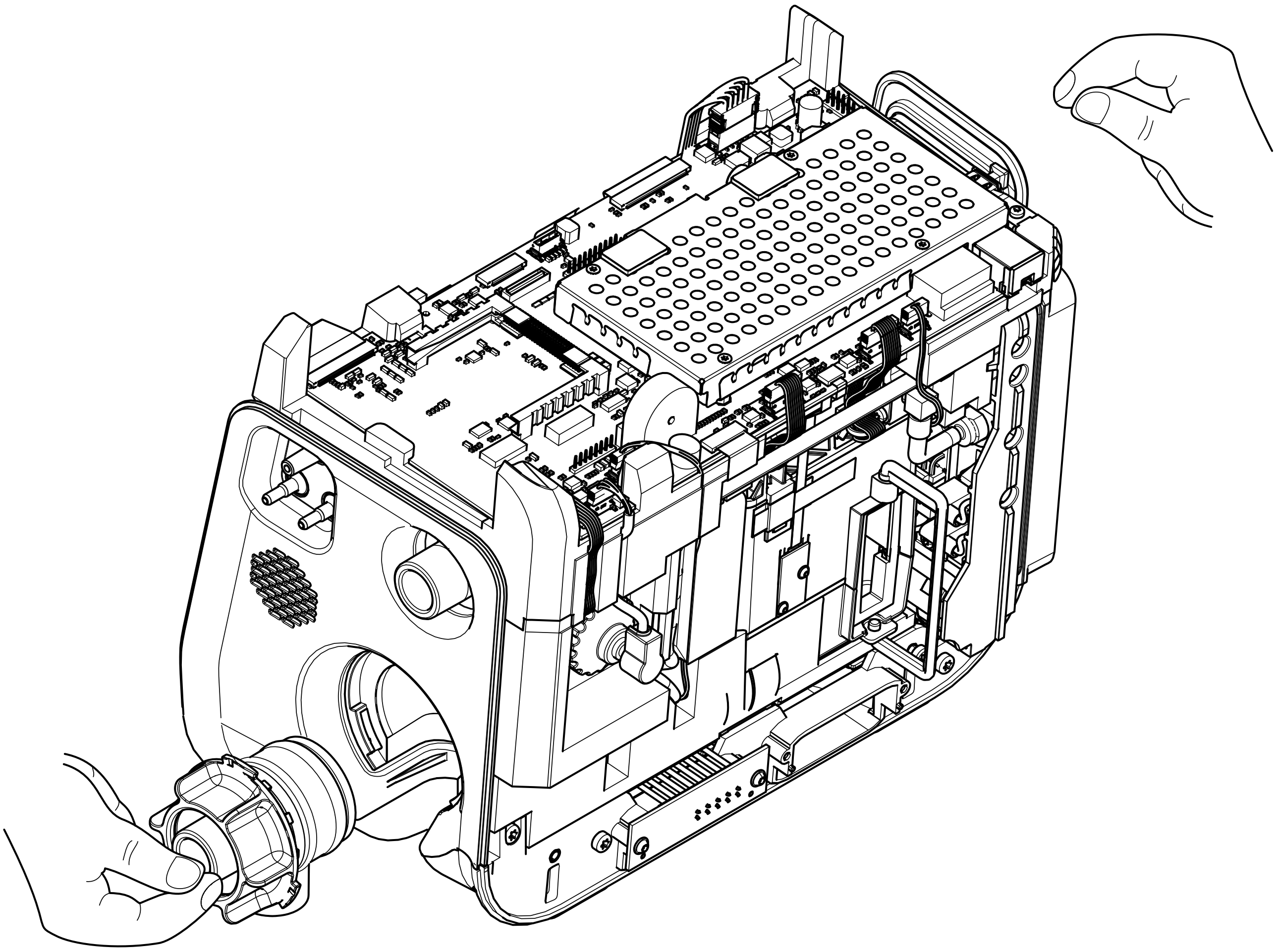


Fig. 212 Expiratory Valve Removal/Assembly

11.14 Left Side Cover

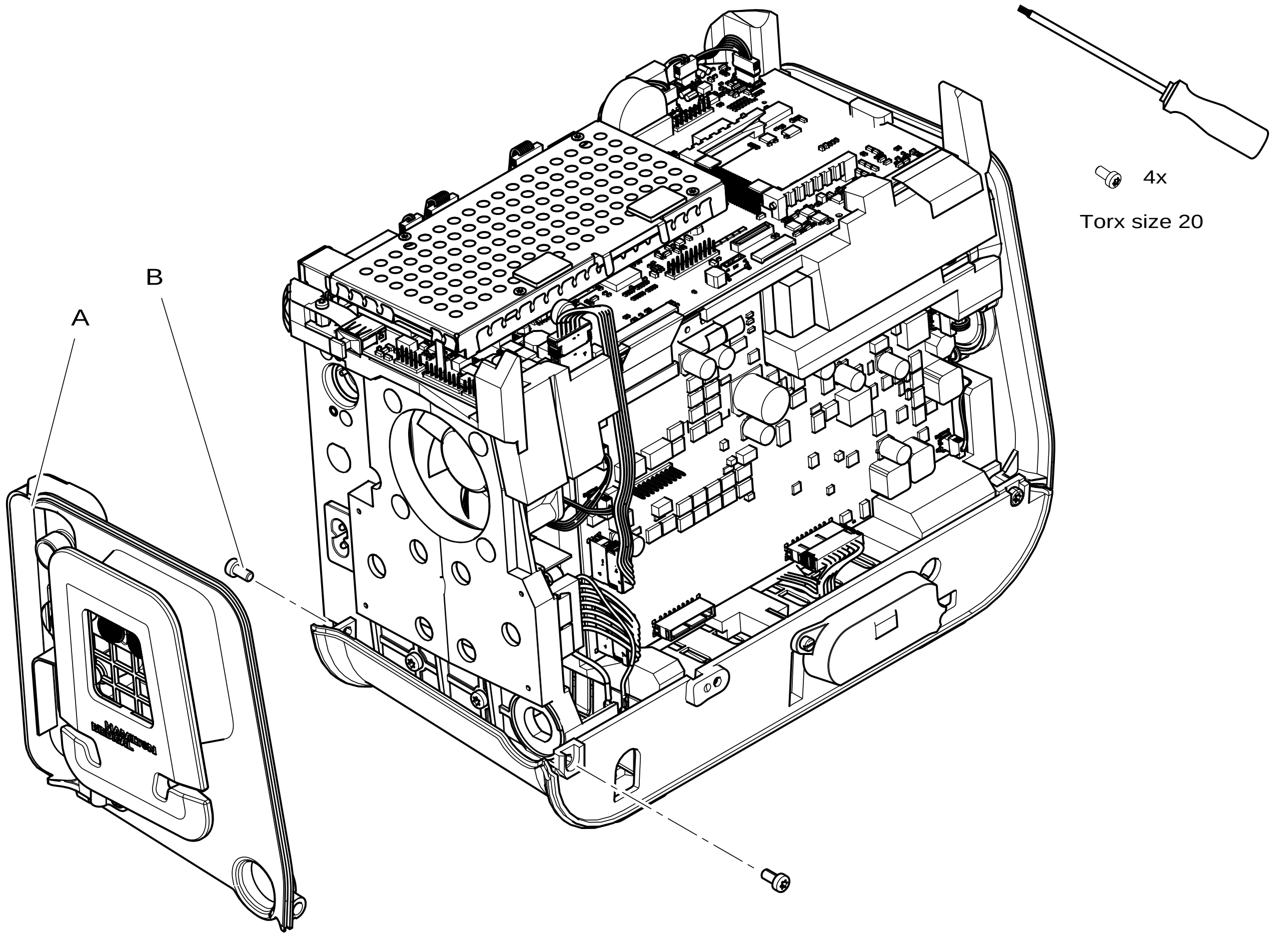


Fig. 213 Left Side Cover Removal/Assembly

1. Remove the two screws (B) (2x PN 420667).
2. Remove the left side cover (A).

11.15 Right Side Cover

1. Remove the 2 screws (A) (2x PN 420667).
2. Disconnect the loudspeaker cable (B).
3. Remove the side cover right (C).
4. Assemble in the reverse order of removal.

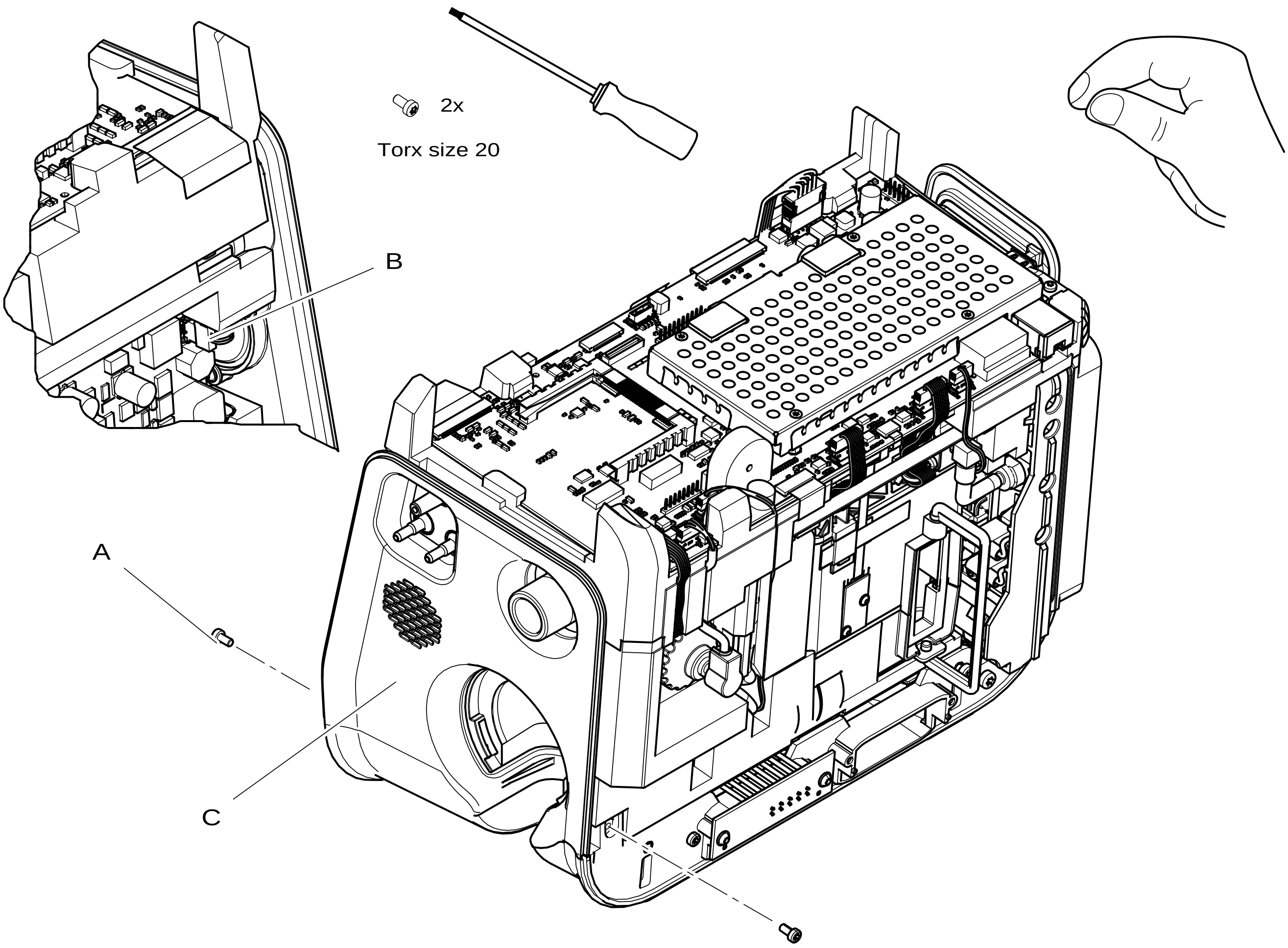


Fig. 214 Right Side Cover

11.16 Control Board and ESM Module (HAMILTON-C1 since SN6000)

1. Remove the 4 screws (A) (PN 420864).
2. Remove the top cover of the ESM module shield housing.

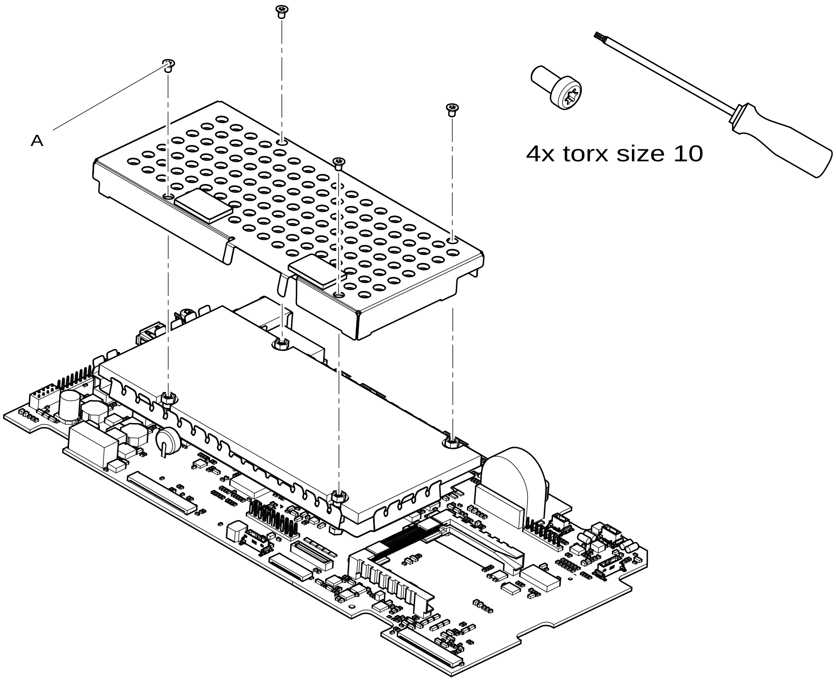


Fig. 215 ESM Module Removal/Assembly 1

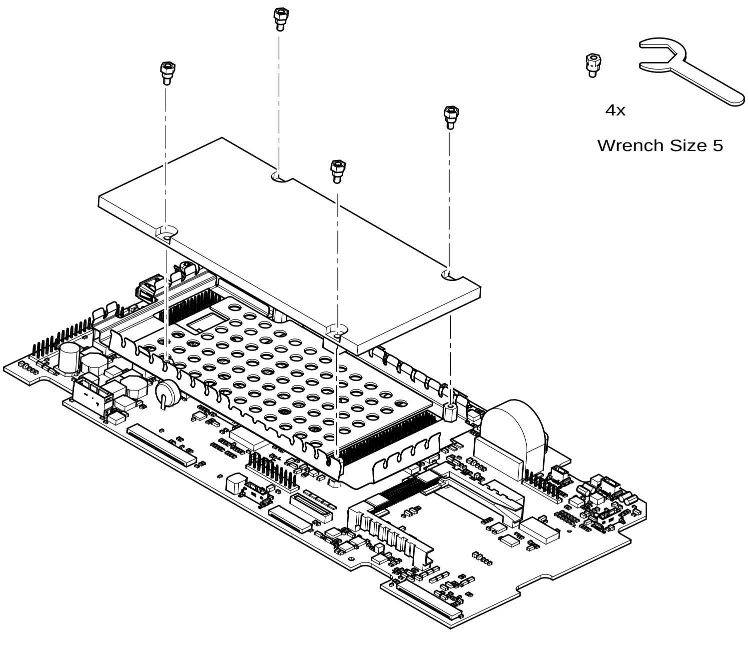


Fig. 216 Control Board and ESM Module

3. Remove the 4 standoffs (PN 257100) holding the ESM module and lift carefully the ESM module with both hands.

4. For Control board replacement: 5. Remove the 3 standoffs (PN 257093).

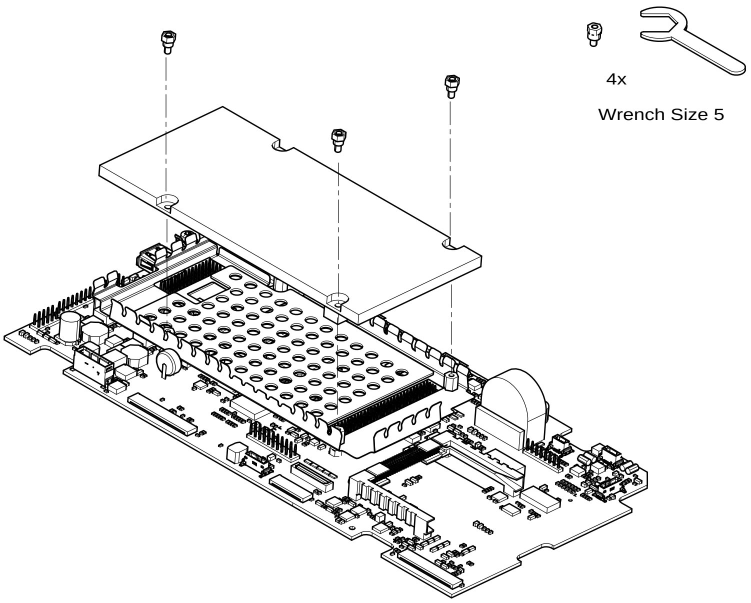


Fig. 217 Control Board and ESM Module

5. Remove the 4 stand up nuts remaining screws.

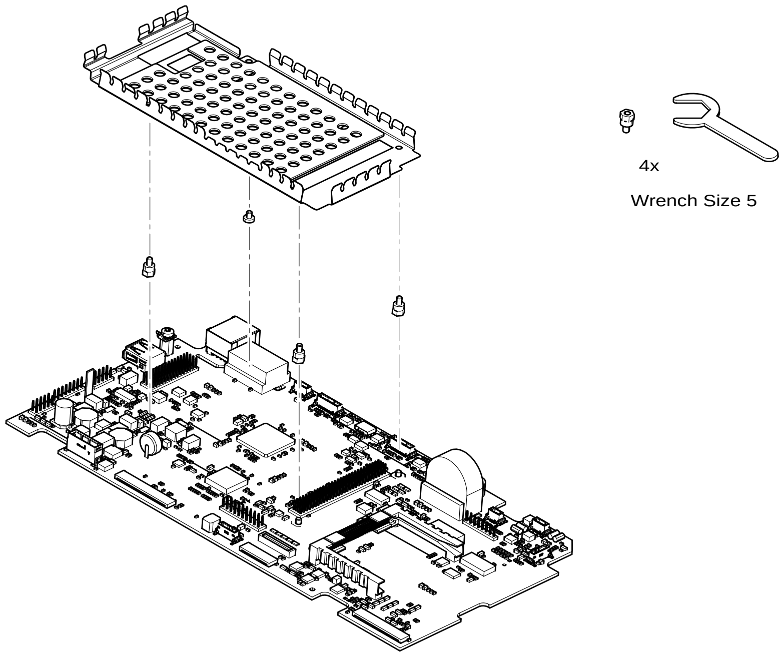


Fig. 218 Control Board and ESM Module

6. Remove the 4 stand up nuts remaining screws and the screws.

7. Assemble in the reverse order of removal.

11.17 Control Board

1. Carefully disconnect the 10 cables (A-J) from the control board.

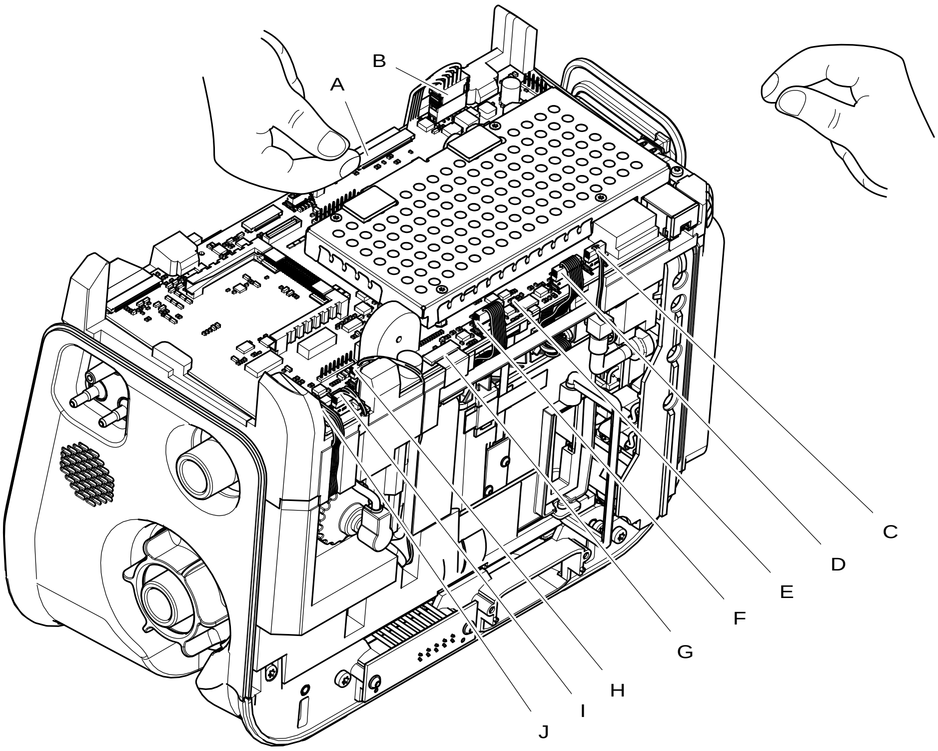


Fig. 219 Control Board Cables Removal/Assembly

11.18 Top Foam

1. Lift up the top foam.

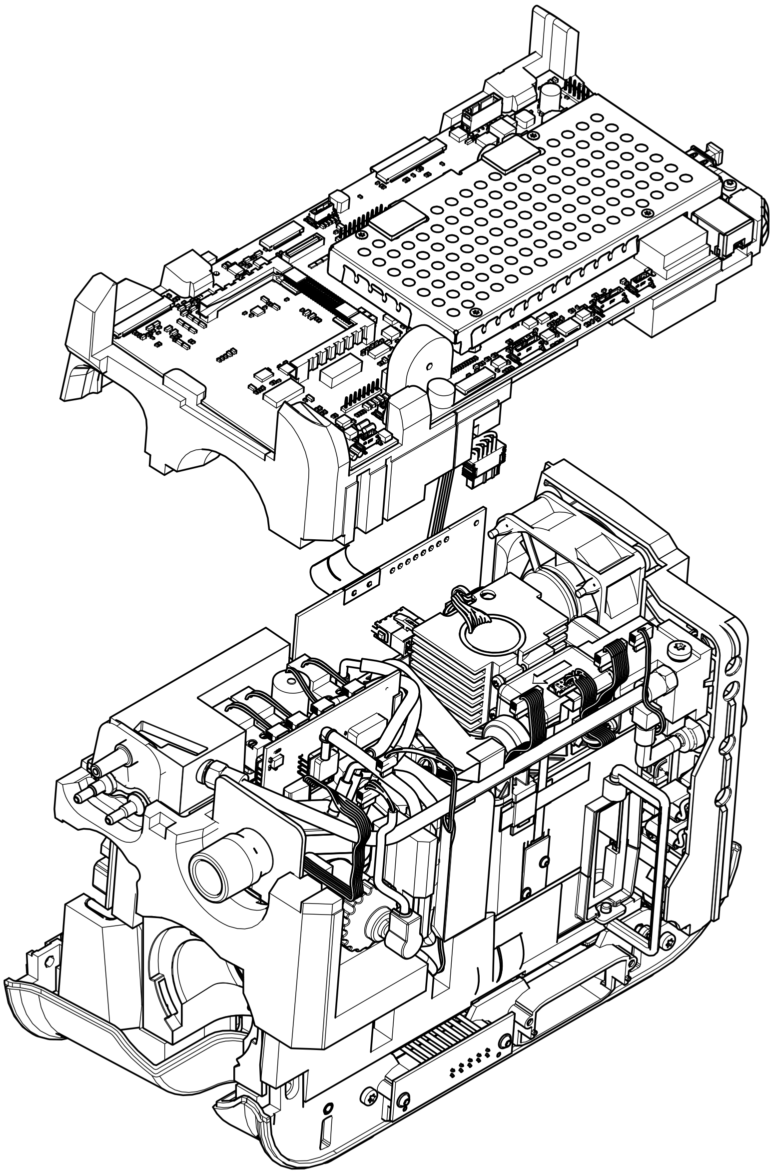


Fig. 220 Top Foam

11.19 Control Board and ESM Module

1. Remove the 4 screws (A) (PN 420864).
2. Remove the top cover of the ESM module shield housing.

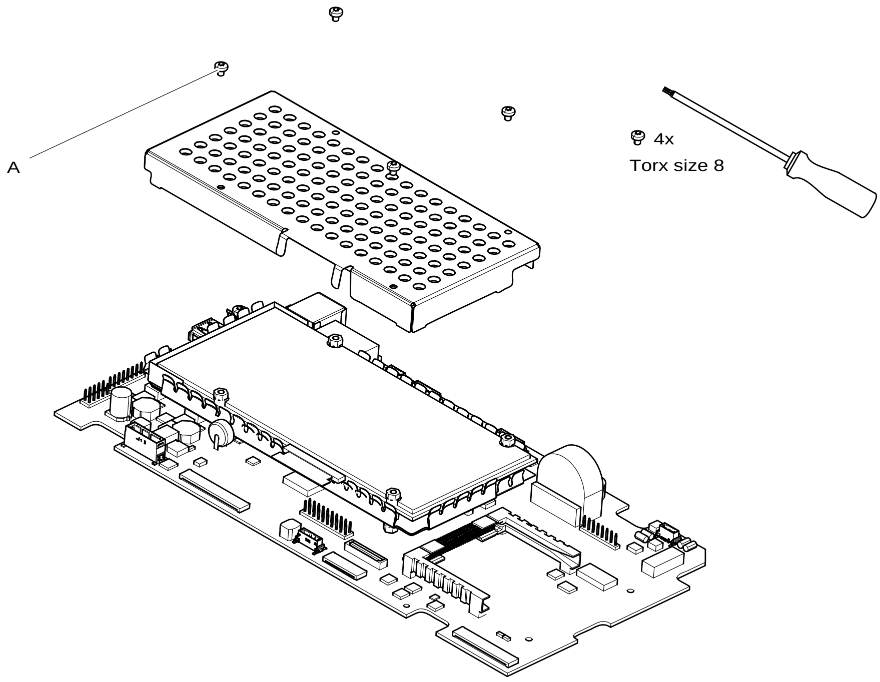


Fig. 221 ESM Module Removal/Assembly 1

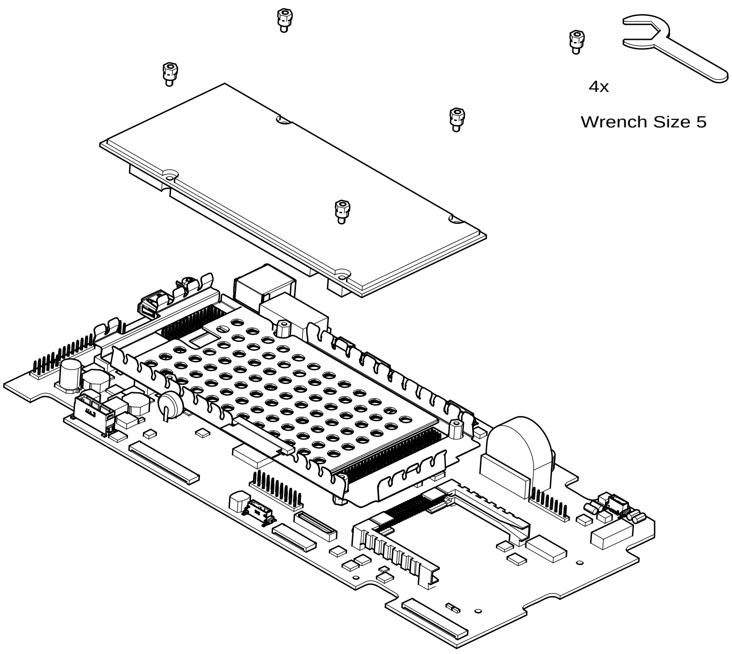


Fig. 222 ESM Module Removal/Assembly 2

3. Remove the 4 standoffs (PN 257100) holding the ESM module and lift carefully the ESM module with both hands.

4. For Control board replacement: Remove the 3 standoffs (PN 257093).

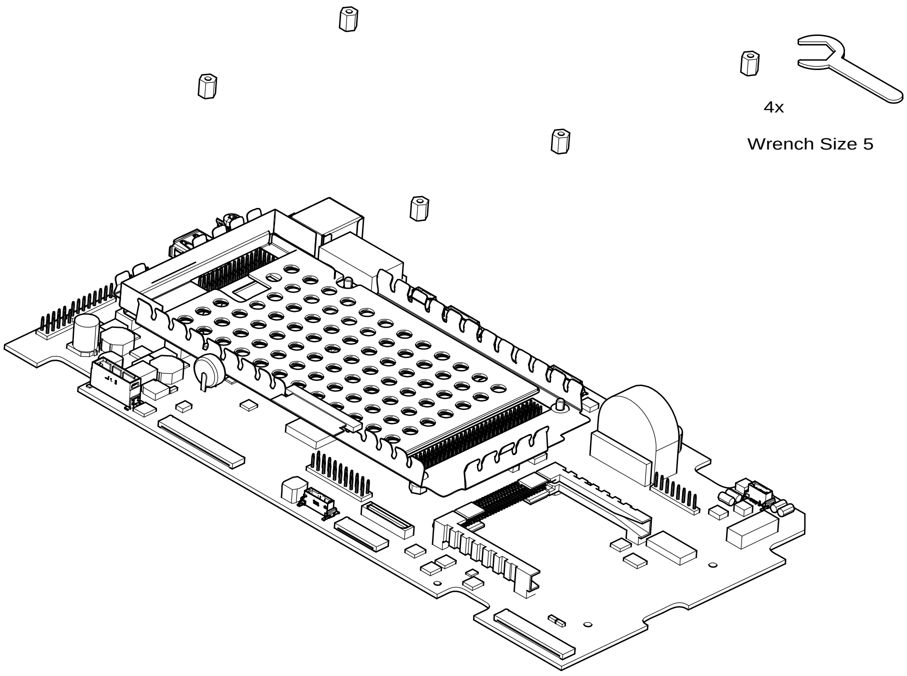


Fig. 223 ESM Module Removal/Assembly 3

5. Remove the 4 stand up nuts remaining screws.

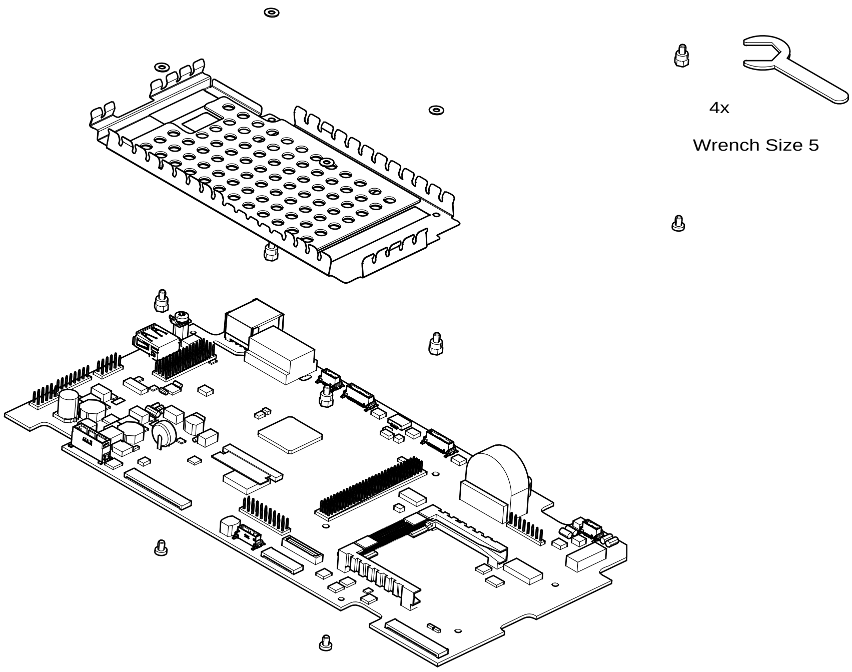


Fig. 224 ESM Module Removal/Assembly 4

6. Remove the 4 stand up nuts remaining screws and the screws.

7. Assemble in the reverse order of removal.

11.20 Connection Plate

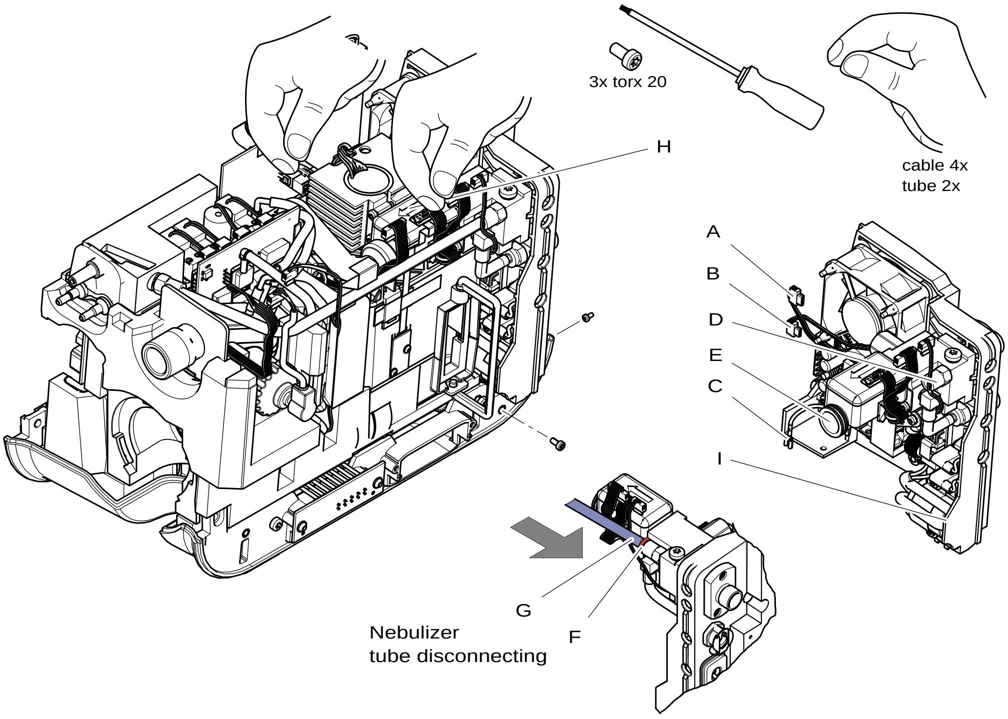


Fig. 225 Fan, Power Supply and O2 Mixer Removal/Assembly

Legend:

A	Fan cable
B	O2 proportional valve cable
C	Ground cable
D	Nebulizer tube connection
E	Flow sensor QO2
F	Tube connector
G	Tube
H	Flow sensor QO2
I	Connection plate

1. Disconnect the cables (A-C).
2. Disconnect the nebulizer tube by pressing the flexible part of mini quick disconnect fitting (G) in the direction of the arrow. Pull out the nebulizer tube (H) to the other direction (see Chapter 11.5).
3. Detach the tube (I) between blower and flow sensor QO2 (O2 mixer assembly) .
4. Remove the three screws at the bottom of the device, two at the side and one in the back. Remove the 2 screws holding the connection plate (J) on the bottom cover (2 on the sides and 2 on the front of the connection plate, holding on the bottom plate.
5. Remove the connection plate including fan, O2 mixer assembly and power supply.

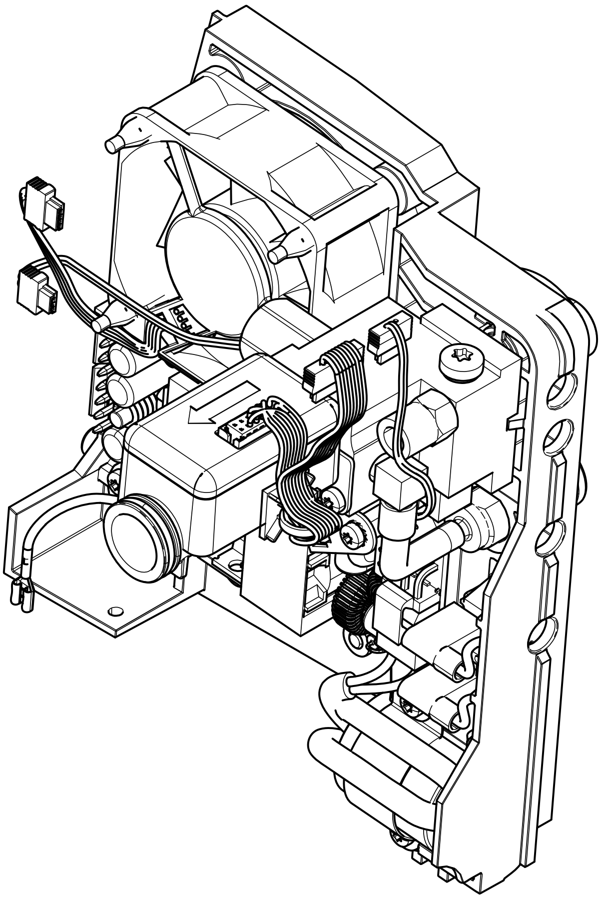


Fig. 226 Fan, Power Supply and O2 Mixer Removal/Assembly

11.21 Pressure Sensor Assembly (HAMILTON-C1 since SN6000)

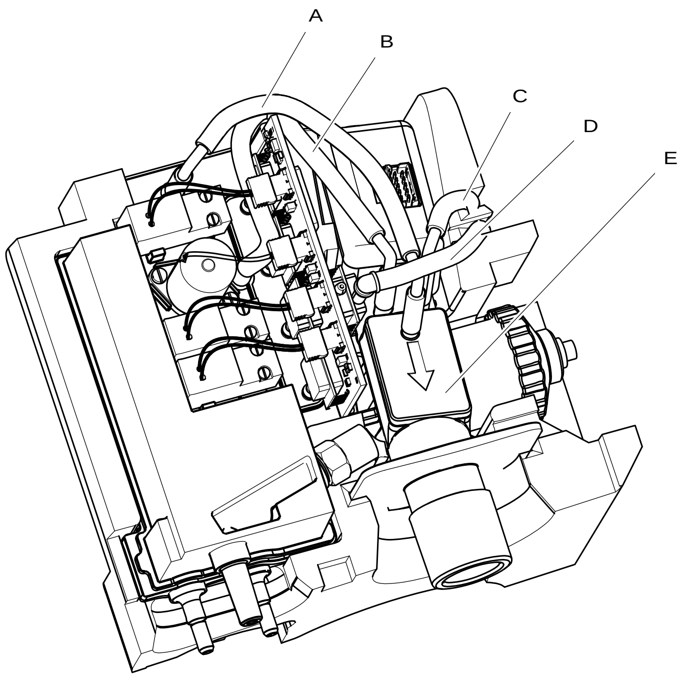


Fig. 227 Pressure Sensore Assembly (HAMILTON-C1 since SN6000)

Legend:

A	Tube inspiratory path to rinse flow tank /pressure sensor Pvent_Monitor
B	Tube inspiratory path to pressure sensor Pvent_Control
C	Tube to expiratory valve
D	Tube from expiratory valve to the pressure sensor Pexpvalve
E	Check valve assembly

1. Disconnect the tube (A) pressure sensor assembly from inspiratory path.
2. Disconnect the tube (B). Check valve assembly (E).
3. Disconnect the tube (D) from the pressure sensor assembly.

4. Lift the pressure sensor assembly up.

5. Assemble in the reverse order of removal.

6.

	Ensure proper connection of the tubing while reassembling.

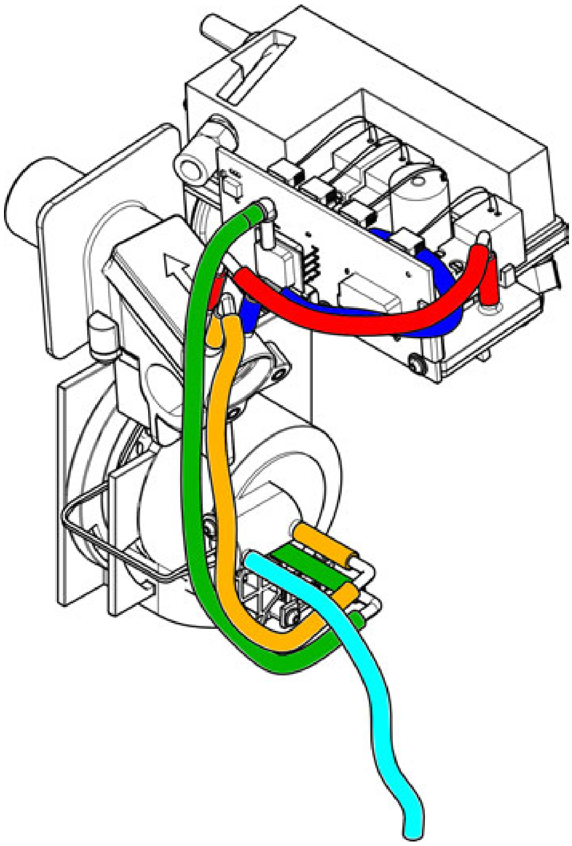


Fig. 228 Tubings Pressure Sensor Assembly

11.22 Pressure sensor assembly (HAMILTON-C1 SN3643-6000)

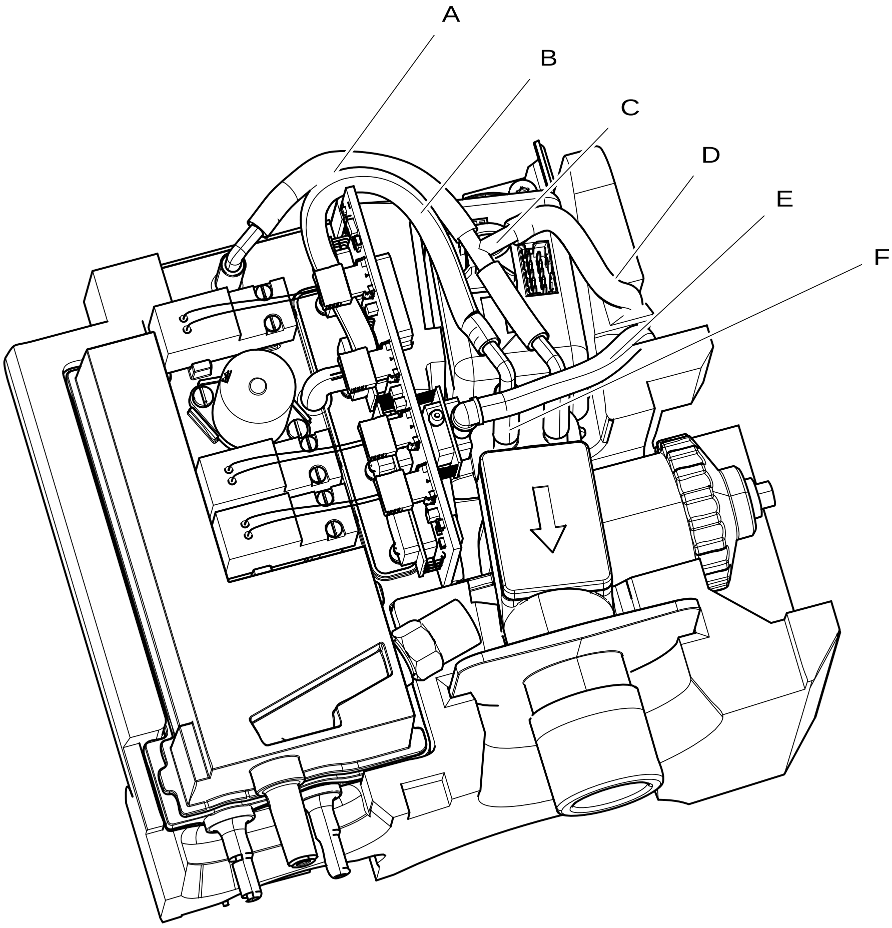


Fig. 229 Pressure sensor assembly (HAMILTON-C1 SN3643-6000)

Legend:

A	Tube inspiratory path to rinse flow tank /pressure sensor Pvent_Monitor
B	Tube inspiratory path to pressure sensor Pvent_Control
C	T-piece
D	Tube to expiratory valve
E	Tube from expiratory valve to the pressure sensor Pexpvalve
F	Inspiratory path tubing

1. Disconnect the tube (A) pressure sensor assembly from inspiratory path.
2. Disconnect the tube (B) from inspiratory path (F).
3. Disconnect the tube (D) from the T-piece

4. Lift the pressure sensor assembly

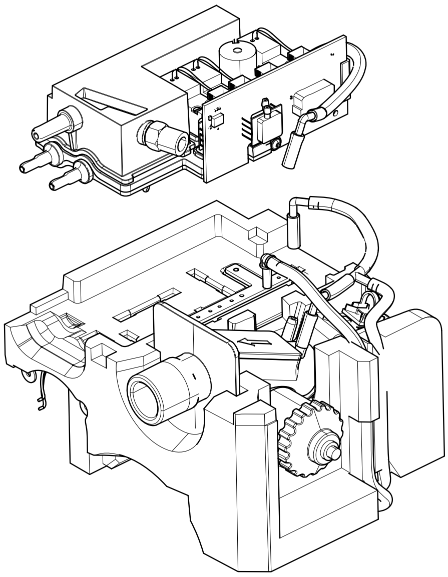


Fig. 230 Pressure Sensor Assembly

5. Assemble in the reverse order of removal.

6.

	Ensure proper connection of the tubings while reassembling.

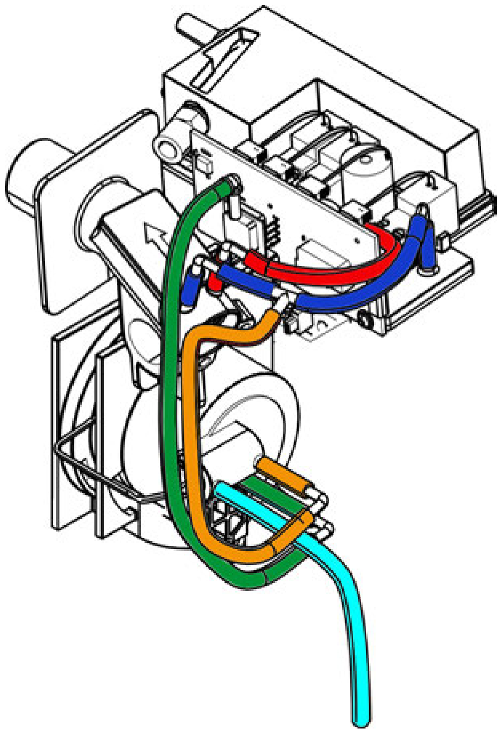


Fig. 231 Tubings Pressure Sensor Assembly

11.23 Pressure sensor assembly (HAMILTON-C1 < SN3643)

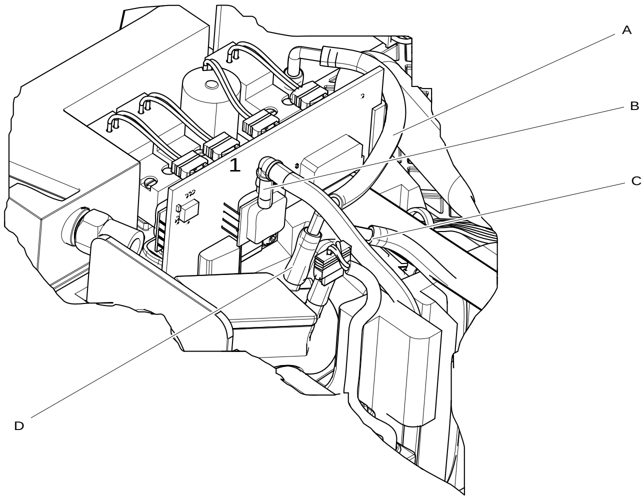


Fig. 232 Pressure sensor assembly (HAMILTON-C1 < SN3643)

Legend:

A	Tube inspiratory path to rinse flow tank /Pressure sensor Pvent_Control and Pvent_Monitor
B	Tube to the pressure sensor Pexpvalve
C	Tube to expiratory valve
D	Inspiratory port tubing

1. Disconnect the tube (A) pressure sensor assembly from inspiratory path (D).
2. Disconnect the tube to the Pexpvalve pressure sensor (B).
3. Lift up the pressure sensor assembly.

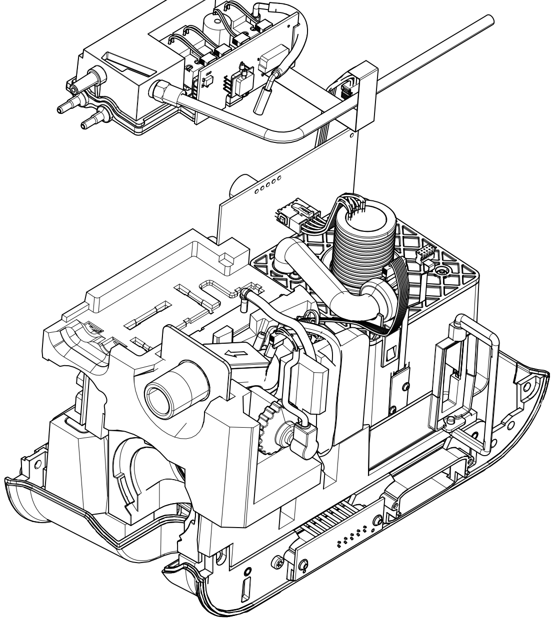


Fig. 233 Pressure Sensor Assembly Removal Step 2

4. Assemble in the reverse order of removal.

5.

	Ensure proper connection of the tubings while reassembling.

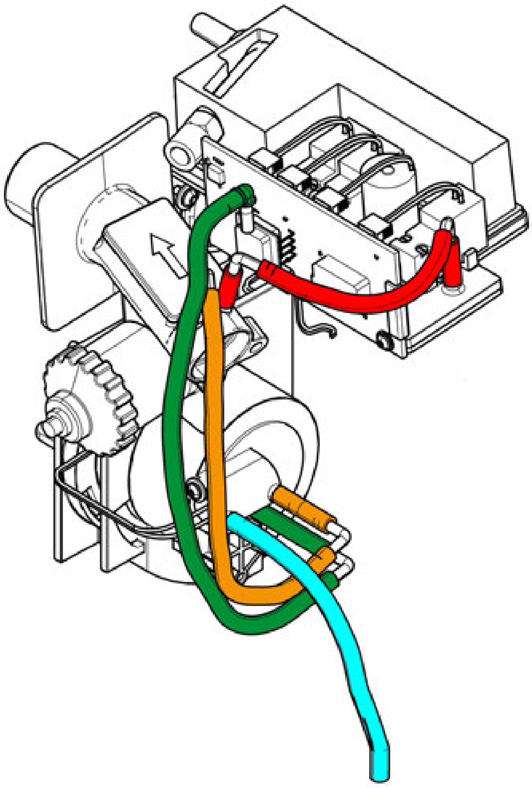


Fig. 234 Pressure Sensor Assembly Tube Connections

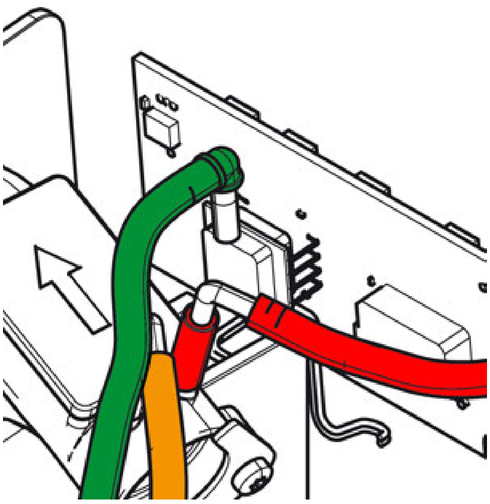


Fig. 235 Tubing Zoom

11.24 Blower Module

1. Disconnect tube to expiratory valve (A).
2. Disconnect blower cable from the driver board (B).
3. Remove the blower module together with the check valve assembly (C) and flow sensor AIR (D).
4. Assemble in the reverse order of removal. Make sure the flow sensor AIR (D) is connected properly with blower module (B). Insert the blower module together with the attached flow sensor AIR (D) and the check valve assembly (C).
5. Note the serial and revision number for updating the technical state (Service Entry Modify tab Chapter 9.7.4).

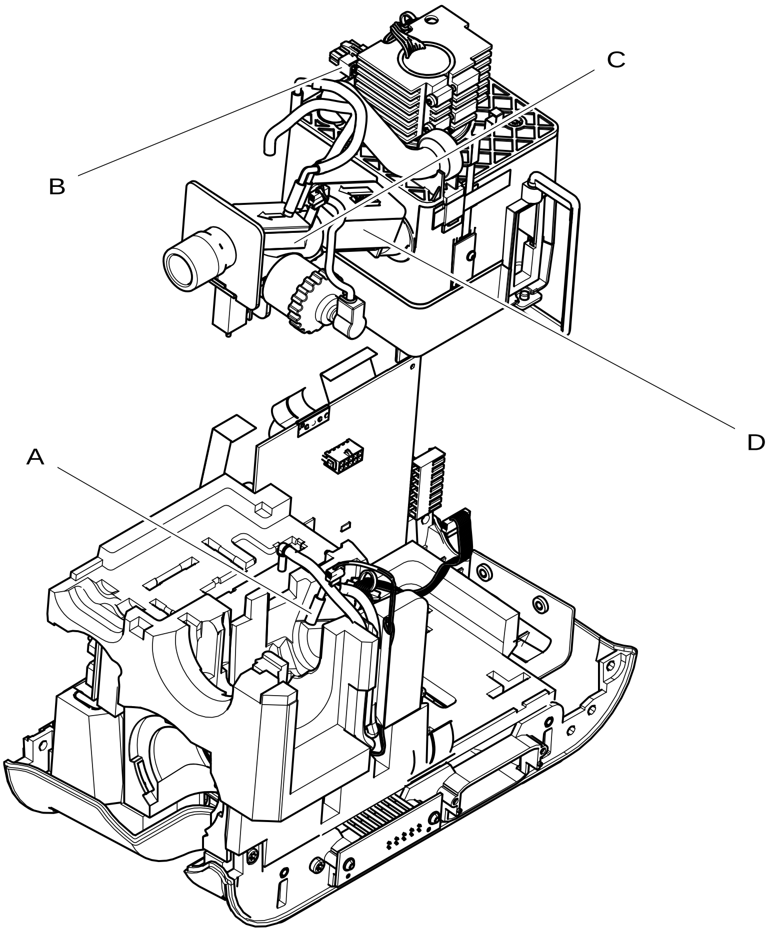


Fig. 236 Blower Module Removal

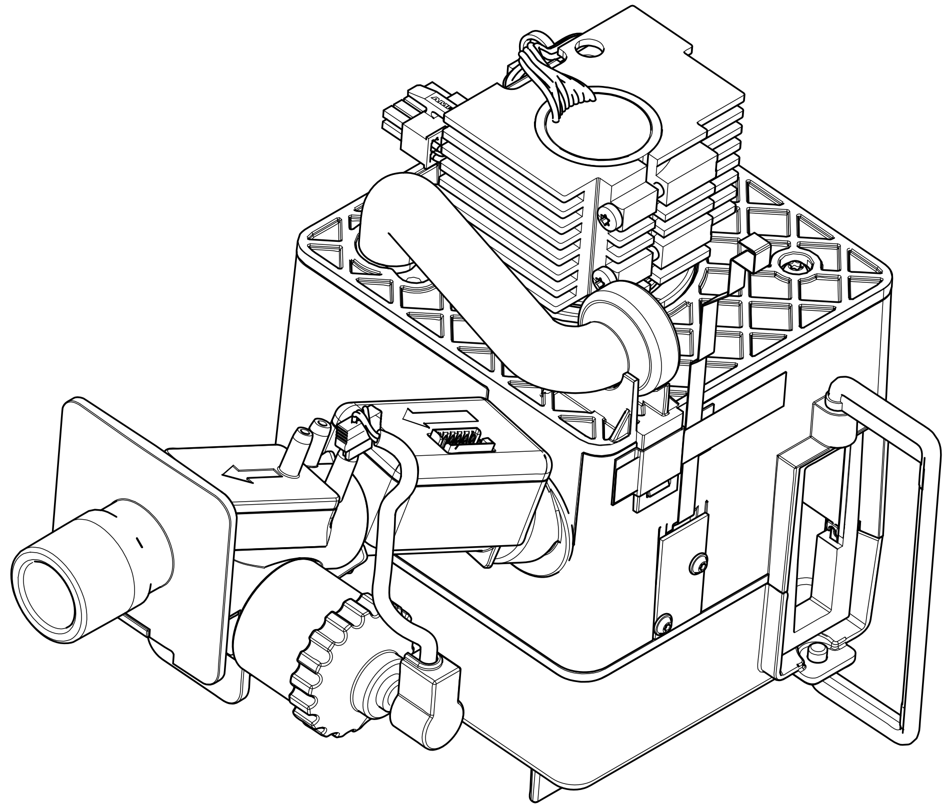


Fig. 237 Blower Module Removal Step 2

11.25 Expiratory Valve

1. Disconnect the tube (A) from the expiratory valve to bottom cover (expiratory proportional valve exhaust tubing).

2. Disconnect the cable of the expiratory proportional valve (B) on driver board.

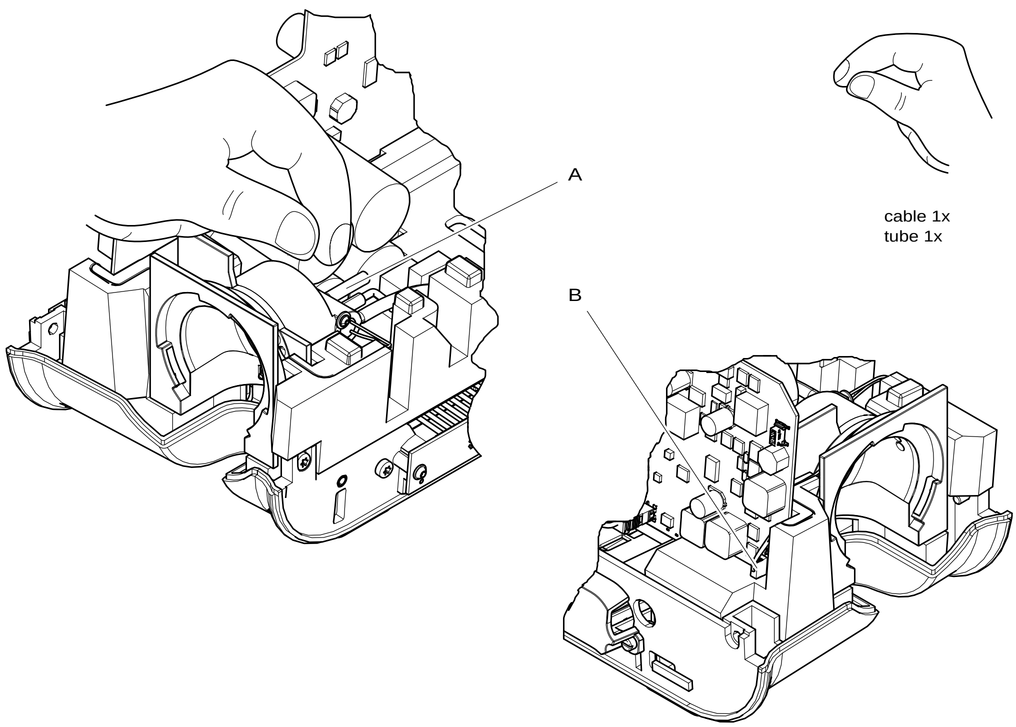


Fig. 238 Expiratory Valve Removal/Assembly I

Legend:

A	Expiratory proportional valve exhaust tubing
B	Cable of the expiratory proportional valve

3. Lift up the expiratory valve.

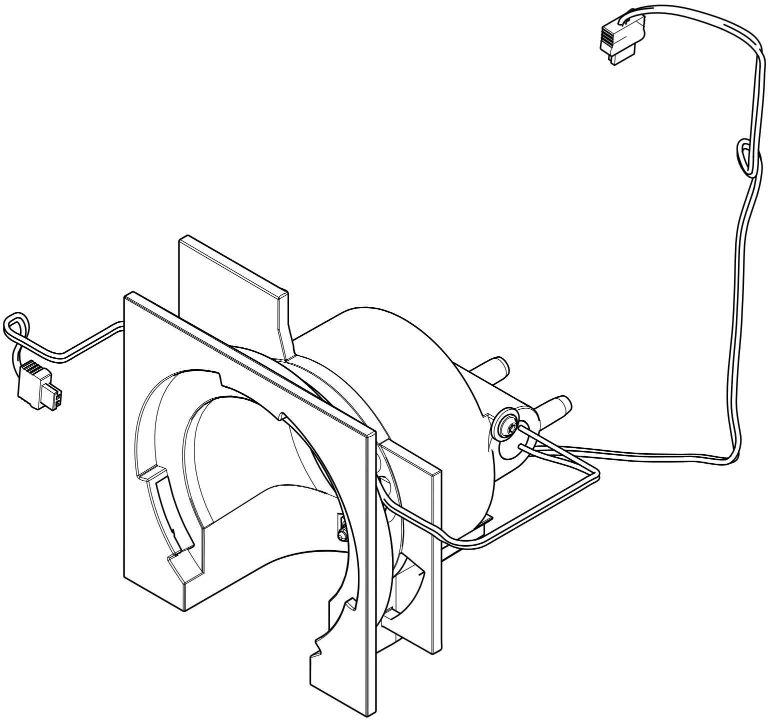


Fig. 239 Expiratory Valve Removal/Assembly

4. Assemble in the reverse order of removal.

5. Note the serial and revision number for updating the technical state (Service Entry Modify Chapter 9.7.4).

6.

	Ensure proper connection of the tubing while reassembling (see Chapter 9.7.4).

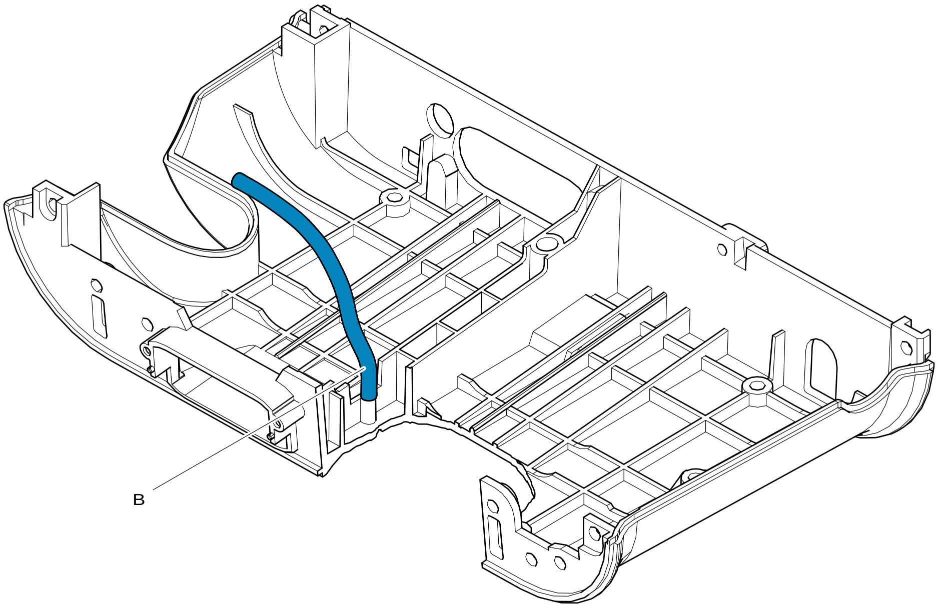


Fig. 240 Expiratory valve bleed port tubing

7.

	In case the expiratory valve bleed port tubing (B) is not connected to bottom cover (release to room air) the expiratory valve will work properly but an O2 enrichment inside the ventilator can occur. Refer to General Tests tubing check expiratory valve bleed port to bottom cover (release to room air.)

11.26 Driver Board

	Ensure all cables are free from the middle foam section.

1. Disconnect the remaining cables from the driver board.

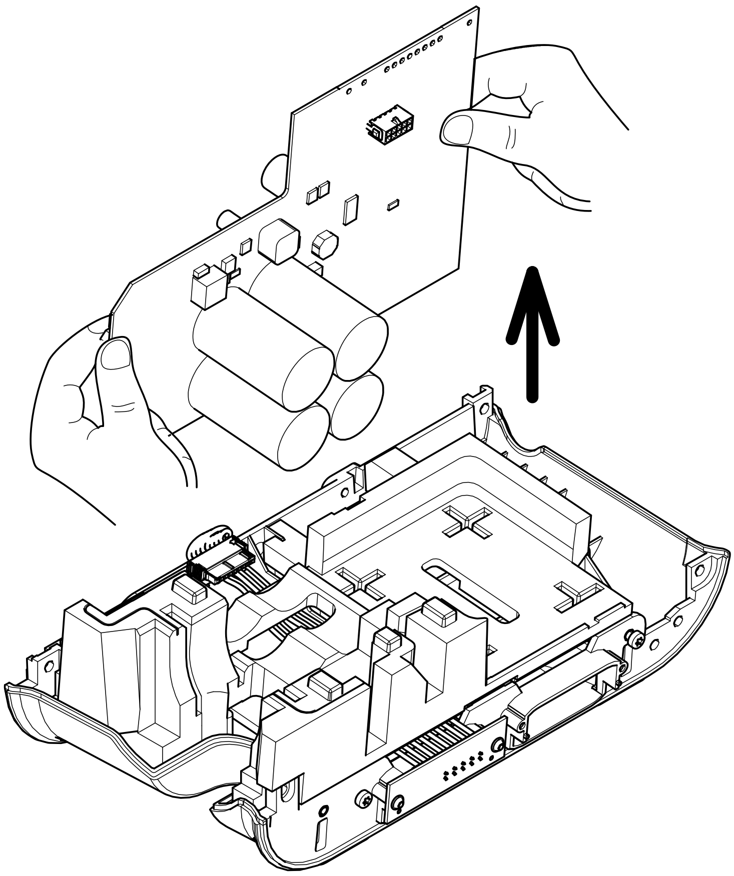


Fig. 241 Driver Board

2. Lift up the driver board with both hands.

11.27 Bottom Foam

	Ensure all cables are free from the middle foam section.

1. Lift up the bottom foam by hand.

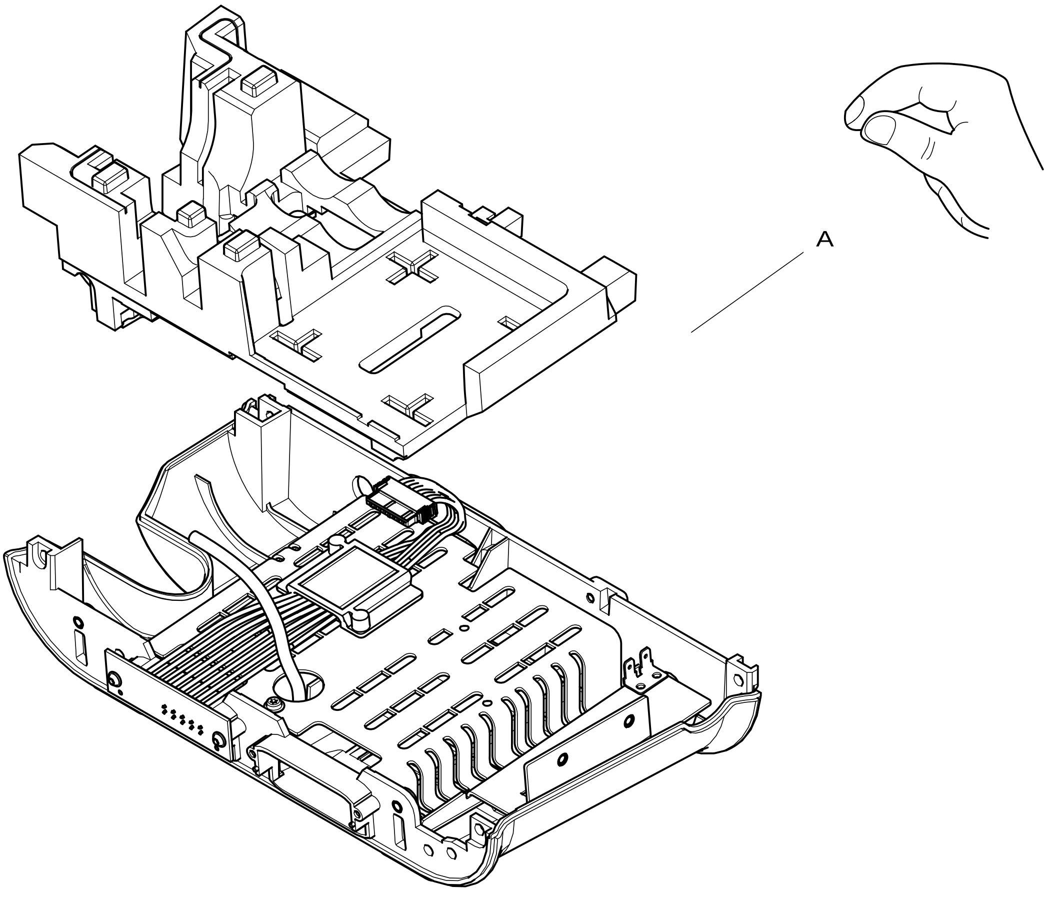


Fig. 242 Remove bottom foam

11.28 Battery Connector Board and mounting plate (HAMILTON-C1 since SN6000)

1. Remove the 2 screws (PN420724) holding the battery connector board on the bottom cover.

2. Remove the all the 5 screws M4x6 (5 x PN 420774) holding the mounting plate on the bottom cover.

3. Remove the mounting plate.

4. Remove the 2 screws (PN420659) holding the ferrite core holder (PN161796) on mounting plate.

5. Remove the battery connector board.

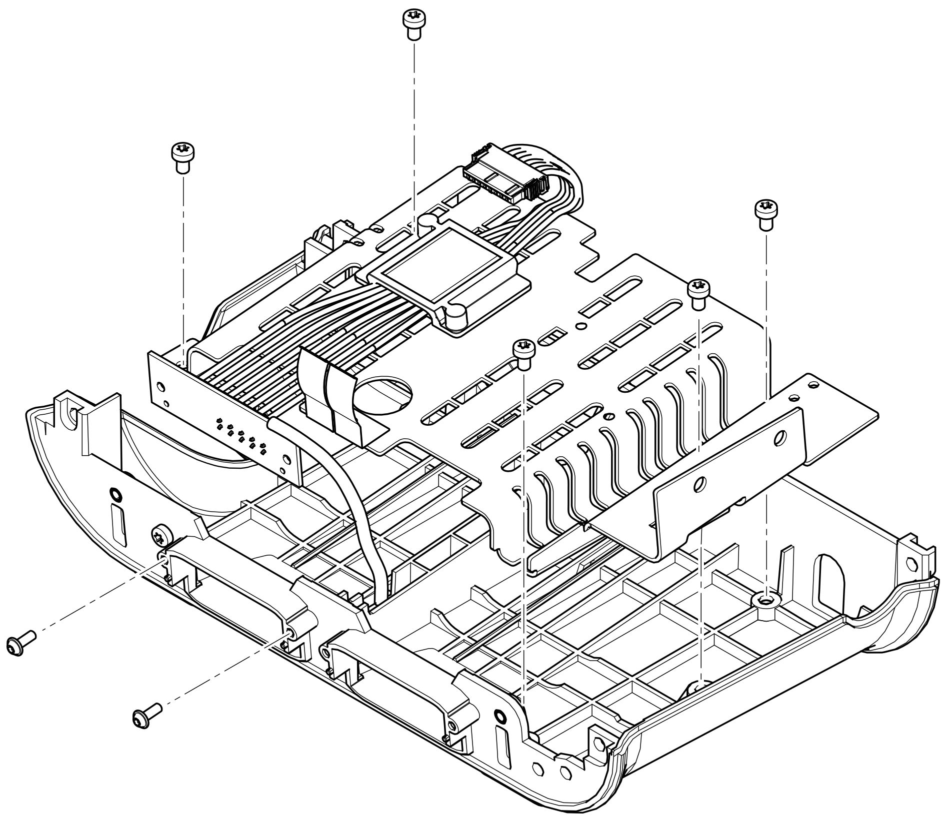


Fig. 243 Battery Connector Board and mounting plate (HAMILTON-C1 since SN6000)

11.29 Battery Connector Board (HAMILTON-C1 <SN6000)

1. Remove the 2 screws (A) holding the battery connector board on the bottom cover.
2. Remove battery connector board (C) from bottom plate.

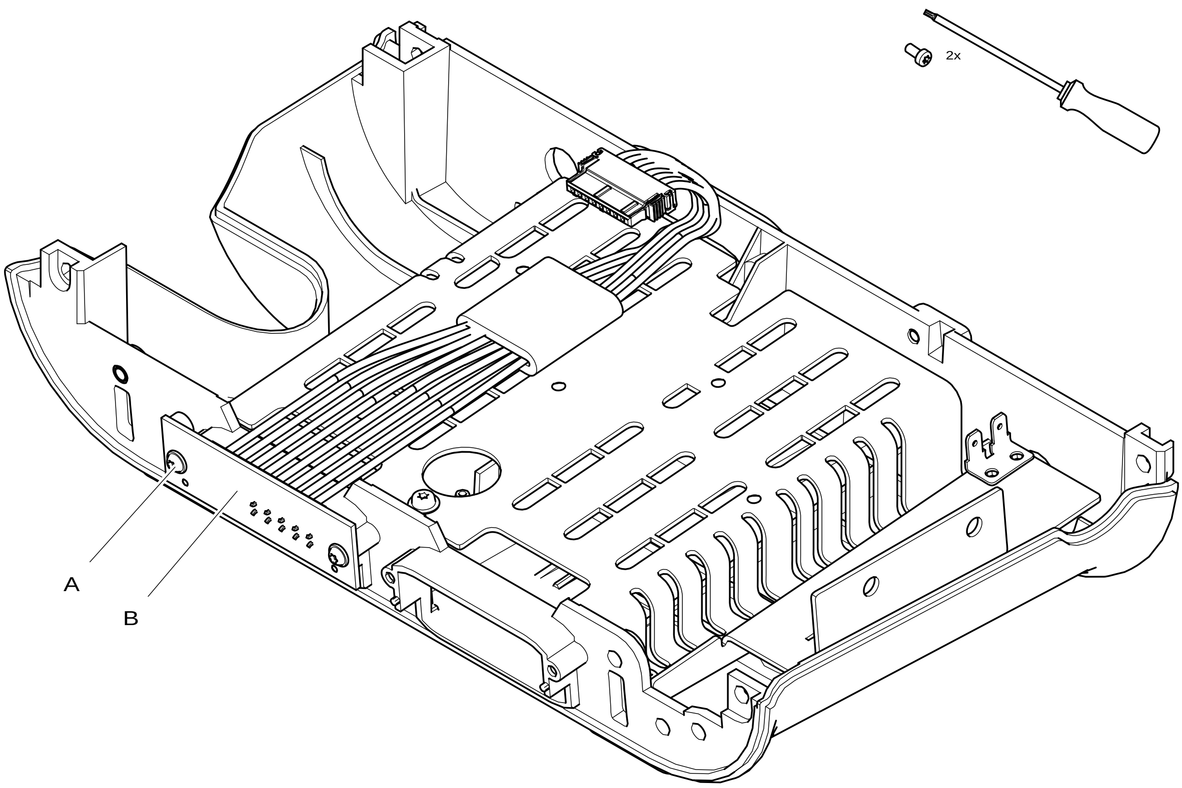


Fig. 244 Battery Connector Board Removal/Assembly HAMILTON-C1 <SN6000

11.30 Mounting plate (HAMILTON-C1 SN1865-6000)

1. Remove the all the 5 screws M4x6 (5 x PN 420774).

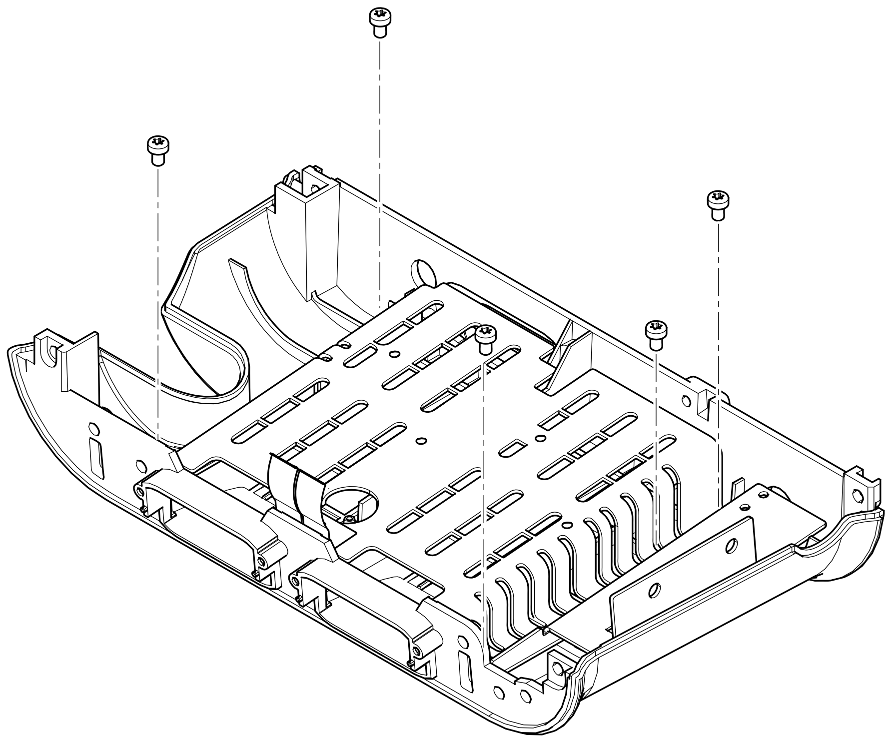


Fig. 245 Mounting plate Removal/Assembly

2. Remove the bottom plate (including the contact spring).
3. Assemble in the reverse order of removal

11.31 Mounting plate (HAMILTON-C1 < SN1865)

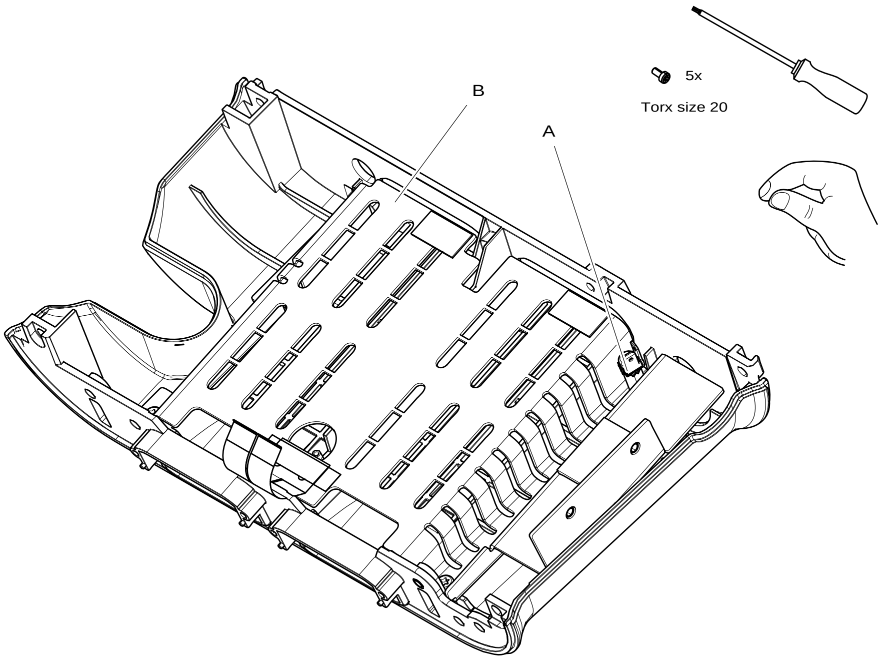


Fig. 246 Mounting plate (HAMILTON-C1 < SN1865)

Legend:

A	Screws (5x PN 420774)
B	Bottom plate

1. Remove the bottom plate.

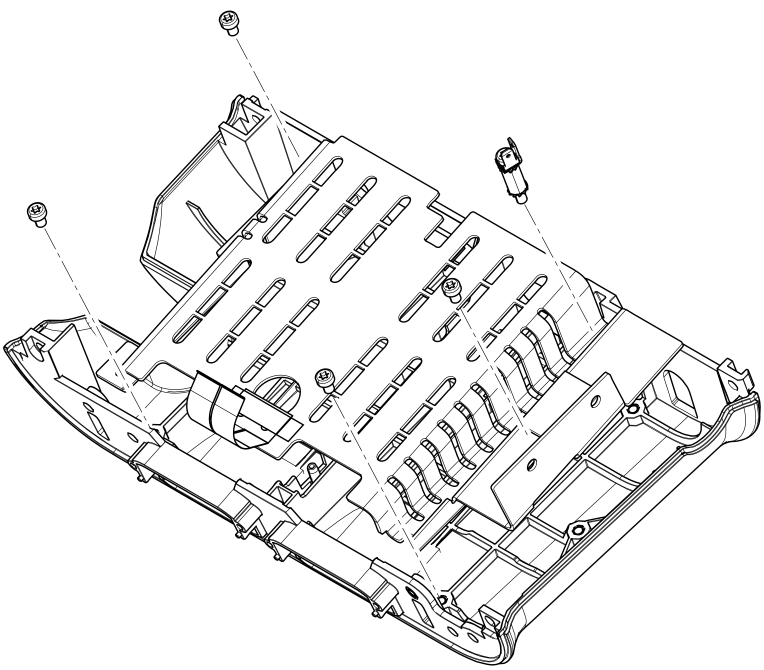


Fig. 247 Mounting plate Removal

11.32 O2 Mixer, DISS / NIST Connector Removal/Assembly

1. For the removal of the connection plate, follow instruction to Chapter 11.20.
2. Disconnect the tube with the screw (D) from the low-pressure O2 inlet connector.
3. Remove the HPO DISS or NIST connector (B) by removing the two screws (A).
4. Remove the O2 mixer assembly by removing the two screws (C).

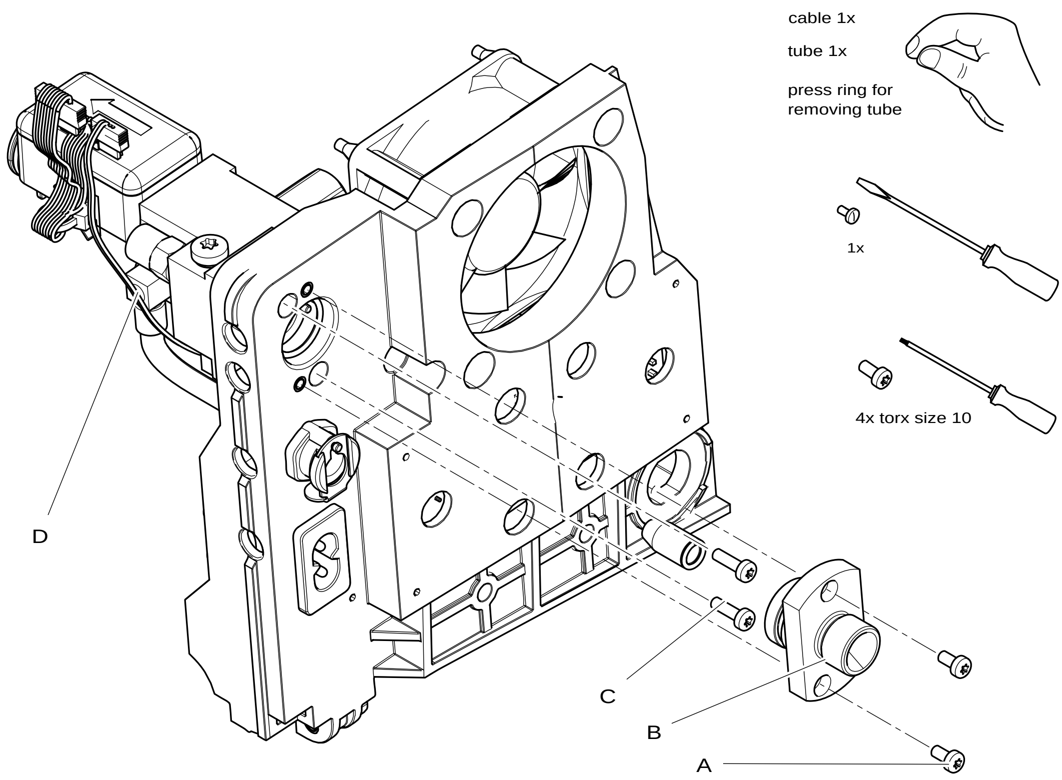


Fig. 248 O2 Mixer, DISS / NIST Connector Removal/Assembly

Legend:

A	Screws (2x PN 420768) holding the DISS/NIST HPO connector on the connection plate
B	DISS / NIST HPO-connector
C	Screws holding the O2 mixer assembly (2x PN 420655)
D	Screw holding the tube from LPO on the O2 mixer assembly

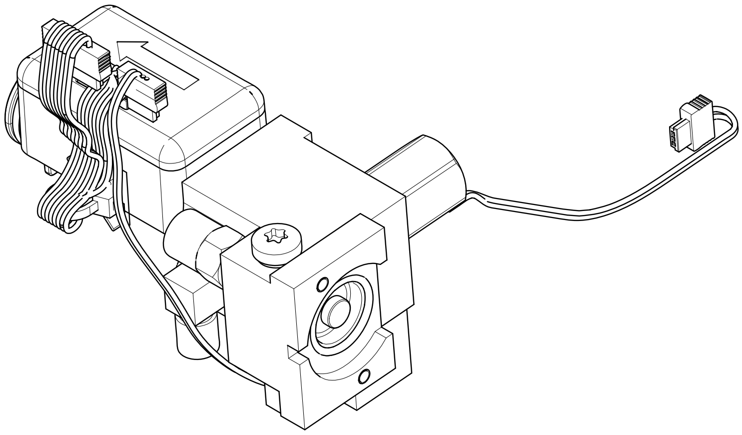


Fig. 249 O2 Mixer Removal/Assembly

5. Assemble in the reverse order of removal.

6. Note the serial and revision number for updating. Update the technical state (Chapter 9.7.4).

11.33 HPO Inlet Filter Removal/Assembly

1. Remove the two screws (A) and the filter holder plate (B).
2. Replace the HPO Inlet filter (C) and the O-rings (D+E). Replace the screws (A) if necessary.
3. Assemble in the reverse order of removal.

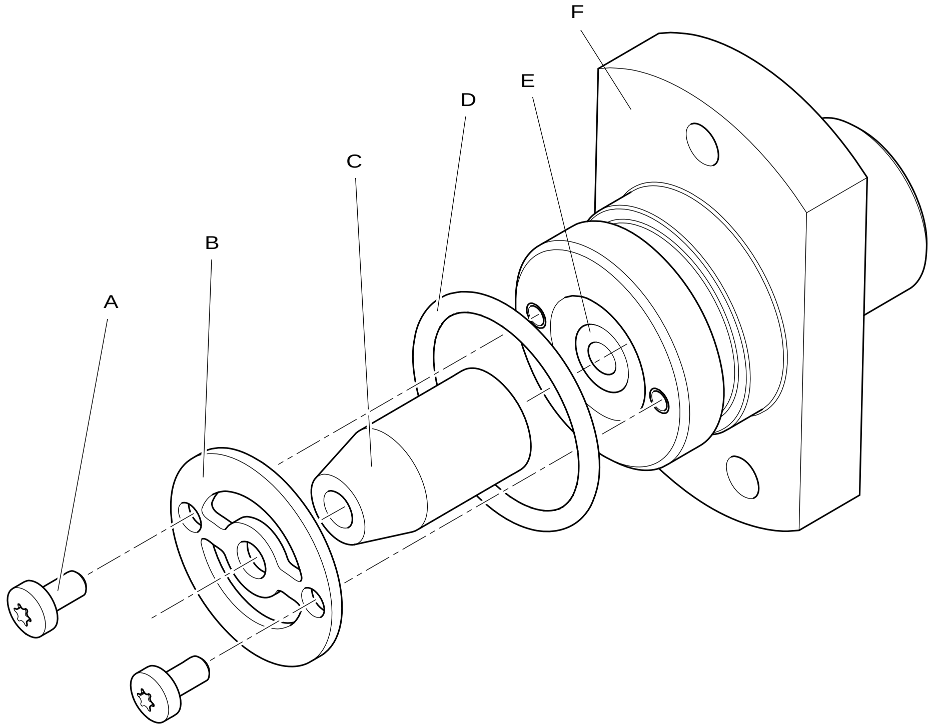


Fig. 250 HPO Inlet Filter Removal/Assembly (PN160497 Service Kit)

Legend:

A	2x Screw PN 420692 (part of the service kit PN 160497)
B	Filter holder plate
C	HPO Inlet filter PN 160491 (part of the service kit PN 160497)
D	O-Ring iD=15x1.5 (part of the service kit PN 160497)
E	O-Ring iD=5.8x1.3 (part of the service kit PN 160497)
F	DISS or NIST connector

11.34 Display Removal/Assembly

1. Unplug the backlight plug (A) from the display.
2. Remove the four screws (D, 4x PN 420767) holding the display holders (B, 2x PN 161257).
3. Remove the display (G).
4. Remove the four screws (H, PN 420638) and the display holders (B).
5. Unplug the display adapter board (F) from the display (G).
6. Assemble in the reverse order of removal.

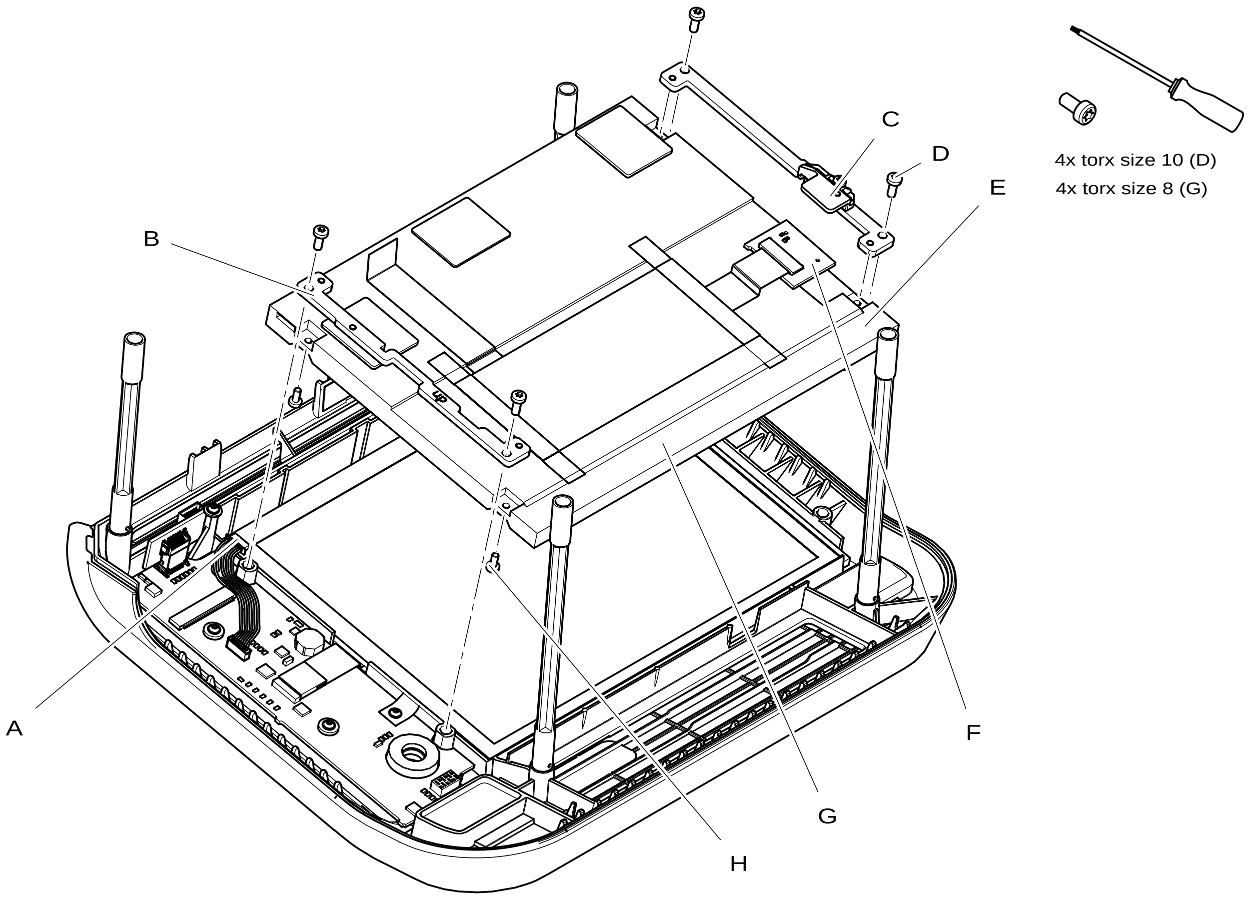


Fig. 251 Display Removal/Assembly

11.35 P+T Knob and Encoder Removal/Assembly

1. Pull out the P+T knob (A) by hand.
2. Remove the nut and washer (B, C) with a torque wrench size 11.
3. Unplug the P+T knob encoder (D) from the front panel board.
4. Remove the P+T knob encoder (D) from the display front.
5. Assemble in the reverse order of removal.
6. Tighten the nut carefully when reassembling.

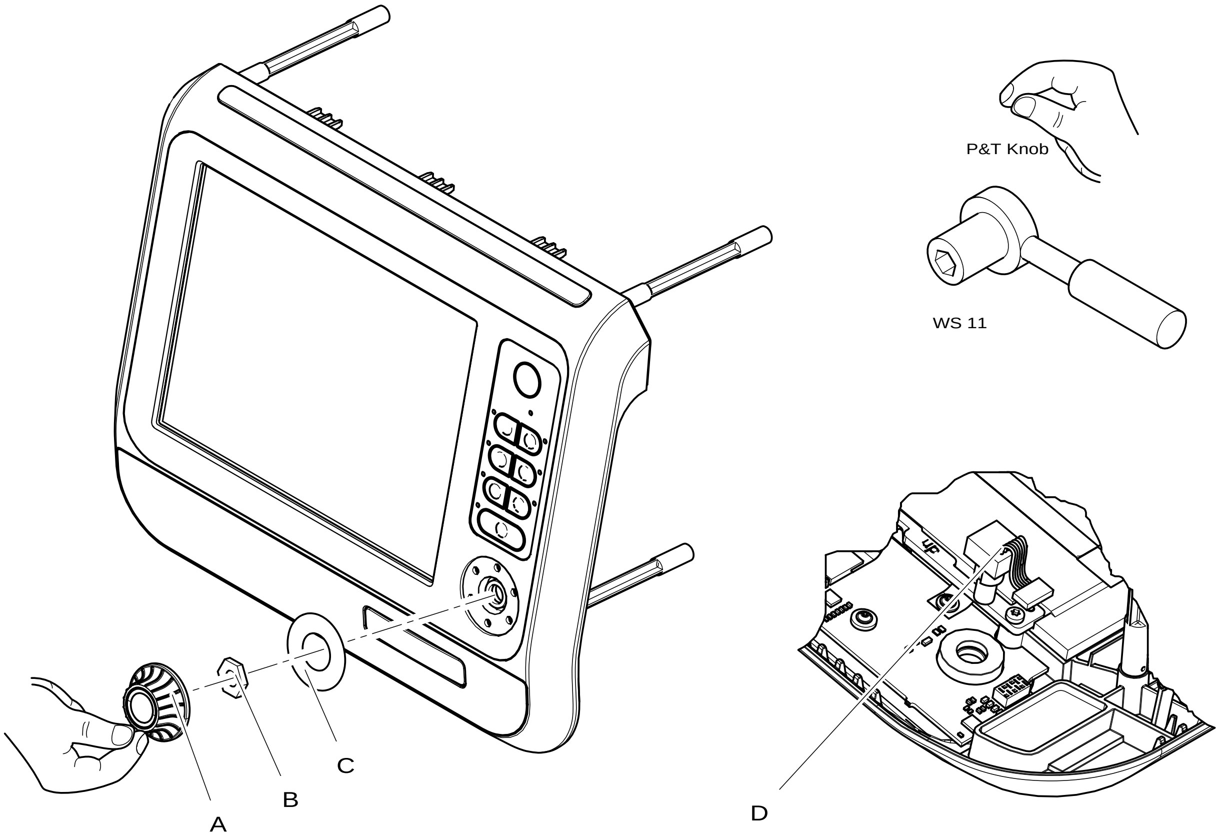


Fig. 252 P+T Knob and Encoder Removal/Assembly

11.36 Front Panel Board and Alarm Lamp Board Removal/Assembly

1. Disconnect the touchscreen (E) from front panel board (D).
2. Disconnect the backlight connector (C) from the LCD display.
3. Remove the two screws (A) and washers holding the alarm lamp board (B) (2x PN420699 screws), (2x PN409210 washers).
4. Remove the alarm lamp board (B) from the plug side.
5. Remove the four screws holding the front panel board (4x PN 420699 screws), (1x PN161333 contact spring), (1x PN409210 washer), (3x PN161349 washer).
6. Remove the front panel board (D).
7. Assemble in the reverse order of removal.

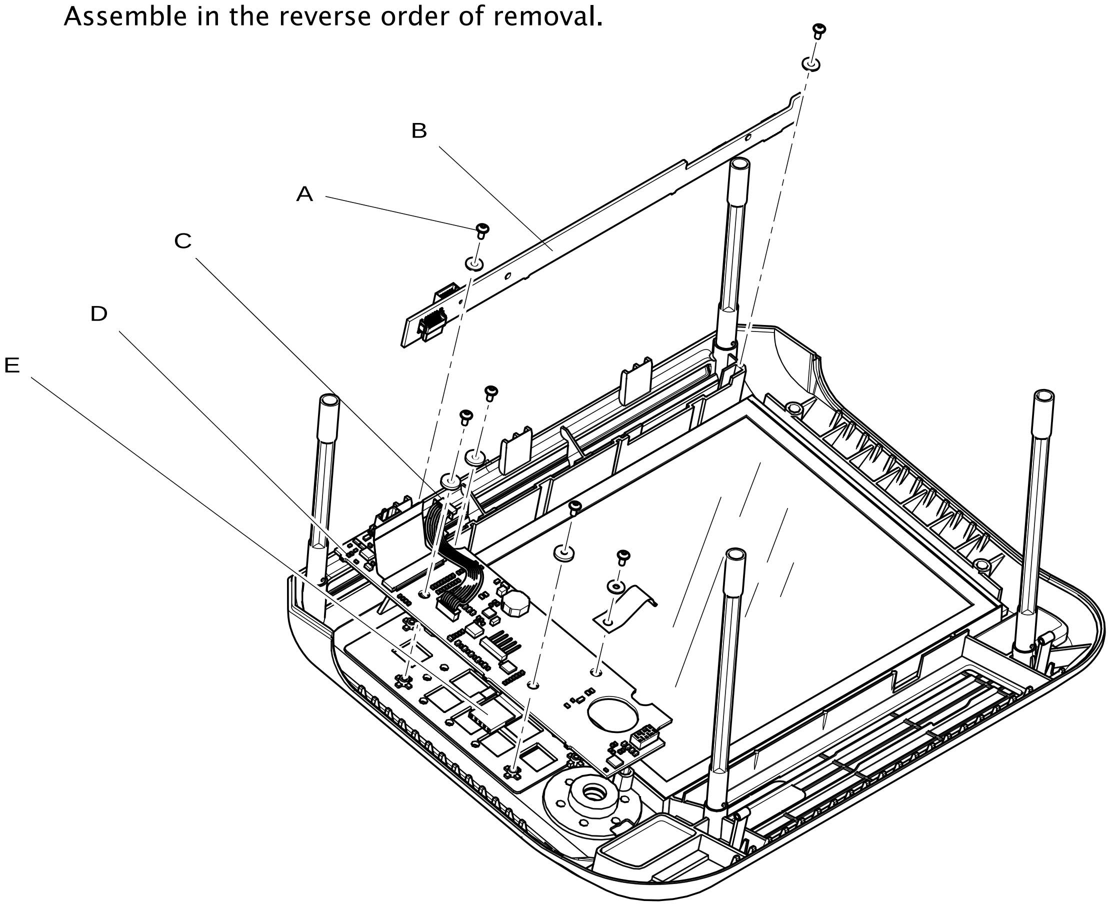


Fig. 253 Front Panel Print and Alarm Lamp Removal/Assembly

11.37 Power Supply, Fan, and Power Cord Removal/Assembly

11.37.1 Mains Power Cable

1. Disconnect the power cable connectors (A) from the AC mains power connector.
2. Disconnect the other end of the cable (B) connected to the protection board (D) of power supply.
3. Remove the 2 screws (C) holding the ferrite on the connection plate and remove the cable (2x PN 420642 screws) (2x PN 409400 washers M3).
4. Assemble in the reverse order of removal.

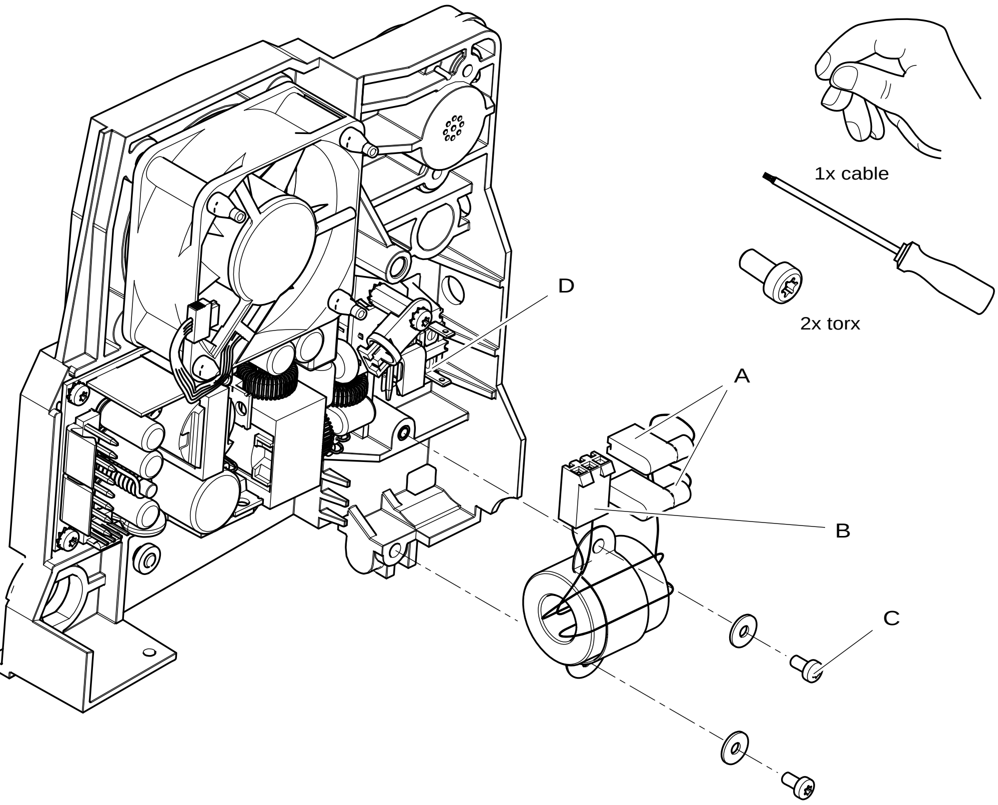


Fig. 254 Mains Power Cable

11.37.2 Power Supply Assembly

1. Disconnect the cable from power supply's protection board to AC power plug (Chapter 11.37.1).

2. Remove the 4 screws (A) as shown (1 holding the protection board, 3 holding the power supply), (4x PN 420642 screws), (4x PN 411001 washers).

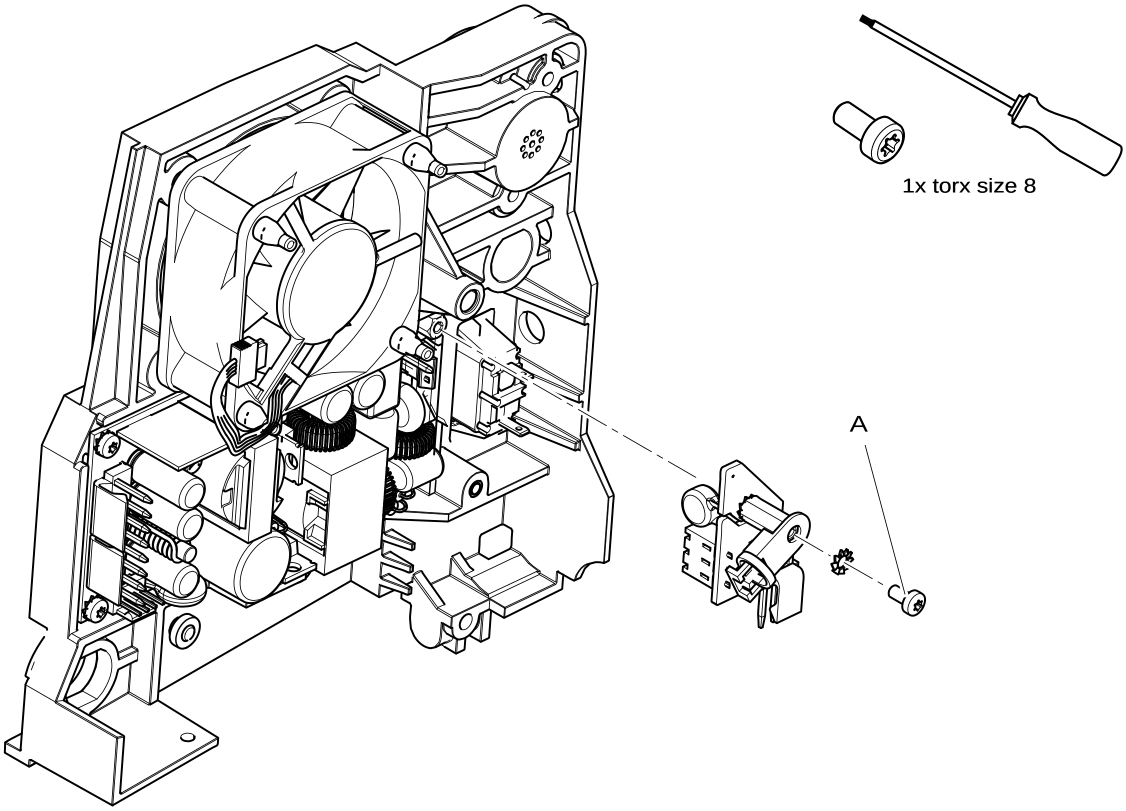


Fig. 255 Power supply protection board

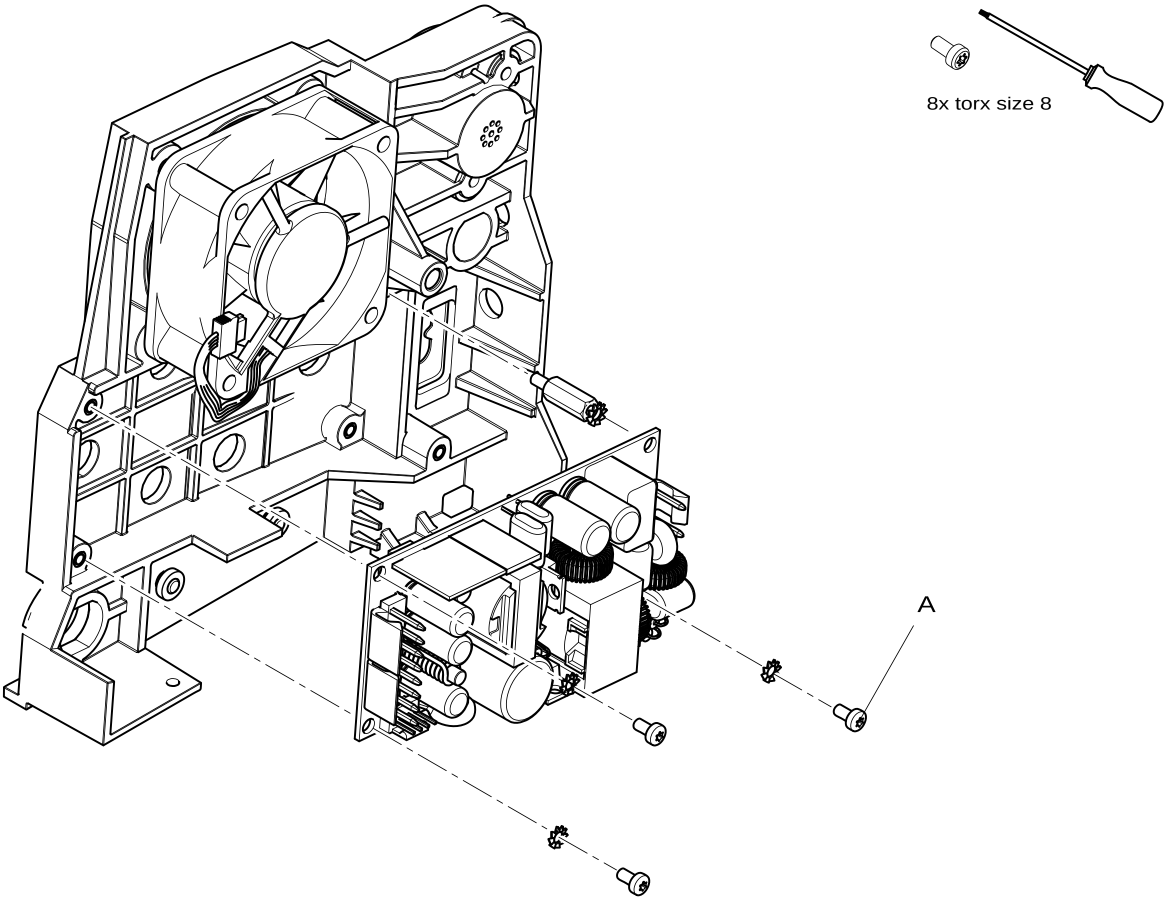


Fig. 256 Power supply

3. Assemble in the reverse order of removal.

4. Note the serial and revision number for updating the technical state Chapter 9.7.4).

Note	To prevent noise in operation by vibrations, look out for correct implementation of the power supply.

12 Maintenance Tools and Test Equipment

12.1 Overview

Standard tools, special tools, electrostatic discharge (ESD) protection, and test equipment detailed in the following sections are required to carry out:

- Preventive Maintenance procedures, Engineer Preventive Maintenance, see Chapter 7.1
- Tests Functions, Service Software, see Chapter 9.9
- Component Replacements, Components Removal / Assembly, see Chapter 11.1

12.2 Standard Tools

To perform basic maintenance on equipment from HAMILTON MEDICAL AG, you require a range of:

- Screwdrivers (both flat and cross-head)
- Metric spanners (wrenches)
- Metric hex (Allen) keys (wrenches)
- Torx screw drivers

12.3 Special Tools

12.3.1 Digital Voltmeter

A Digital Voltmeter (DVM) is required for measuring voltage (to a tolerance of 0.5%) or resistance (to a tolerance of 1 (less than 1 Ohm).

Fig. 257 Digital Voltmeter

12.3.1.2 Electrical Safety Tester

Electrical safety testing is required according to IEC 62353. A RIGEL 288, or similar equipment is required.

Fig. 258 Rigel 288 Safety Analyzer

12.3.1.3 ESD (ElectroStatic Discharge) Protection

ESD (ElectroStatic Discharge) equipment must be used to prevent damage to sensitive electronic circuits. Typically, this comprises:

- ESD grounding (earthing) cable and wrist band connected to the ventilator for use when working inside the ventilator.
- Fig 260 shows a wristband and connecting cable complete with the crocodile clip that must be attached to the ventilator or work surface.

Fig. 259 ElectroStatic Discharge

Fig. 260 ESD Wrist Strap and Cable

Fig. 261 PN500009 ESD Service Kit

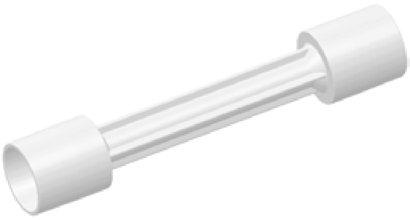
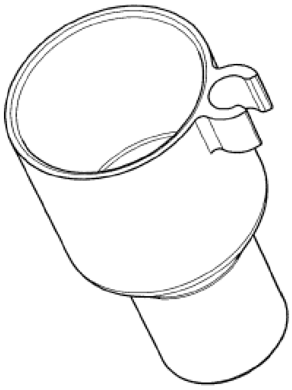
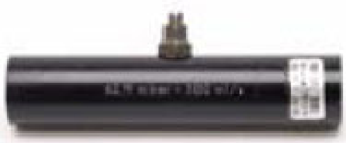
12.4 Test Equipment

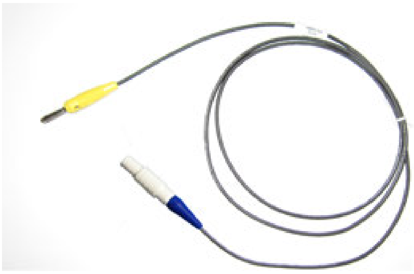
The following test equipment is required, as well as the tools listed above, to complete the test's and adjustments included in chapter 9 Service Software Chapter 9.1.

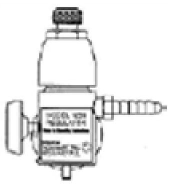
Pictures and details of most of these items are in the product catalog.

Part Number	Description	Photo
500058	Pressure measurement kit – A complete WIKA gauge set can be obtained from HAMILTON MEDICAL AG Pressure gauge with the following specifications: – Range: 0-400 mbar accuracy: 0.5%	
500084 TSI Flow meter kit contains: 500308 TSI Flow meter 500085 TSI-Flow meter Battery box 500086 TSI-Flow meter Soft carrying case 279204 Bacteria filter 260100 Silicone tube 35cm 22F	Flow meter	
500330	Hand pump	
–	Digital voltmeter With crocodile clip red and black	
260206	Coaxial breathing circuit Adult	

282442	Breathing circuit Neonatal	
281637 / 155362	Flow sensor pediatric/adult (single use / reusable)	 
155500	Flow sensor Neonatal	

279962	Adapter for flow sensor calibration Neonatal	
279928	Adapter for flow sensor calibration Adult/Ped.	
281717	Stopper for use in creating equipment setups to perform test's.	
500300	Pressure connector	
500290	Capillary tube, 500ml/s(required for expiratory valve calibration)	
279812	Clamp, flow restrictor	
500077	ESD wristband	
500009	ESD Service Kit	

151815	Adult demo lung with 7mm ET tube	
281420	Connector 22M/15F-22M/15F	
279913	Connector 15M/4M	
7249057	2 meters of silicone tube 4mm ID, 7mm OD	
161618	Electrical safety test cable	
159171	Electrical safety test cable CO2 option	
159681	Electrical safety test cable SPO2 option	

—	Safety analyzer (Electric Safety Tester) or safety analyzer hand held device (Electric Safety Tester)	 
396207	USB memory stick Specification for the USB stick: – File system: Fat or FAT32 – Unpartitioned memory – No operating system or security software installed	
369104	External battery charger	
159172	CO2 gas regulator For CO2 sensor accuracy check (if CO2 monitor option is installed).	
159173	CO2 calibration gas For CO2 sensor accuracy check (if CO2 monitor option is installed).	
281803	Adapter (three pieces for CO2 Accuracy check required)	

12.4.1 Calibration of Test Equipment

Some test equipment must be tested and calibrated periodically. Hamilton Medical AG recommends the following schedule:

Item	Schedule	Action
Pressure gauge	As recommended by the manufacturer, or at least once per year.	Send the pressure gauge back to the manufacturer for testing. (for example, www.thommenag.ch or www.wika.com for calibration information).
Digital voltmeter (DVM)	As recommended by the manufacturer.	As recommended by manufacturer.
Flow analyzer	As recommended by the manufacturer.	As recommended by manufacturer.

13 Spare Parts

13.1 Introduction

Appendix B lists replacement parts that are available for the HAMILTON-C1. The first sections of the appendix contains four diagrams that enable you to locate major components. Later sections offer much more detailed listings.

Note	– For information about consumables (such as tubing) and complete assemblies (such as the support arm, quick positioning, basic), see the HAMILTON MEDICAL AG Product Catalog (PN 689060). It can be located on the HAMILTON MEDICAL AG (http://www.hamilton-medical.com). – Some pictures shown in later sections may not be displayed to scale. – Some spare parts have a preffix MSP (Medical Spare Part). If you exchange a MSP you usually have to update the technical state of the device with the new serial and revision number.

Fig. 262 HAMILTON-C1

13.2 Overview Components Ventilation Unit

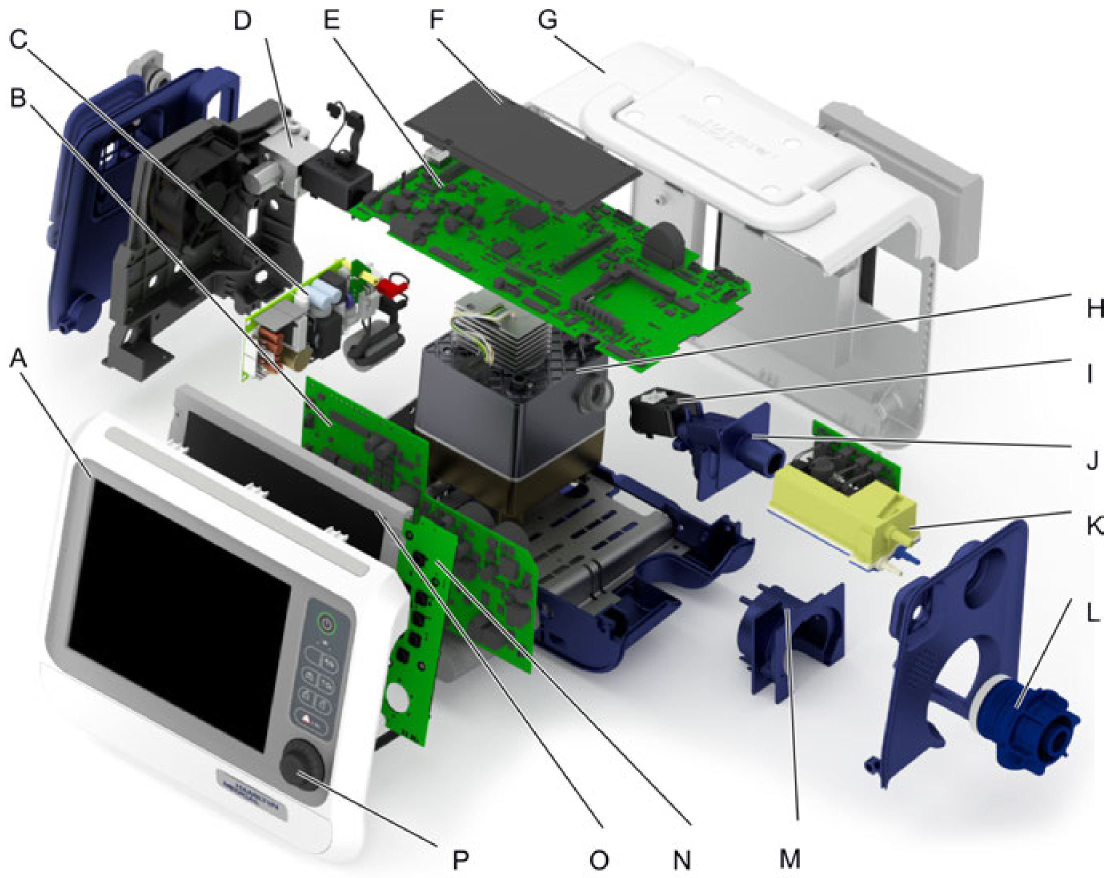
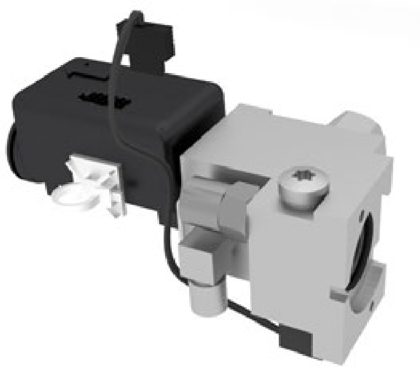
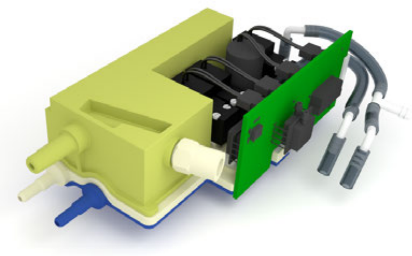
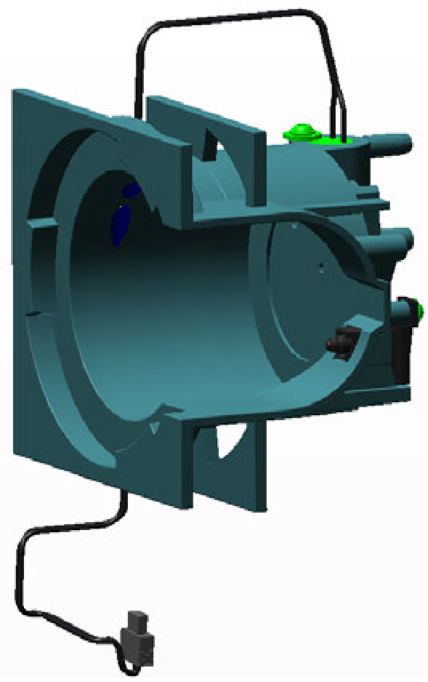


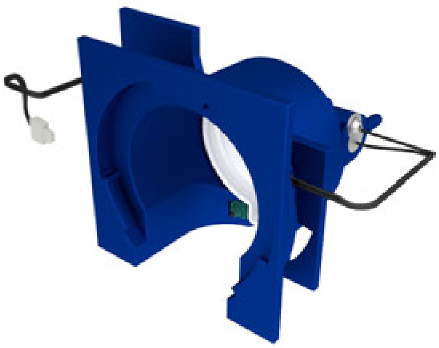
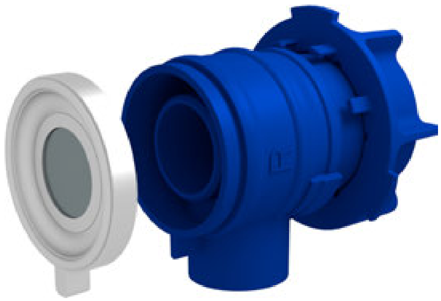
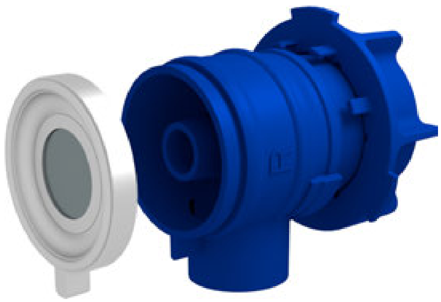
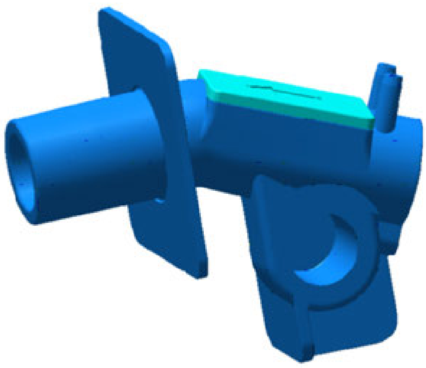
Fig. 263 Overview Components Ventilation Unit

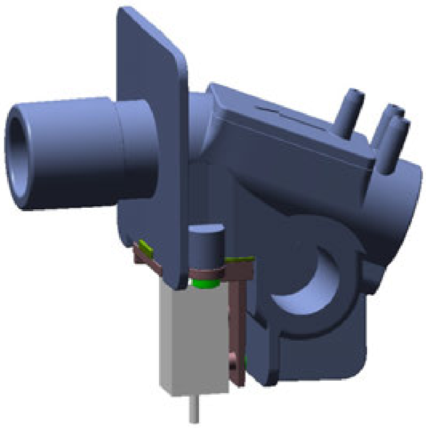
	Description	Part Number (HAMILTON-C1 <**SN6000**)	Part Number (HAMILTON-C1 ≥**SN6000**)	Spare part detail	Compatibility information
A	Display Front Complete	MSP161290		Chapter 13.2.4	Chapter 16.7.4
B	Driver board	MSP161498		Chapter 13.2.2	Chapter 16.4.3
C	Power supply	MSP396232		Chapter 13.2.3	
D	O2 mixer assembly	MSP161179	MSP161609	Chapter 13.2.1	Chapter 16.3.6
E	Control board	MSP161502		Chapter 13.2.2	Chapter 16.4.2
F	ESM-Board (Embedded system module)	MSP161529	MSP161658	Chapter 13.2.2	Chapter 16.4.1
G	Rear cover	MSP161331		Chapter 13.2.4	Chapter 16.6.5
H	Blower module	MSP161170		Chapter 13.2.1	Chapter 16.3.3
I	Flow sensor air (Qvent)	MSP399123	MSP161657	Chapter 13.2.1	Chapter 16.3.5
J	Check valve assembly	161243	MSP161192	Chapter 13.2.1	Chapter 16.3.2
K	Pressure sensor assembly	MSP161228		Chapter 13.2.1	Chapter 16.3.4
L	Expiratory valve cover and membrane	161175	161175 / 161188	Chapter 13.2.1	Chapter 16.3.1
M	Expiratory valve assembly	MSP161174	MSP161265	Chapter 13.2.1	
N	Front panel board	MSP161512		Chapter 13.2.2	Chapter 16.4.4
O	LCD Display	MSP380033		Chapter 13.2.2	
P	P+T knob	MSP161250		Chapter 13.2.4	

13.2.1 Main Assemblies

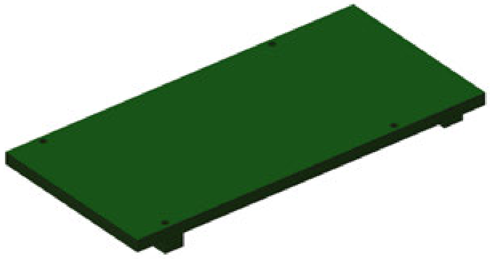
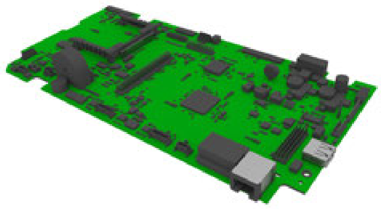
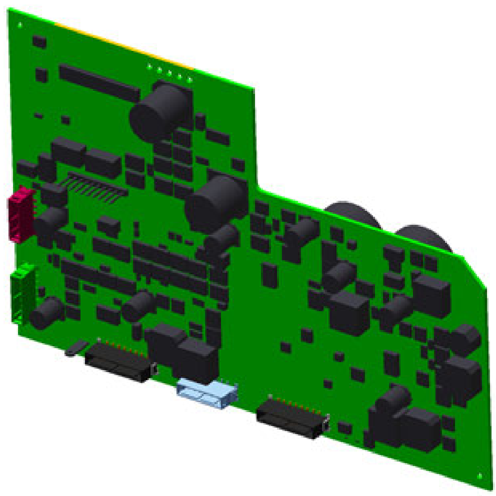
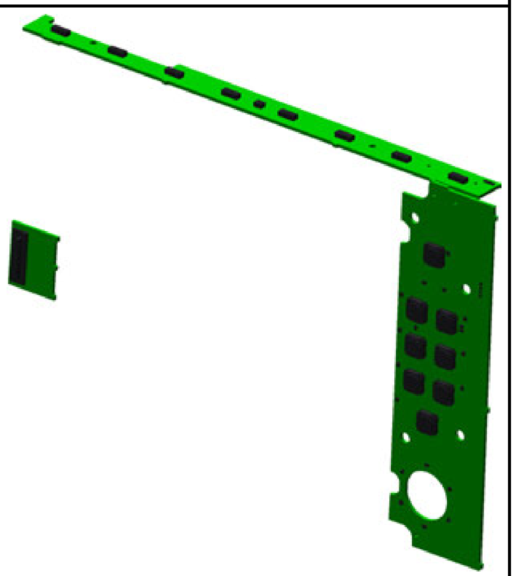
Part Number	Description	Photo
MSP161170	Blower module contains: – Top foam PN 161247 (for HAMILTON-C1 units < **SN6000**)	
MSP161179	O2 Mixer Assembly (for HAMILTON-C1 units with < **SN6000**)contains: – Flow sensor O2 (TSI)	
MSP161609	O2 Mixer Assembly (for HAMILTON-C1 units with ≥ **SN6000**)contains: – Flow sensor O2 (Sensirion)	

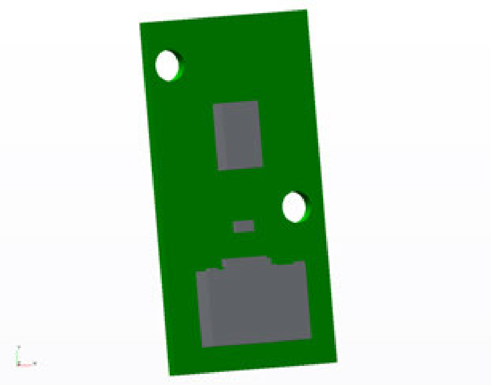
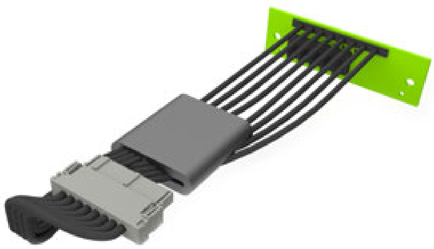
Part Number	Description	Photo
MSP399123	Flow sensor AIR (TSI, for HAMILTON-C1 units with < **SN6000**) Includes: – tie wrap L=100 B=2.5MM (PN 361000) – cable holder 12.7x12.7MM (PN 361087) Does not include: Cable to flow sensor AIR (Qvent) , PN 161566	
MSP161657	Flow sensor AIR (Sensirion, for HAMILTON-C1 units with ≥ **SN6000**) Includes: – tie wrap L=100 B=2.5MM (PN 361000) – cable holder 12.7x12.7MM (PN 361087) Does not include: Cable to flow sensor AIR (Qvent) , PN 161566	
MSP161228	Pressure Sensor Assembly	
MSP161174	Expiratory valve Assembly (for HAMILTON-C1 units with < **SN6000**) contains: – Expiratory valve housing – Expiratory Proportional valve – Bottom foam PN 161245 – Middle foam PN 161246 – Top foam PN 161247	

Part Number	Description	Photo
MSP161265	Expiratory valve Assembly (for HAMILTON-C1 units with ≥ **SN6000**) contains: – Expiratory valve housing – Expiratory Proportional valve – Micro Switch for Neonatal expiratory valve cover detection	
161175	Expiratory Valve Cover Set (Adult/Ped, Reusable) – contains 1 silicone membrane	
161188	Expiratory Valve Cover Set (Neonatal, Reusable) – contains 1 silicone membrane	
161390	Expiratory valve silicone membrane, Resuable – PN 161390 contains 5pcs	
161243	Check valve assembly (for HAMILTON-C1 units with < **SN6000**) contains: – To Patient Port – Check valve – O2 cell holder	

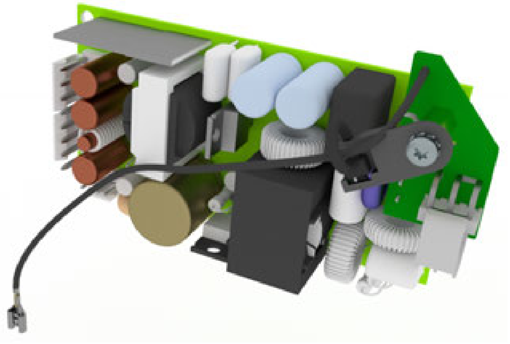
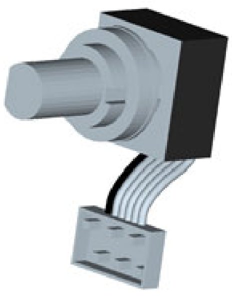
Part Number	Description	Photo
MSP161192	Check valve assembly (for HAMILTON-C1 units with ≥ **SN6000**) contains: – To Patient Port – Check valve – O2 cell holder – Obstruction valve	

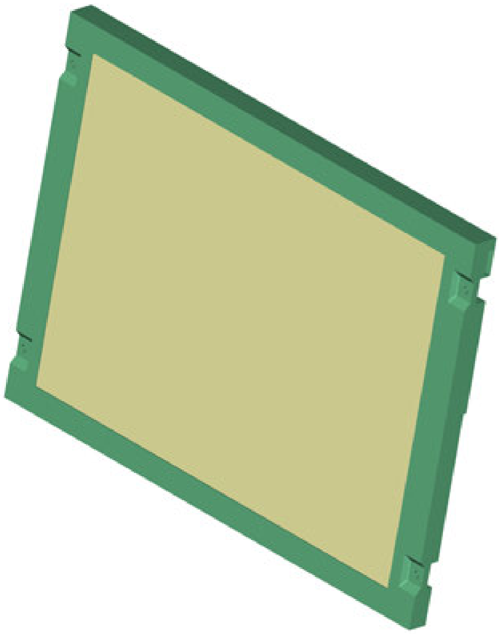
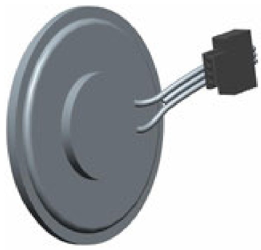
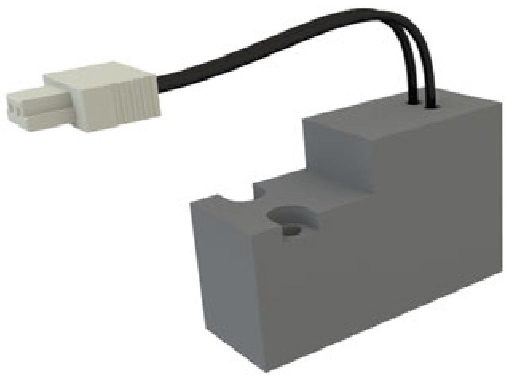
13.2.2 Printed Circuit Boards (PCB)

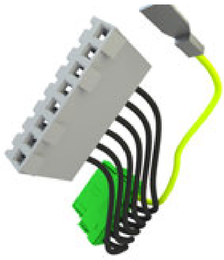
Part Number	Description	Photo
MSP161529	EM01A ESM-Board (for HAMILTON-C1 Units < **SN6000**)	
MSP161658	EM10A ESM-Board (for HAMILTON-C1 units ≥ **SN6000**)	
MSP161502	Control Board	
MSP161498	Driver Board	
MSP161512	Front Panel Board contains: – Front Panel Board – Alarm Lamp Board – Display adapter board All these 3 boards are manufactured and shipped as one board.	

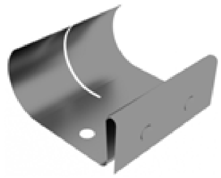
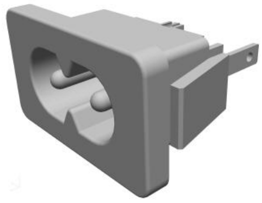
Part Number	Description	Photo
MSP161516	Filter Pressure sensor board (Pfilter) – 2 screws – O-ring – Cable to Pfilter PN 161553	
161508	Battery connector board For compatibility see Chapter 16.4.5	
161520	Communication board 1 (CO2, COM1, Nurse Call)	
161521	Communication board 3 (Nurse Call)	
161636	Comm. board 2 (CO2, SPO2, COM1)	

13.2.3 Electronic Devices and Cables

Part Number	Description	Photo
MSP396232	Power Supply includes: -Protection board (PN 161526)	
MSP161526	Protection board	
372036	P+T Knob Encoder	

Part Number	Description	Photo
MSP380033	LCD Display	
MSP161531	Fan includes: -Fan holder (4x PN 161799)	
161532	Loudspeaker	
MSP161367	Nebulizer valve (incl.Screws)	

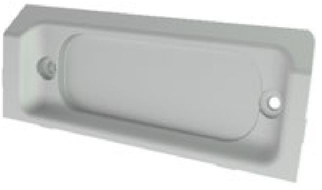
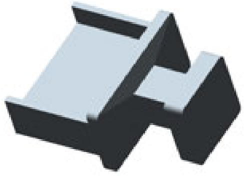
Part Number	Description	Photo
161564	Cable power to control board	
161560	Cable AC power input	
MSP161561	Cable power supply/driver board	
161552	FFC to pressure sensor board	
161554	FFC to driver board	
161569	Cable to backlight	
MSP380042	LED-Backlight	
161550	FFC to display requires: – 161365 ESD protection foil – 161695 ESD protection foil – 7279391 Kapton Tape 9mm	
161551	FFC to front panel board	
161553	Cable to filter pressure board (Pfilter)	
161566	Cable to flow sensor (QO2/Qvent)requires: – tie wrap PN 361000	
161567	Cable to O2 cell	

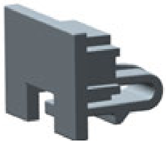
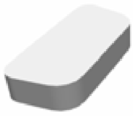
Part Number	Description	Photo
161795	Contact spring Driver Board/LCD	
340530	AC power plug	
355198	USA power cable POL 3MT C7 G (United States)	
355199	GB power cable 2 POL 3MT C7 G (Great Britain)	
355200	EU power cable 2 POL 3MT C7 G (European)	
369104	Battery charger / calibrator	
MSP369108	Lithium ion battery	
161545	Cable to COM1 260mm C1/T1	
161650	Cable to COM1 500mm C1/T1	

Part Number	Description	Photo
160166	Cable Nurse Call	

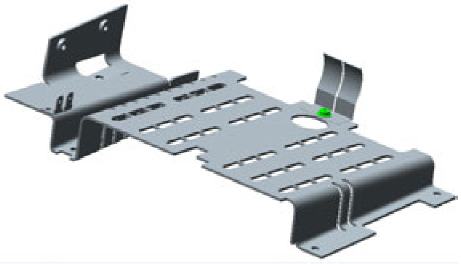
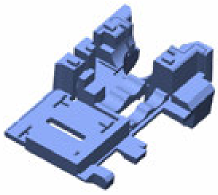
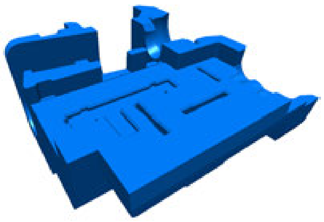
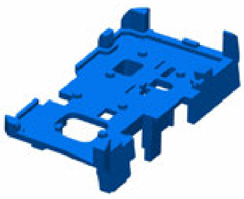
13.2.4 Display Front, Covers and External components

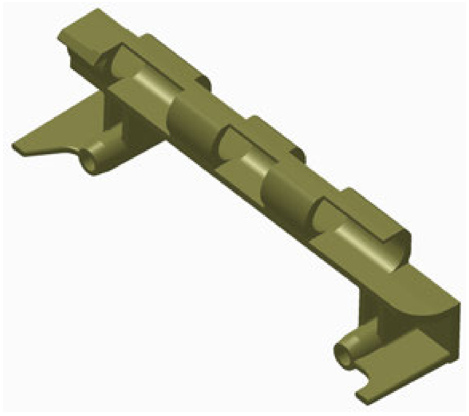
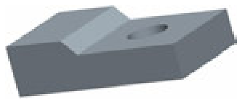
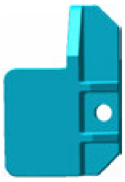
Part Number	Description	Photo
MSP161290	Display Front Complete contains: – Front Cover including HAMILTON MEDICAL Badge – Touchscreen Does not include: – Front Panel Board – P+T Knob – P+T Knob Encoder – LCD Display	
MSP161250	P+T Knob	
MSP161350	Side cover left with labels	
MSP161362	Side cover right —includes 161640 gasket for flow sensor / nebulizer port	
MSP161331	Rear cover – Device handle – Labels	

Part Number	Description	Photo
MSP161505	Device handle	
MSP161313	Filter cover	
161380	Bottom cover includes: -Rubber feet	
MSP161314	Battery door	
161312	Option board cover	
341458	USB cover	

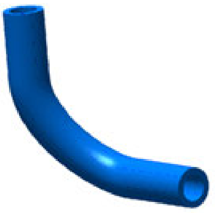
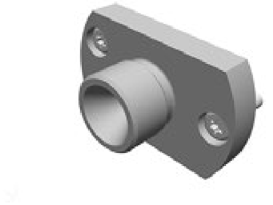
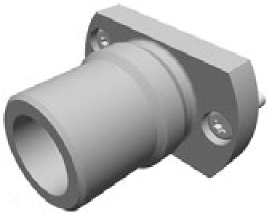
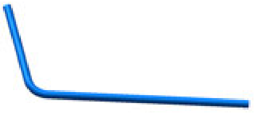
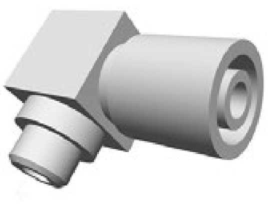
Part Number	Description	Photo
160509	Ethernet cover	
161269	Rubber foot	
500257	Protection cap for option board connectors	
161640	Gasket for flow sensor / nebulizer port	

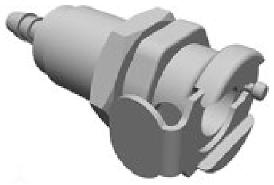
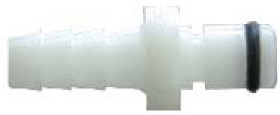
13.2.5 Internal mounting components

Part Number	Description	Photo
MSP161240	Mounting plate (contains contact spring)	
161245	Bottom foam	
161246	Middle foam	
161247	Top foam	
MSP161620	Connector Plate includes: – Connector Plate PN 161222 – Fan holder 4x PN 281634 (for Fan PN 161531 Rev < 03) – Fan holder 4x PN 161799 (for Fan PN 161531 Rev ≥ 03) – AC power plug (PN 340530) – Check valve HPO Inlet (PN 279888) – Buffer stud (PN 281635) – LPO Qxygen quick disconnect ID=3.2 (PN 279856)	

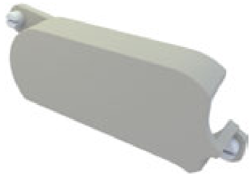
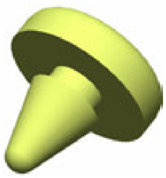
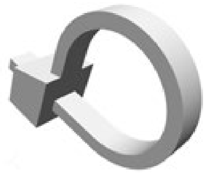
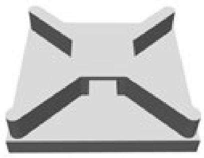
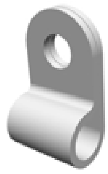
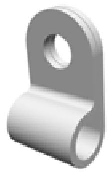
Part Number	Description	Photo
161378	Bracket for the option board cover	
161257	Display holder M4	
161917	Display holder	
161916	Display connector adapter	

13.2.6 Tubing and Fittings

Part Number	Description	Photo
161218	Tube mixer / blower	
161223	Tube LPO / mixer	
160470	O2- DISS connector	
160471	O2- NIST connector	
161229	Nebulizer tubing	
MSP161177	Tubing set pressure sensor assembly	
279591	Mini quick disconnect fitting	

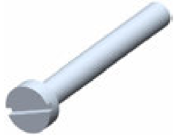
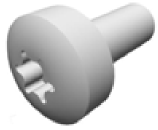
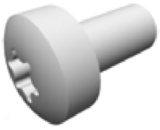
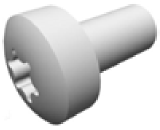
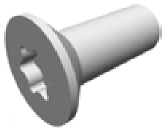
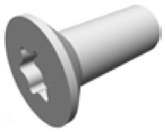
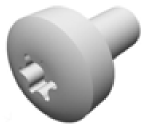
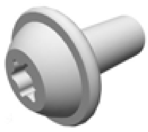
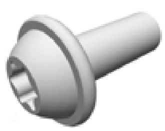
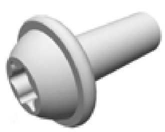
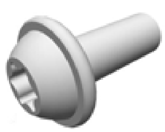
Part Number	Description	Photo
254516	O-Ring loudspeaker (ID 33x1.5)	
279856	Qxygen quick disconnect ID=3.2	
279888	One way check valve (HPO inlet)	
279913	Coupling insert 4.8mm ID for the low pressure O2 inlet	
161219	Clamp Qvent/Check valve assembly	

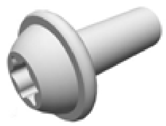
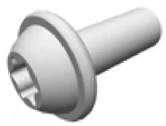
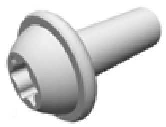
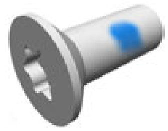
13.2.7 Clamps and Fasteners

Part Number	Description	Photo
MSP161373	Battery cap (incl. screws)	
281634	Fan holder L=58mm (for Fan PN 161531 Rev. < 03 and Fan PN 161527)	
161799	Fan holder L=70mm (for Fan PN 161531 ≥ Rev. 03)	
281635	Buffer stud D=14mm	
361000	Tie wrapL=100 B=2.5MM	
361087	Cable holder12,7x12,7MM	
361061	Cable security clamp D=5.0 for power cords: -PN 355199 GB -PN 355200 EU	
361097	Cable security clamp D=6.2 for power cords: -PN 355198 USA -PN 355308 CN	
7279391	Kapton Tape 9mm (to secure ESD protection foil)	

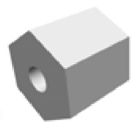
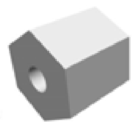
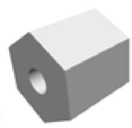
Part Number	Description	Photo
161365	ESD protection foil (FFC cable to display)	
281813	Fan filter holder (Velcro Tape D=13)	

13.2.8 Screws

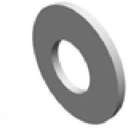
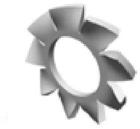
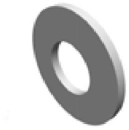
Part Number	Description	Photo
420796	M3x20 DIN854	
420638	Torx roundhead screw I-6-R M2.5x6 A4	
420641	Torx fillister head screw M3x5	
420642	Torx roundhead screw I-6-R M3x6 A4	
420664	Torx C-Sunk screw I-6-R M3x8	
420659	Torx C-Sunk screw I-6-R M3x6	
420692	Torx roundhead screw I-6-R M2x4 A4	
420699	Torx fillister head screw 22x5 D1=2.2, L=5, 6 IP	
420724	Torx fillister head screw 30x8	
420765	Round washer head screw 25x6 (Loudspeaker)	
420767	Torx roundhead screw I-6-R M3x8	

Part Number	Description	Photo
420667	Torx fillister head screw M4x8	
420773	Torx fillister head screw M5x6	
420774	Torx fillister head screw M4x6	
420864	Torx C-Sunk screw M2.5x4 (with TufLok® thread lock)	

13.2.9 Standoffs

Part Number	Description	Photo
257080	Standoff M2.5x11	
257094	Standoff M2.5X5	
257098	Standoff M2.5X5	
257093	Standoff M2.5X6	
257100	Standoff M2.5X5	

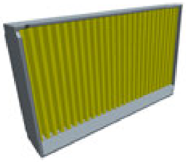
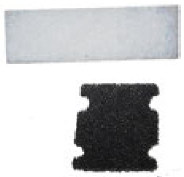
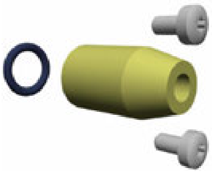
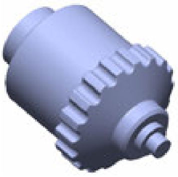
13.2.10 Washers

Part Number	Description	Photo
409912	Washer M2.5 (loudspeaker)	
411001	Star washer M3 DIN6798	
409210	Washer M2.3 (front panel board)	
282008	Slot nut M6 (Trolley column)	

13.2.11 Stickers and Labels

Part Number	Description	Photo
161291	Rear Label	
160429	HAMILTON MEDICAL label	
255358	Sticker	

13.2.12 Preventive Maintenance Parts

Part Number	Description	Photo
161236	HEPA filter	
161825	Dust filter for HEPA fan, set of 5	
160497	HPO Inlet Filter Service Kit	
396200	O2 cell	

13.3 Overview Components Trolley

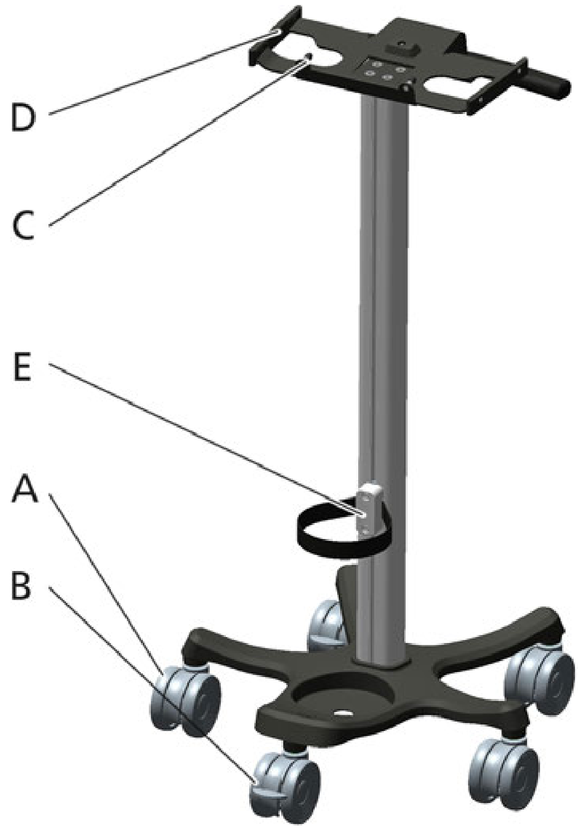
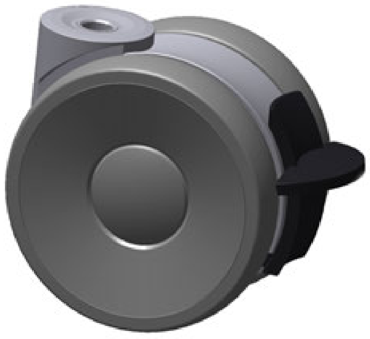
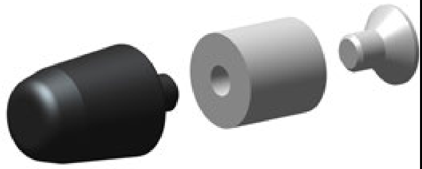
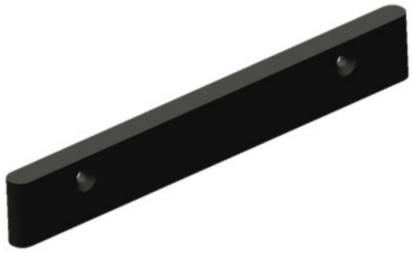
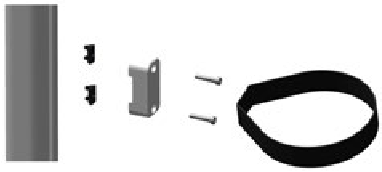


Fig. 264 Major Components Trolley

A	Trolley wheel without break (PN 281998) Chapter 13.3.1
B	Trolley wheel with break (PN 281672) Chapter 13.3.1
C	Centering Pin for Trolley and Shelf mount (MSP161408) Chapter 13.3.1
D	Rail (PN 161405) Chapter 13.3.1
E	Cylinder mount (PN 161152) Chapter 13.3.1

13.3.1 Spare Parts Trolley

Part Number	Description	Photo
281672	Trolley wheel with break	
MSP161408	Centering pin for trolley and shelf mount	
MSP161405	Rail	
161152	Cylinder mount	

14 Schematics

14.1 Schematics

Pneumatic Diagrams

Component	Number/Revision
Pneumatic Diagram HAMILTON-C1 < SN6000	n/a
Pneumatic Diagram HAMILTON-C1 ≥ SN6000	n/a

Block Diagrams

Component	Number/Revision
Block Diagram HAMILTON-C1	BD614252/00

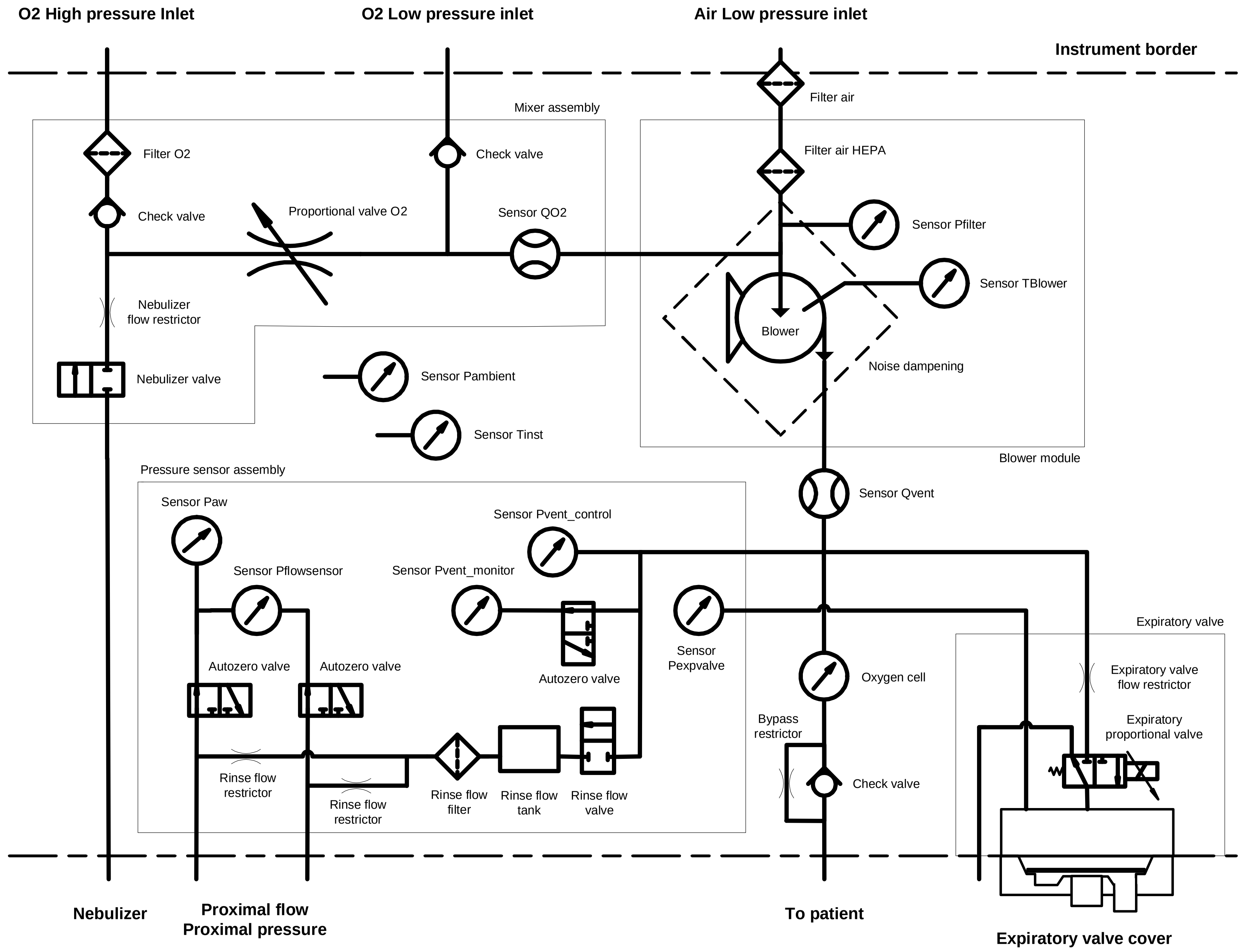
Wiring Diagrams

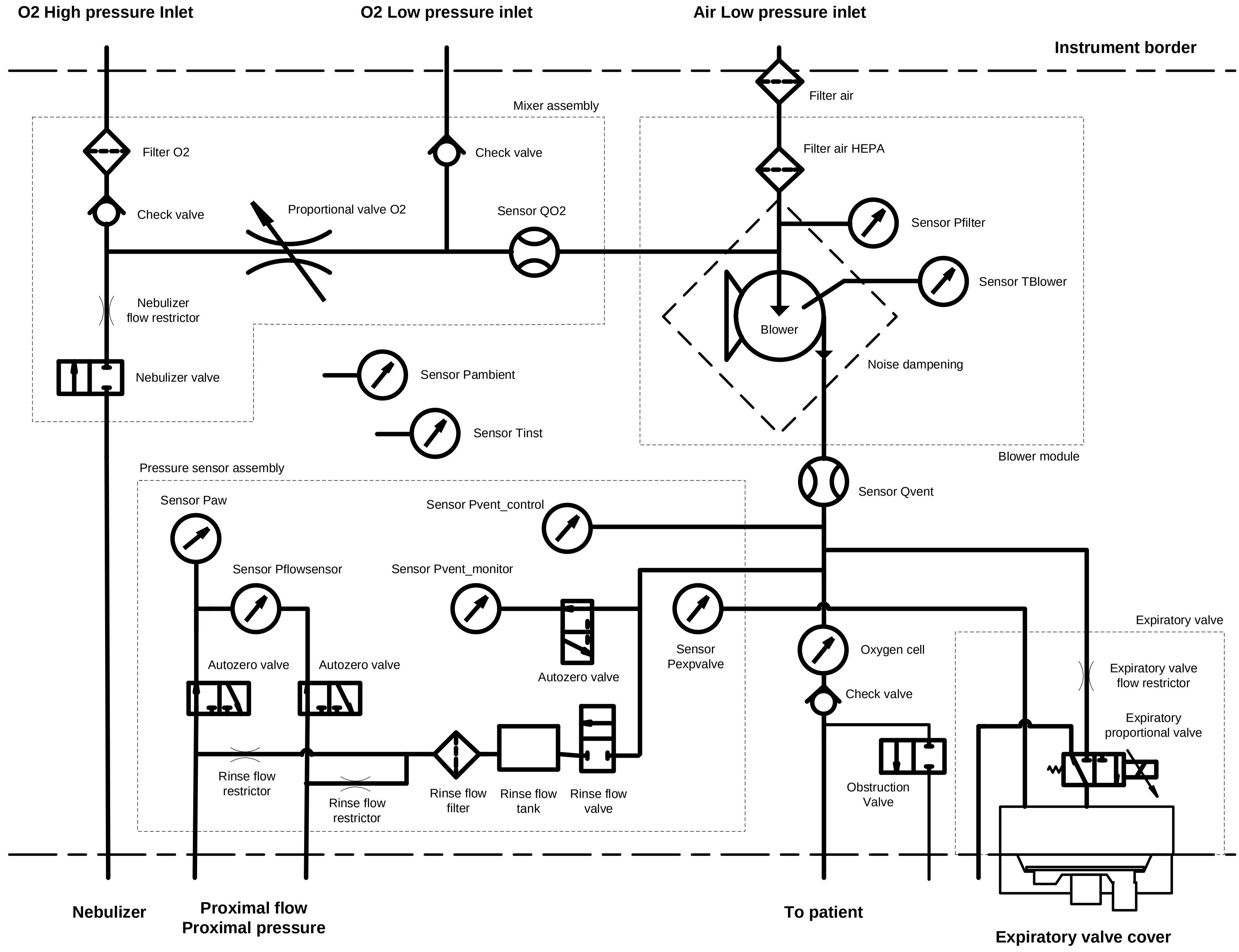
Component	Number/Revision
Wiring Diagram HAMILTON-C1	WD616093

Voltage Distribution

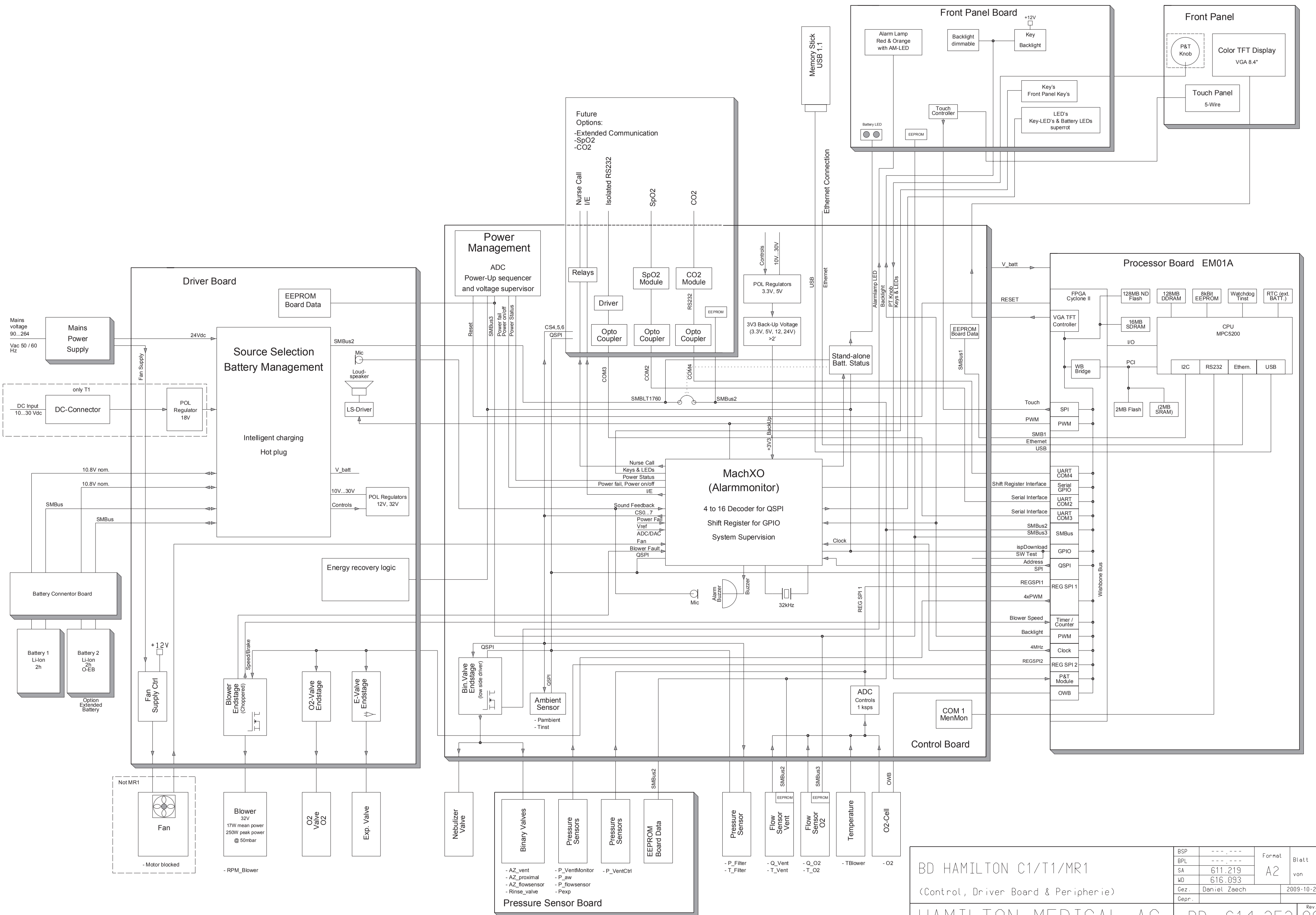
Component	Number/Revision
Voltage Distribution HAMILTON-C1	624429 / 00

Diagrams are on next pages.


O2 High pressure Inlet
O2 Low pressure inlet
Air Low pressure inlet
Instrument border
Mixer assembly
Filter air
Filter air HEPA
Filter O2
Check valve
Check valve
Proportional valve O2
Sensor QO2
Sensor Pfilter
Sensor TBlower
Blower
Noise dampening
Nebulizer
flow restrictor
Nebulizer valve
Sensor Pambient
Sensor Tinst
Blower module
Pressure sensor assembly
Sensor Qvent
Sensor Paw
Sensor Pvent_control
Sensor Pflowsensor
Sensor Pvent_monitor
Sensor
Pexpvalve
Expiratory valve
Autozero valve
Autozero valve
Autozero valve
Oxygen cell
Expiratory valve
flow restrictor
Expiratory
proportional valve
Bypass
restrictor
Check valve
Rinse flow
restrictor
Rinse flow
restrictor
Rinse flow
filter
Rinse flow
tank
Rinse flow
valve
Nebulizer
Proximal flow
Proximal pressure
To patient
Expiratory valve cover



O2 High pressure Inlet
O2 Low pressure inlet
Air Low pressure inlet
Instrument border
Filter air
Mixer assembly
Filter O2
Check valve
Filter air HEPA
Check valve
Proportional valve O2
Sensor QO2
Sensor Pfilter
Sensor TBlower
Nebulizer
flow restrictor
Blower
Noise dampening
Nebulizer valve
Sensor Pambient
Sensor Tinst
Blower module
Pressure sensor assembly
Sensor Qvent
Sensor Paw
Sensor Pvent_control
Sensor Pflowsensor
Sensor Pvent_monitor
Expiratory valve
Sensor
Pexpvalve
Oxygen cell
Autozero valve
Autozero valve
Autozero valve
Expiratory valve
flow restrictor
Check valve
Expiratory
proportional valve
Rinse flow
restrictor
Rinse flow
restrictor
Rinse flow
filter
Rinse flow
tank
Rinse flow
valve
Obstruction
Valve
Nebulizer
Proximal flow
Proximal pressure
To patient
Expiratory valve cover



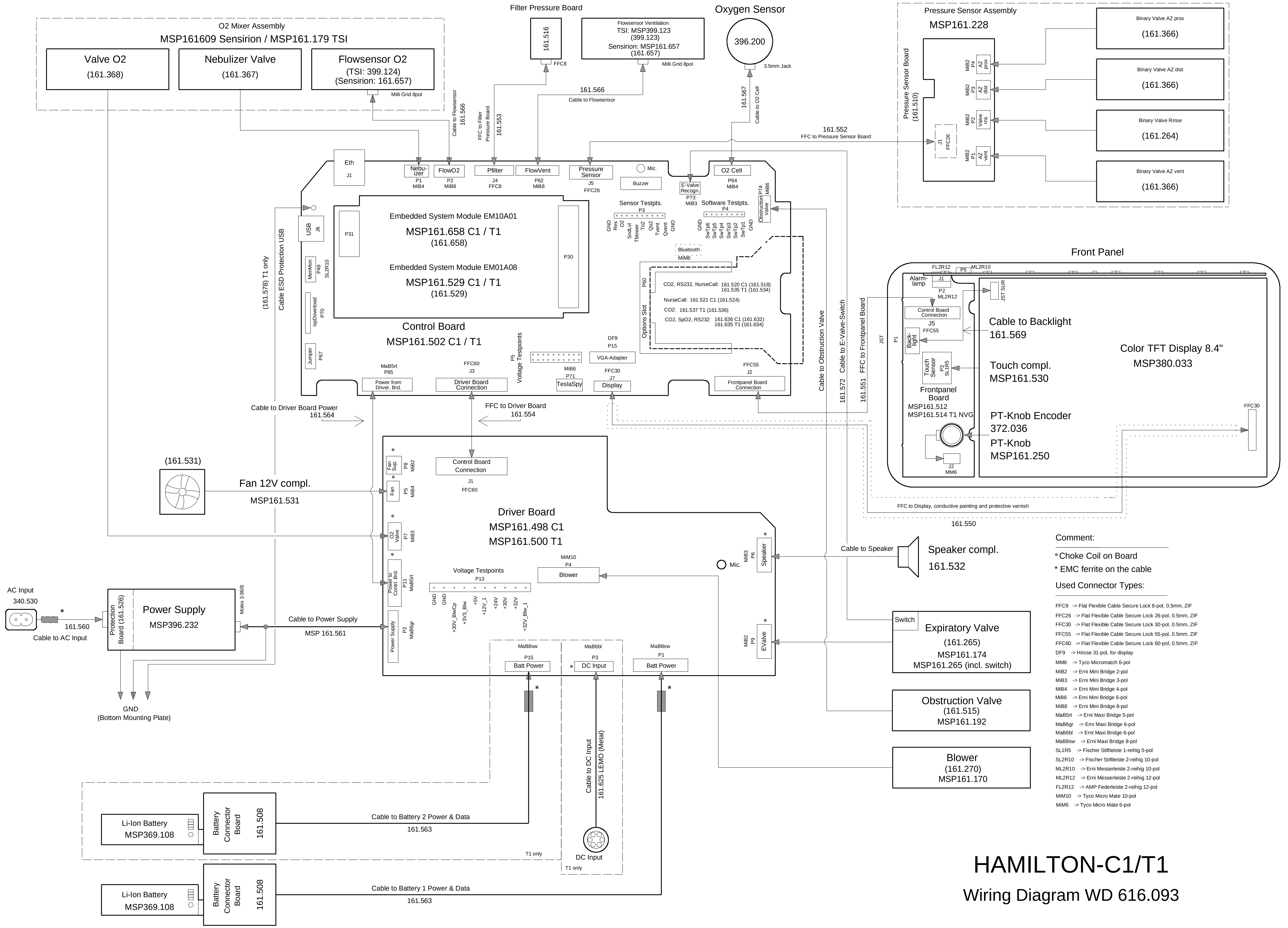
Diese Zeichnung gilt als dem jeweiligen Inhaber persoenlich anvertraut. Das Eigentum und das Urheberrecht verbleibt der Firma. Ohne schriftliche Genehmigung darf sie weder kopiert noch Drittpersonen zugaenglich gemacht werden.

Revision	Aend. Nr.	Datum	Name
Aenderg.			

BD HAMILTON C1/T1/MR1	BSP ---.---	Format A2	Blatt 1 von 1
(Control, Driver Board & Peripherie)	BPL ---.---		
	SA 611.219		
	WD 616.093		
	Gez. Daniel Zaech	2009-10-26	
	Gepr.		
HAMILTON MEDICAL AG	BD 614.252	Rev. 00	

Design Path: $PROJECT_FRODO_EL/Blockdiagram/BD_614_252_00_HAMILTON-C1
Plot Abs.: Elias Just 2010-10-07T14:59:19

CADel



Comment:

° Choke Coil on Board

* EMC ferrite on the cable

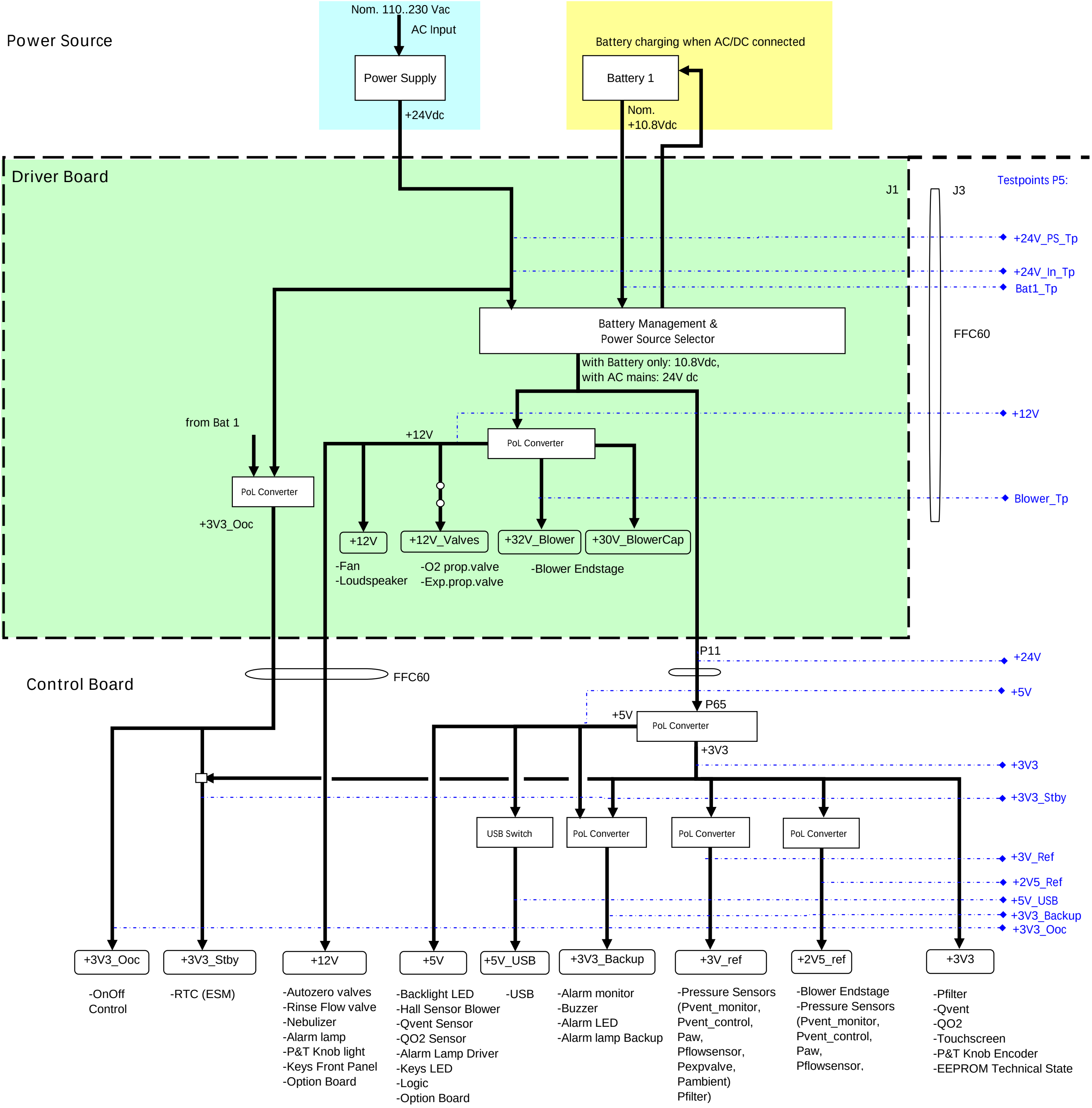
Used Connector Types:

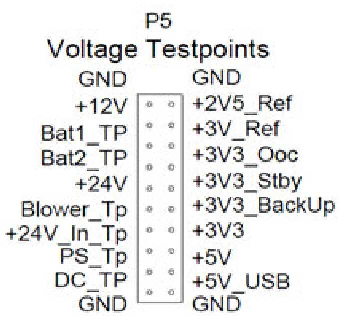
FFC8 -> Flat Flexible Cable Secure Lock 8-pol, 0.5mm, ZIF
FFC26 -> Flat Flexible Cable Secure Lock 26-pol, 0.5mm, ZIF
FFC30 -> Flat Flexible Cable Secure Lock 30-pol, 0.5mm, ZIF
FFC55 -> Flat Flexible Cable Secure Lock 55-pol, 0.5mm, ZIF
FFC60 -> Flat Flexible Cable Secure Lock 60-pol, 0.5mm, ZIF
DF9 -> Hirose 31-pol, for display
MM6 -> Tyco Micromatch 6-pol
MiB2 -> Erni Mini Bridge 2-pol
MiB3 -> Erni Mini Bridge 3-pol
MiB4 -> Erni Mini Bridge 4-pol
MiB6 -> Erni Mini Bridge 6-pol
MiB8 -> Erni Mini Bridge 8-pol
MaB5rt -> Erni Maxi Bridge 5-pol
MaB6gr -> Erni Maxi Bridge 6-pol
MaB6bl -> Erni Maxi Bridge 6-pol
MaB8sw -> Erni Maxi Bridge 8-pol
SL1R5 -> Fischer Stiftleiste 1-reihig 5-pol
SL2R10 -> Fischer Stiftleiste 2-reihig 10-pol
ML2R10 -> Erni Messerleiste 2-reihig 10-pol
ML2R12 -> Erni Messerleiste 2-reihig 12-pol
FL2R12 -> AMP Federleiste 2-reihig 12-pol
MiM10 -> Tyco Micro Mate 10-pol
MiM6 -> Tyco Micro Mate 6-pol

HAMILTON-C1/T1

Wiring Diagram WD 616.093

HAMILTON-C1 Voltage Distribution and Testpoints





Control Board

P5 Testpoints:	Voltage Range:
+2V5_Ref:	2.45..2.57V
+3V_Ref:	2.91..3.09V
+3V3_Ooc:	3.00..4.20V
+3V3_Stby:	3.00..4.20V
+3V3_Backup:	3.00..3.60V
+3V3:	3.10..3.60V
+5V:	4.60..5.40V
+5V_USB:	4.75..5.25V
+12V:	9..13.12V
Bat1_tp:	9..12.6V
+24V:	9..24.24V
Blower_tp:	*8.57..21.14V
+24V_In_tp:	23.76..24.24V
PS_tp:	*13.57..13.85V

*due to voltage divider

15 Software Revisions, Features and Compatibilty

15.1 Software Revisions, Features and Compatibility

Note	For current information and latest software, log in to HAMILTON MEDICAL AG Partner Web Site (http://www.hamilton-medical.com). There, you can also find information about upgrading and updating the HAMILTON-C1.

Introduction

The appendix gives an overview of all published HAMILTON-C1 software. It concludes information about new features introduced with software upgrades and software updates information about compatibility between software of different versions. The improvement list is not meant to be complete and covers only the most relevant changes.

15.1.1 Software Versions

SW version	Date	Description
1.1.0	July 2011	First official release
1.1.2	January 2012	CO2 functionality implemented
1.3.1	May 2013	The HAMILTON-C1 software version 1.3.1 introduces the following improvements: – Reduced O2 consumption – Display of the current O2 consumption on the ventilator system screen – Based on customer feedback, we changed the High tidal volume alarm to Inspiratory volume limitation (or similar in other languages) – Based on customer feedback, we removed tidal volume alarm limits from the AUTO alarm setting during ventilation – Minor bug fixes (refer to Ky2Help knowledge base ID 2742, for complete list) It is mandatory to update the HAMILTON-C1 with this software version 1.3.1 or a higher version. HAMILTON-C1 with SN3261 and higher have SW version 1.3.1 installed.
1.3.2	November 2013	Flow sensor calibration improvement (Autozero of Pexpvalve)
1.3.5	March 2014	Timing problem in the flow sensor calibration procedure (Autozero of Pexpvalve)All HAMILTON-C1 with SN4783 and higher have SW version 1.3.5 installed.
2.1.1	August 2014	The HAMILTON-C1 software version 2.1.1 introduces the following major improvements / changes: **SW EM01A_2.1.1 for HAMILTON-C1 units < SN6000** —Blower Lifetime calculation adjusted —GUI languages Romanian, Croatian and Finnish included —Trend 24h changed to 72h (requires key) —IntelliSync (requires key) —Block protocol introduced —New Start up screen (link to Hamilton Page) —Several Bugfixes (refer to ky2help knowledge base KB3068 for complete list) **SW EM10A_2.1.1 for HAMILTON-C1 units ≥ SN6000** —Neonatal ventilation (Optional) —nCPAP/nCPAP-PC (option) —Neo Expiratory Valve detection function (active only with Neonatal) —Blower Lifetime calculation adjusted —GUI languages Romanian, Croatian and Finnish included —Trend 24h changed to 72h —Day/ night hard key (requires key) —IntelliSync (requires key) —SpO2 monitoring (Masimo only)

			—Block protocol introduced —Pressurization performance increased —Start-up time reduced (<28s) —New Start up screen (link to Hamilton Page) —Several Bugfixes (refer to ky2help knowledge base KB3067 for complete list)
		IMPORTANT: After installing SW 2.x.x, a downgrade to a lower SW version is not possible.	

16 Hardware Revisions, Features and Compatibility

16.1 Component History Chart

This appendix brings together information found in other parts of the Service manual concerning hardware components that have changed over time. It also provides additional information, including associated HAMILTON-C1 serial numbers and the dates when changes were implemented.

Date (MM/YY-YY)	Serial Nr.	Description	Part	Part No	Chapter
09.2011	1001	First release	HAMILTON-C1	161001	Chapter 16.2
10.2011	1024	Driver board components repositioned, EMC robustness improved, new microphone for loudspeaker monitoring	Driver board	161500/01	Chapter 16.4.3
02.2012	n/a	Fan assembly replacement (PN161527 replaces PN161531/01)	Fan assembly	161527	Chapter 16.5.6
03.2012	1611	FFC cable length increased easier connection	FFC cable to display	161550/01	Chapter 16.5.3
03.2012	1611	Check valve assembly improved	Check valve assembly	161243	Chapter 16.3.2
03.2012	1615	Bottom cover modification	Bottom cover	161380	Chapter 16.6.2
03.2012	1865	Bottom mounting plate modified	Bottom mounting plate	161240	Chapter 16.6.1
03.2012	1865	Battery door fixation improved	Battery door	MSP161302	Chapter 16.6.6
03.2012	1615	Housing improved (Material modification)	Rear cover, filter cover, side covers, bottom cover	several	Chapter 16.6.4
05.2012	1711	Control board EMC robustness improved, firmware changed	Control Board	161502/04	Chapter 16.4.2
05.2012	1721	EMC robustness improved by introducing the ESD protection foil	ESD protection foil	161365	Chapter 16.7.6
05.2012	n/a	One MSP O2 Mixer assembly created for HAMILTON-C1/T1	O2 Mixer assembly	MSP161179	Chapter 16.3.6
06.2012	1865	Battery door fixation improved	Battery door	MSP161302	Chapter 16.6.6
07.2012	1927	Contact spring modified (indentations instead of hooks)	Contact spring (Driver board)	161287	Chapter 16.7.2
02.2012	1933	Contact force optimized	Contact spring (Mounting Plate)	161363 replaces 161332	Chapter 16.7.5
10.2012	2099	Battery with EMC shielding introduced	Battery	369108	Chapter 16.5.5
08.2012	2200	O2 cell cable connector improved	O2 cell cable	161567	Chapter 16.5.2
09.2012	2631	Rear cover improved (thread insert)	Rear cover	MSP161321/161284	Chapter 16.6.5
05.2013	2727	Tighter connection, lower O2 consumption	Expiratory valve (Cover and Membrane)	161175	Chapter 16.3.1
05.2013	2727	Glue for magnets changed (better adhesive properties)	Battery door	MSP161302	Chapter 16.6.6
05.2012	2743	ESM Shield housing introduced	ESM shield housing	MSP161338	Chapter 16.7.3
05.2013	2785	Tubing to Pexpvalve pressure sensor improved	Tubing	7249089	Chapter 16.7.7

05.2013	3103	To avoid possible liquid penetration through the flow sensor/nebulizer port	Gasket for flow sensor/Nebulizer Port	161640	Chapter 16.6.3
05.2013	3192	New option board bracket introduced to ensure that the option board closes firmly	Option board bracket	161378	Chapter 16.7.2
05.2013	3261	Software version 1.3.1 introduced	SW 1.3.1	n/a	Chapter 15.1.1
05.2013	3263	Mounting of the left side cover improved	Washer M4	409234	Chapter 16.6.8
05.2013	3346	New loudspeaker introduced (robustness improved)	Loudspeaker	161532	Chapter 16.5.4
07.2013	3048	Output stage of the expiratory proportional valve optimized	Driver board	161498/02	Chapter 16.4.3
07.2013	3643	Tubing line separated, Pressure controlling improved	Pressure sensor assembly	MSP16122 8	Chapter 16.3.4
07.2013	n/a	Temperature compensation improved	O2 cell	396200/01	Chapter 16.5.1
07.2013	3694	Control Board Rev.07 (USB Stability improved)	Control board	MSP16150 2	Chapter 16.4.2
07.2013	3815	Hot plug ability improvement for battery slot 2 (HAMILTON-T1 related modification)	Battery connector board	161508/03	Chapter 16.4.5
11.2013	n/a	Fan assembly replacement (PN161531/02 replaces PN161527 and PN161531/01)	Fan assembly	161531/02	Chapter 16.5.6
12.2013		MSP O2 Mixer assembly with valves for +50°C	O2 Mixer assembly	MSP16117 9	Chapter 16.3.6
01.2014	4333	Blower cooling improved (required for neonatal mode)	Blower module	MSP16117 0	Chapter 16.3.3
04.2014	4733	Fan Rev.03 , cooling performance improved	Fan	MSP16153 1	Chapter 16.5.6
04.2014	4987	Battery Rev. 04 capacity increased	Battery	369108	Chapter 16.5.5
08.2014	6000	Pressure sensor assembly valves with temp.range to +50°C	Pressure sensor assembly	MSP16122 8	Chapter 16.3.4
08.2014	6000	ESM Board EM10A introduced	ESM Board	MSP16165 8	Chapter 16.4.1
08.2014	6000	Control Board Rev. 09 (Neonatal related changes)	Control board	MSP16150 2	Chapter 16.4.2
08.2014	6000	Battery connector board rev.04 (Smaller ferrite core)	Battery connector board	161508	Chapter 16.4.5
08.2014	6000	Mounting plate modified for the ferrite core holders	Mounting plate	161336	Chapter 16.6.1
08.2014	6000	Check valve assembly with obstruction valve introduced	Check valve assembly	MSP16119 2	Chapter 16.3.2
08.2014	6000	O2 Mixer assembly with Sensirion QO2 introduced	O2 Mixer assembly	MSP16160 9	Chapter 16.3.6
08.2014	6000	New Flow sensor AIR (Sensirion) introduced	Flow sensor AIR	MSP16165 7	Chapter 16.3.5
09.2014	6064	Control Board Rev. 10 — Layout change (components repositioned)	Control Board	161502/10	Chapter 16.4.2

16.2 Venitlation unit

Ventilation unit (PN161001)		
Description / Notes	Introduction	Compatibility
HAMILTON-C1 1st generation	HAMIL-TON-C1 SN1000-5999	Requires the following components: – MSP399123 Flow sensor AIR (TSI) – MSP161179 Mixer assembly with flow sensor O2 (TSI) – MSP161174 Expiratory valve – PN 161243 Check valve assembly – PN 161512 Front panel board – MSP161529 ESM (EM01A)
	Note	Unit cannot be upgraded to 2nd generation
HAMILTON-C1 2nd generation – Neonatal ventilation (SW option required) – SpO2 measurement (Option board required) – Day/Night hardkey – Start-up time <28s	HAMIL-TON-C1 ≥ SN6000	Requires the following components: – MSP161567 Flow sensor AIR (Sensirion) – MSP161609 Mixer assembly with flow sensor O2 (Sensirion) – MSP161265 Expiratory valve with neonatal E-valve recognition – MSP161192 Check valve assembly with obstruction valve – MSP161170 Blower module (Rev. 01 or higher) – PN 161531 Fan (Rev. 03 or higher) – PN 161502 Control Board (Rev. 09 or higher) – PN 161658 ESM Board EM10A – SW version EM10A 2.1.1 or higher – PN 161508 Battery connector (Rev. 04 or higher) – PN 161500 Driver Board Rev (Rev. 04 or higher) – PN 161512 Front panel board

16.3 Main Assemblies

16.3.1 Expiratory Valve (Cover and Membrane)

A new expiratory valve and membrane offering improved performance have been introduced.

Use of the new valve and membrane offers a tighter connection, resulting in lower oxygen consumption.

Note	For optimal performance, use the new valve with the new membrane. While use of the new valve with a previous version membrane or the new membrane with a previous version expiratory valve may result in increased oxygen consumption, it does not pose any risk to the patient.

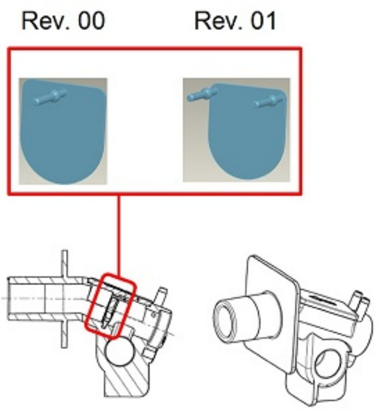
The components are color coded and/or distinctively marked to help ensure that you use the appropriate combination of new valve/new membrane or old valve/old membrane. The following table provides the differences:

	New expiratory valve and membrane	**Previous version expiratory valve and membrane**
Membrane color	White	Orange
Membrane materials	Silicone	Silicone
Expiratory valve housing color	Blue	Blue
Expiratory valve housing materials	Polycarbonate	Glass-reinforced polypropylene
Identifying markings on housing	Embossed letter **R**	Embossed part number **PN 161227**
		

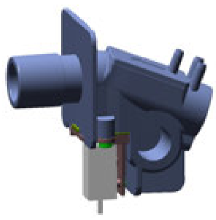
The new expiratory valve cover and membrane are included with HAMILTON-C1 ≥ SN2727.

16.3.2 Check valve assembly modification (MSP161243/161192)

Check valve assembly (MSP161243)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– First release	HAMILTON-C1 SN1000	HAMILTON-C1 < SN1611
01	– The check valve flap is secured with a lug before being welded to the patient connection. The previous-version flap was only secured by a single lug in the middle of the flap, which allowed the flap to rotate and possibly not provide a tight seal. As a result, the device could fail the Check valve test (Service software).	HAMILTON-C1 SN1611	HAMILTON-C1 < SN6000

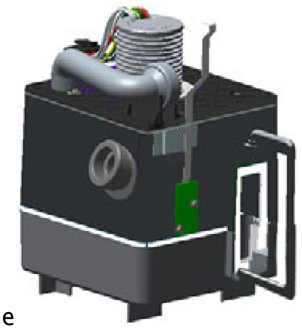


Check valve assembly with obstruction valve (MSP161192)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– First release – To fulfill the new regulatory requirements (3rd Edition IEC 60601) the obstruction valve was implemented in the check valve assembly 161192 regarding pressure release during situations where exhalation obstructed is present.	HAMILTON-C1 SN6000	HAMILTON-C1 units ≥ SN6000



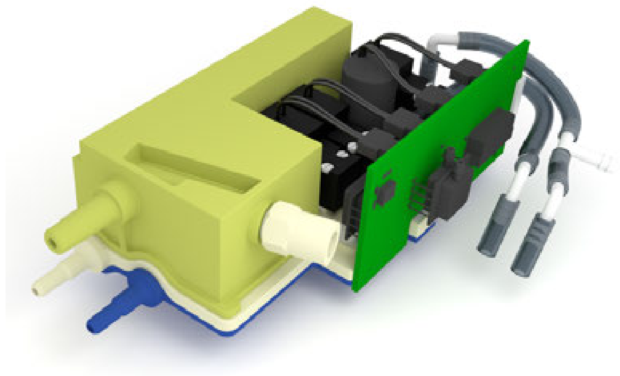
Note	With SW version 2.1.x the Check valve assembly was added to the technical state. Make sure to select the correct part number of the check valve assembly. Refer to Chapter 9.7.4.

16.3.3 Blower module (MSP161170)

Blower module (MSP161170)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	 First release	HAMILTON-C1 SN1000	For HAMILTON-C1 units < SN6000
01	– Mounting process of the blanket insulator improved – New grommet (geometry and material change) as noise reduction – Blower cooling improved (required for neonatal mode) 	HAMILTON-C1 SN4333	For HAMILTON-C1 units ≥ SN6000 install MSP161170 rev. 01 or higher
			For HAMILTON-C1 units ≥ SN6000 replace the top foam PN 161247 which comes along with the MSP161170 Rev. 01 or higher

16.3.4 Pressure sensor assembly (MSP161228)

Pressure sensor assembly (MSP161228)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– One MSP for HAMILTON-C1 and HAMILTON-T1 created (replaces MSP161172, MSP161217) – Autozero valves for extended low temperature range from 0°C —15°C: – Autozero valve (PN 161366, Label "833-631016") replaces (PN 161267, Label "833-630989")	MSP since May 2012	
01	– To improve the pressure controlling, the tubing line to pressure sensors (Pvent_monitor and Pvent_control) have been separated.	HAMILTON-C1 SN3643	
02	– Valves with extended temp.range to +50°C introduced: – Autozero valve (PN 161366, Label "833-631016") Revision changed to 02) – Rinse flow valve (PN 161264, Label "833-622762", Revision changed to 02)	HAMILTON-C1 SN6000	For HAMILTON-C1 units ≥ SN6000 use MSP161228 rev. 02 or higher



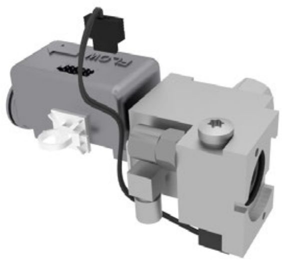
16.3.5 Flow sensor AIR (MSP399123/161657)

Flow sensor AIR (MSP399123)			
PN. Nr.	Description / Notes	Introduction	Compatibility
MSP399123	– First release	HAMILTON-C1 SN1000	HAMILTON-C1 < SN6000

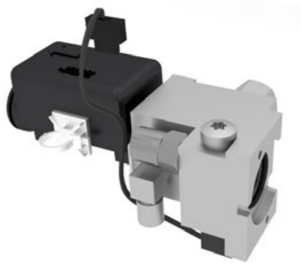
Flow sensor AIR (MSP161657)			
PN. Nr.	Description / Notes	Introduction	Compatibility
MSP161657	-Can be used up to 8000m above seal level -Better resolution in lower flows -Bidirectional flow measurement -Better temperature compensation	HAMILTON-C1 SN6000	HAMILTON-C1 ≥ SN6000

16.3.6 O2 Mixer assembly (MSP161179/161609)

O2 Mixer assembly (MSP161179)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– One MSP for HAMILTON-C1 and HAMILTON-T1 created (replaces MSP161171, MSP161178) Valves for low temperature (-15°C) introduced: – Nebulizer valve (PN 161367, Label "833-622918") replaces (PN 161273, Label "833-622820") – O2 proportional valve (PN161368, Label "12-216C-04525") replaces (PN161293, Label "12-216C-04521")	May 2012	HAMILTON-C1 < SN6000
01	– Installation guide corrected	April 2013	HAMILTON-C1 < SN6000
02	Valves with extended temp.range to +50 °C introduced: – Nebulizer valve (PN 161367 Label "833-622918") replaces (PN 161273, Label "833-622820") – O2 proportional valve (PN 161368, Label "12-216C-04525 F120129") replaces (PN 161368, Label "12-216C-04525 F120111")	December 2013	HAMILTON-C1 < SN6000



O2 Mixer assembly (MSP161609)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	New flow sensor O2 introduced: -Can be used up to 8000m above seal level -Better resolution in lower flows -Bidirectional flow measurement -Better temperature compensation	HAMILTON-C1 SN6000	HAMILTON-C1 ≥ SN6000



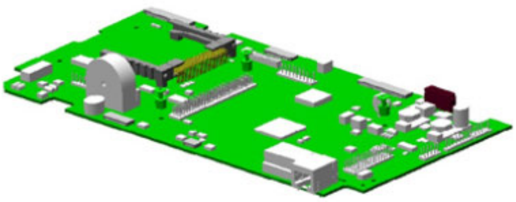
16.4 Printed Circuit Boards (PCB)

16.4.1 ESM Board (MSP161529 /161658)

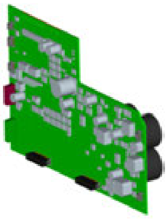
ESM Board EM01A (MSP161529)			
Description / Notes		Introduction	Compatibility
First official release		HAMILTON-C1 SN1000	HAMILTON-C1 < SN6000
Processor:	PowerPC MPC5200 / 384 MHz		
FPGA:	Altera Cyclone II Current version: A.8		
Memory:	NAND Flash 128MB		
USB:	1.1		
SW versions	– 1.x.x.tar – C1_EM01A_2.1.1.tar or higher		

ESM Board EM10A (MSP161658)			
Description / Notes		Introduction	Compatibility
First official release		HAMILTON-C1 SN6000	HAMILTON-C1 ≥ SN6000
Processor:	PowerPC MPC5123 / 400 MHz		
FPGA:	Altera Cyclone III Current version: A.2		
Memory:	Micro SD 512MB		
USB:	2.0		
SW versions	C1_EM10A_2.1.1.tar or higher		

16.4.2 Control Board (MSP161502)

Control Board 161502 (MSP161502)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
03	First official release	HAMILTON-C1 SN1000	
04	EMC robustness improved, firmware changed	HAMILTON-C1 SN1711	
05	Not released, for internal purposes only		
06	Not released, for internal purposes only		
07	– USB stability improved (some USB Sticks didn't work, USB crashed) – OWB (One wire Bus-> O2 cell recognition during start-up) stability improved – Electronic components removed from the area close to option board (Resistors could be damaged by the option board cover)	HAMILTON-C1 SN3694	SW version 1.3.x or higher
08	Rev 08 Not released, for internal purposes only		
09	With Control Board Rev. 09 the following changes were made: – Connector to Micro Switch for Neo-E-valve detection – Prepared for Bluetooth module (connector underneath the PCB) – The Alarm lamp can be controlled to blink (IEC 60601-1-8) – To control the NVG (Night vision goggle on HAMILTON-T1 only) – Connector to Obstruction valve (3rd Edition IEC 60601-1) – the PCB has been lacquered to improve the robustness against humidity	HAMILTON-C1 SN6000-6063	HAMILTON-C1 units ≥ SN6000 require Control Board rev. ≥ 09 Use only the following option boards with Control Board 09: – Comm. board 2 PN161636/01 or higher (PCB 161632/02 or higher) – Comm. board 1 PN161520/04 or higher (PCB 161518/04 or higher) The use of any other option board can seriously damage the HAMILTON-C1.
10	Layout change (components repositioned) to make compatible for older option boards	HAMILTON-C1 SN6064	
			

16.4.3 Driver Board (MSP161498)

Driver Board 161498 (MSP161498)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– First official release	HAMILTON-C1 SN1000	
01	– not released	n/a	
02	– Components repositioned – EMC robustness improved – new microphone for loudspeaker monitoring	HAMILTON-C1 SN1024	
03	– Output stage of the expiratory proportional valve optimized	HAMILTON-C1 SN3048	For HAMILTON-C1 units ≥ SN6000 use driver board rev. 03 or higher
			

16.4.4 Front panel board (MSP161512)

Front panel board 161512 (MSP161512)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– First official release	HAMILTON-C1 SN1000	
01	– Electronic components around the alarm lamp connector relocated – Changes required for HAMILTON-MR1 only	HAMILTON-C1 SN1021	
02	– Connector J2 modified, required for the alarm lamp cable of the HAMILTON-MR1	HAMILTON-C1 SN1927	

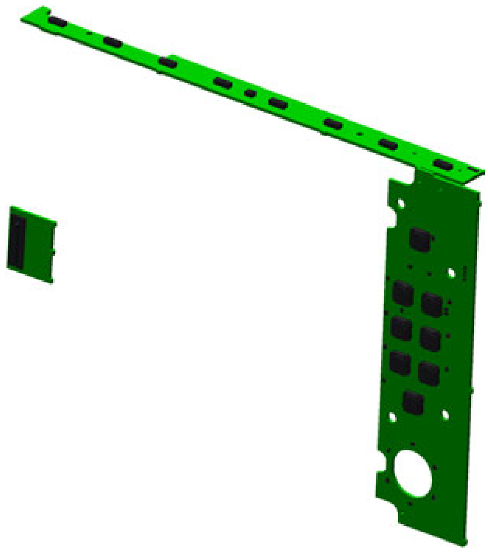
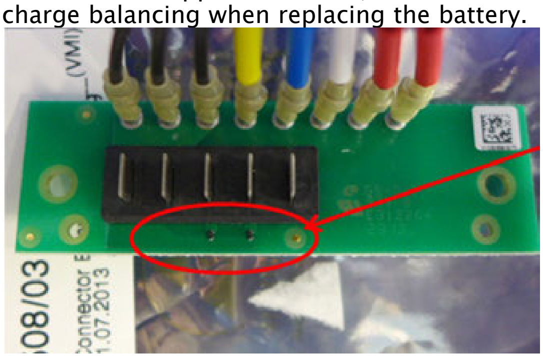
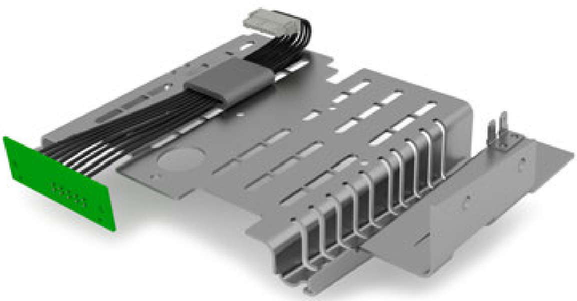


Fig. 265 Front panel board (MSP161512)

16.4.5 Battery Connector Board (PN 161508)

Battery connector board (161508)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
02	– First official release	HAMIL-TON-C1 SN1000	For HAMILTON-C1 units < SN6000
03	– The hot-swap battery connector for the HAMILTON-T1 battery slot 2 was improved. Since the HAMILTON-C1 uses the same battery connector, this improvement takes affect in the HAMILTON-C1 as well. – The new battery connector board Rev. 03 contains an ESD Suppressor Diode, which avoids charge balancing when replacing the battery.  ESD suppressor diode soldered on the backside	HAMIL-TON-C1 SN3815	
04	Due to results of stress test, the battery connector board was improved to reduce the compression force on the connector).The battery connector board PN 161508 with Rev. 04 includes the following improvements: – Stranded wires (PN 161563) – Smaller ferrite core (screwed into bottom mounting plate) 	HAMIL-TON-C1 SN6000	For HAMILTON-C1 units SN3815-SN6000 order addtionally: – MSP161240 Bottom mounting plate – PN 161245 Bottom foam – PN 161246 Middle foam – PN 161247 Top foam – PN 161796 Ferrite core holder – PN 420659 countersunk-head screw I-6-R M3x6 For HAMILTON-C1 units < SN3815 order addtionally: – MSP161240 Bottom mounting plate – PN 161245 Bottom foam – PN 161246 Middle foam – PN 161247 Top foam – 161380 Bottom cover – PN 161796 Ferrite core holder – PN 420659 countersunk-head screw I-6-R M3x6

16.5 Electronic Devices and Cables

16.5.1 O2 Cell (PN 396200)

O2 cell (PN 396200)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– First official release	HAMILTON-C1 SN1000	
01	– Temperature compensation improved	July 2013	
			

16.5.2 O2 Cell Cable (PN 161567)

O2 cell cable (PN 161567)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– First official release	HAMILTON-C1 SN1000	
01	– A molded connector (O2 cell plug side) improves the connectivity between the O2 cell cable (PN 161567).	HAMILTON-C1 SN2200	
			

16.5.3 FFC cable to display length changed (PN 161550)

FFC cable to display (PN 161550)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– First official release (cable length 247mm)	HAMILTON-C1 SN1000	
01	– Cable length changed to make it easier to connect (cable length 280mm)	HAMILTON-C1 SN1611	
			

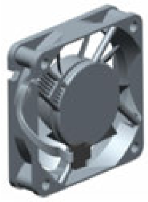
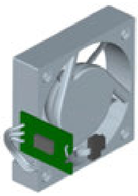
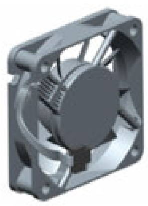
16.5.4 Loudspeaker (PN 161532)

Loudspeaker (PN 161532)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– First official release	HAMILTON-C1 SN1000	
01	– Loudspeaker robustness improved. – The new loudspeaker (1.5W, with transparent membrane) replaces the old loudspeaker (1W, with black membrane).	HAMILTON-C1 SN3346	A further improvement was made with SW1.3.1 by optimizing the parameters for loudspeaker. Please update to the latest SW version after installing the new loudspeaker.

16.5.5 Li-Ion Battery (PN 369108)

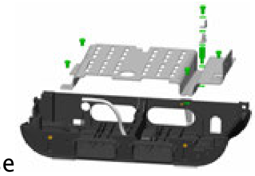
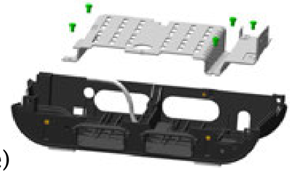
Li-Ion Battery PN 369108			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– First official release – Energy: 46 Wh	– September 2010 – HAMILTON-C1 SN1000	
01	– Energy: 46 Wh – Gauge corrected. – UL-Label and bar code added.	– September 2011	
02	– Battery with conductive coating introduced to improve the EMI behavior. – Energy: 46 Wh	– October 2012	
03	– Battery case material changed – Energy 46 Wh – Battery Rev. 03 has Serial No ≥ 4000	– April 2013	
04	– Capacity increased – Energy 72Wh	– April 2014 – HAMILTON-C1 SN4987	For HAMILTON-C1 units ≥ SN6000 use Battery Rev.04 or higher

16.5.6 Fan (PN 161531, PN 161527, MSP161531)

Fan (PN 161531, PN 161527, MSP161531)			
Fan part number / Rev.	Description / notes	Compatibility	Photo
161531/01	**First official release (09.2011)** Fan assembly PN 161531 contains: -Fan PN 391165/01 “2406KL-04W-B56-L62” -Cable with connector	compatible with HAMILTON-C1 units < SN6000	 60x60x15mm
161527/00	**Introduced as replacement due to a temporary unavailability of PN 161531/01 (02.2012)** Fan assembly PN 161527/00 contains: -Fan PN 391222 “2406KL-04W-B59-L00” -Fan Board PN 1610562 -Cable with connector	compatible with HAMILTON-C1 units < SN6000	 60x60x15mm
MSP161531/00	**Spare part introduced (11.2012)** contains: -Fan assembly PN 161527/00 -Fan holders 4x PN 281634	compatible with HAMILTON-C1 units < SN6000	
161531/02	**Introduced as replacement for PN 161531/01 and PN 161527/00 due to unavailability (11.2013)** Fan assembly PN 161531/02 contains: -Fan PN 391165/02 “2406VL-04W-B56-B01” -Cable with connector	compatible with HAMILTON-C1 units < SN6000	 60x60x15mm
MSP161531/02	**Spare part introduced (11.2013)** -Fan assembly PN 161531/02 -Fan holders 4x PN 281634	compatible with HAMILTON-C1 units < SN6000	
161531/03	**Introduced to improve the cooling performance in neonatal mode (HAMILTON—C1 ≥ SN6000)** Introduced with HAMILTON-C1 SN4733 Fan assembly PN 161531/03 contains: -Fan PN 391234 “2410SB-04W-B76-B01” -Cable with connector	compatible with all HAMILTON-C1 units	 60x60x25mm
MSP161531/03	**Spare part introduced (05.2014)** -Fan assembly PN 161531/03 -Fan holders 4x PN 161799	compatible with all HAMILTON-C1 units.For HAMILTON-C1 units ≥ SN6000 please install MSP161531 Rev. 03 or higher	

16.6 Display Front, Covers and External components

16.6.1 Mounting Plate Modification (PN 161240)

Mounting plate (PN161240)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00 /01	– First official release 	HAMIL-TON-C1 SN1000	compatible with HAMILTON-C1 < SN1865
02	– Due to modifications on bottom cover, the geometry of the bottom mounting plate was changed as well – Additionally the connection for the ESD protection cable USB was modified as well as the cable itself. (HAMILTON-T1 related  change)	HAMIL-TON-C1 SN1865	For replacing the mounting plate in HAMILTON-C1 < SN1865 order additionally: – 161380 Bottom cover – PN 161245 Bottom foam – PN 161246 Middle foam – PN 161247 Top foam
03-04	manufacturing process changed		
05	– The mounting plate was modified with 2 holes to hold ferrite core of the battery connector board wires.	HAMIL-TON-C1 SN6000	For replacing the mounting plate in HAMILTON-C1 < SN1309 order additionally: – 161380 Bottom cover – PN 161245 Bottom foam – PN 161246 Middle foam – PN 161247 Top foam

16.6.2 Bottom Cover Modification (PN 161380)

Bottom cover (PN 161380)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
00	– First official release	HAMILTON-C1 SN1000	compatible with HAMILTON-C1 < SN1615
01	– To improve the weld line strength and to eliminate possible cracks, the bottom cover was improved by revising the injection molding and modifying the material PC/ASA. The geometry of the cover was slightly changed.	HAMILTON-C1 SN1615	For replacing the bottom cover in HAMILTON-C1 < SN1615 please order additionally: – MSP161240 Bottom mounting plate – PN 161245 Bottom foam – PN 161246 Middle foam – PN 161247 Top foam

16.6.3 Gasket for Flow Sensor/Nebulizer Port Introduced (PN 161640)

To avoid possible liquid penetration (through, for example, a cleaning agent) through the flow sensor/nebulizer port, a gasket PN 161640 has been added.

Fig. 266 Gasket for Flow Sensor/Nebulizer Port (PN 161640)

The gasket was introduced with HAMILTON-C1 SN3103.

16.6.4 Housing Improved (Material Modification)

To improve the weld line strength and to eliminate possible cracks, several housing parts have been improved by revising the injection molding and modifying the material PC/ASA.

Parts improved are:

- Rear cover
- Filter cover
- Side covers
- Bottom cover

This improvement is included in units with SN 1310 and higher.

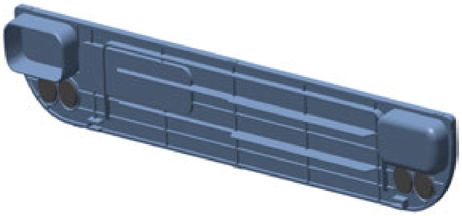
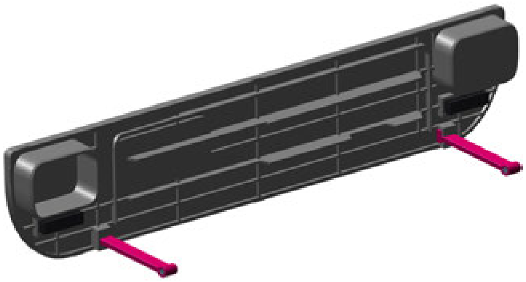
16 Hardware Revisions, Features and Compatibility

16.1 Component History Chart

This appendix brings together information found in other parts of the Service manual concerning hardware components that have changed over time. It also provides additional information, including associated HAMILTON-C1 serial numbers and the dates when changes were implemented.

Date (MM/YY-YY)	Serial Nr.	Description	Part	Part No	Chapter
09.2011	1001	First release	HAMILTON-C1	161001	Chapter 16.2
10.2011	1024	Driver board components repositioned, EMC robustness improved, new microphone for loudspeaker monitoring	Driver board	161500/01	Chapter 16.4.3
02.2012	n/a	Fan assembly replacement (PN161527 replaces PN161531/01)	Fan assembly	161527	Chapter 16.5.6
03.2012	1611	FFC cable length increased easier connection	FFC cable to display	161550/01	Chapter 16.5.3
03.2012	1611	Check valve assembly improved	Check valve assembly	161243	Chapter 16.3.2
03.2012	1615	Bottom cover modification	Bottom cover	161380	Chapter 16.6.2
03.2012	1865	Bottom mounting plate modified	Bottom mounting plate	161240	Chapter 16.6.1
03.2012	1865	Battery door fixation improved	Battery door	MSP161302	Chapter 16.6.6
03.2012	1615	Housing improved (Material modification)	Rear cover, filter cover, side covers, bottom cover	several	Chapter 16.6.4
05.2012	1711	Control board EMC robustness improved, firmware changed	Control Board	161502/04	Chapter 16.4.2
05.2012	1721	EMC robustness improved by introducing the ESD protection foil	ESD protection foil	161365	Chapter 16.7.6
05.2012	n/a	One MSP O2 Mixer assembly created for HAMILTON-C1/T1	O2 Mixer assembly	MSP161179	Chapter 16.3.6
06.2012	1865	Battery door fixation improved	Battery door	MSP161302	Chapter 16.6.6
07.2012	1927	Contact spring modified (indentations instead of hooks)	Contact spring (Driver board)	161287	Chapter 16.7.2
02.2012	1933	Contact force optimized	Contact spring (Mounting Plate)	161363 replaces 161332	Chapter 16.7.5
10.2012	2099	Battery with EMC shielding introduced	Battery	369108	Chapter 16.5.5
08.2012	2200	O2 cell cable connector improved	O2 cell cable	161567	Chapter 16.5.2
09.2012	2631	Rear cover improved (thread insert)	Rear cover	MSP161321/161284	Chapter 16.6.5
05.2013	2727	Tighter connection, lower O2 consumption	Expiratory valve (Cover and Membrane)	161175	Chapter 16.3.1
05.2013	2727	Glue for magnets changed (better adhesive properties)	Battery door	MSP161302	Chapter 16.6.6
05.2012	2743	ESM Shield housing introduced	ESM shield housing	MSP161338	Chapter 16.7.3
05.2013	2785	Tubing to Pexpvalve pressure sensor improved	Tubing	7249089	Chapter 16.7.7

16.6.6 Battery Door (MSP161314)

Battery door 161314 (MSP161314)			
Rev. Nr.	Description / Notes	Introduction	Compatibility
01	– First official release – Contains round magnets 	HAMILTON-C1 SN1000	HAMILTON-C1 < SN1815
02	– Fixation improved (rectangular magnets, retainer geometry changed) 	HAMILTON-C1 SN1865-SN2726	HAMILTON-C1 < SN2727
03	– The glue for the magnets was changed to improve the bond strength.	HAMILTON-C1 SN2727	To update the older units order MSP161314.For HAMILTON-C1 units < SN1815 the following parts are required due to compatibility issue: – Display Front Complete (MSP161290) – Bottom cover (MSP161380) – Mounting plate (MSP161240) Also contact Technical Support for upgrading the units < SN1815.

16.6.7 Device handle (MSP161505)

Device handle introduced for the HAMILTON-C1.

HAMILTON-C1 units with SN3173 and higher have the device handle included.

Order MSP161505 for upgrading your HAMILTON-C1 with the device handle.

Fig. 268 Device handle (MSP161505)

16.6.8 Mounting of the left side cover improved (Washer introduced)

A washer M4 (PN 409231) was added to improve the mounting of the left side cover.

All HAMILTON-C1 units with SN3263 and higher have the washer included.

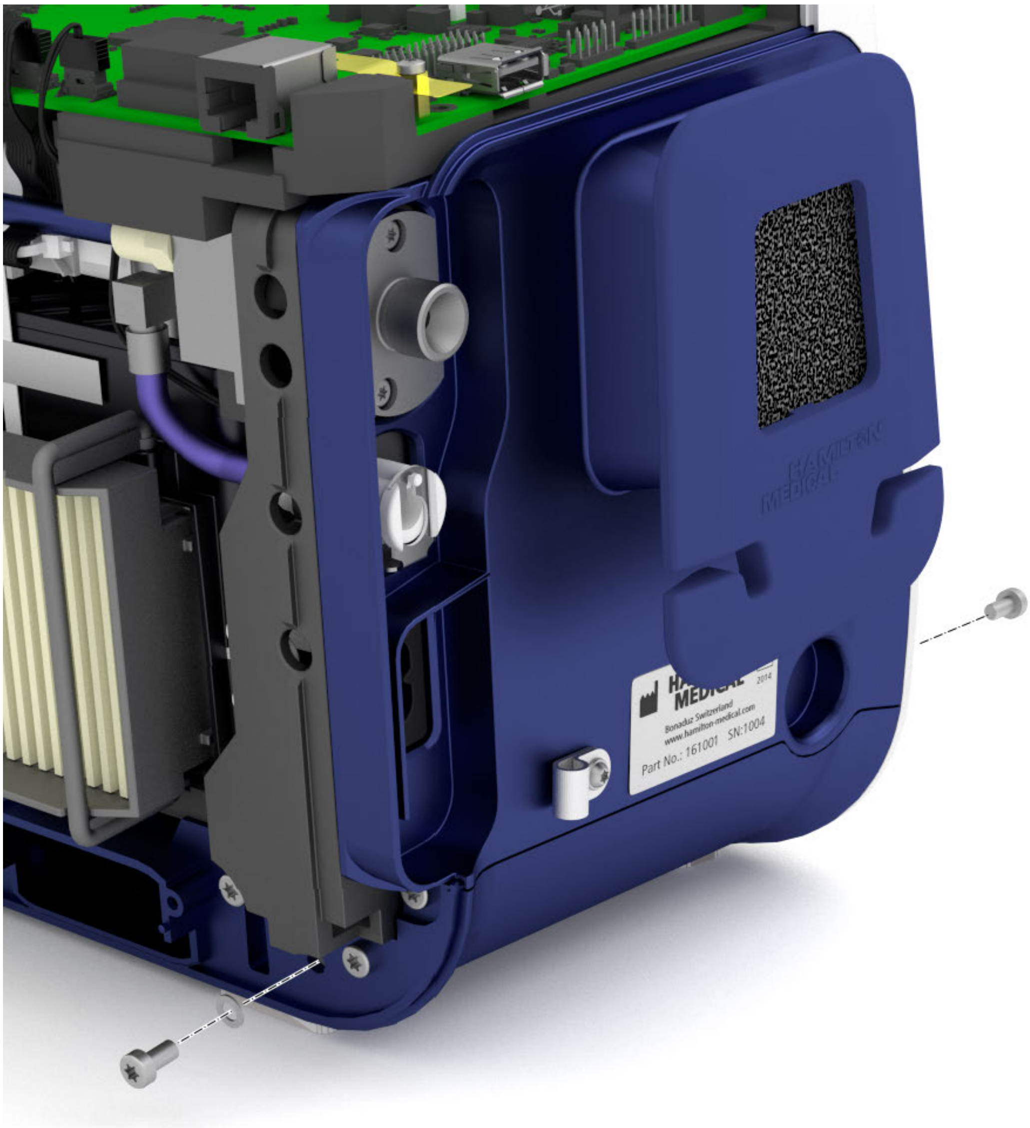


Fig. 269 Mounting of the left side cover improved (Washer introduced)

16.7 *Internal mounting components*

16.7.1 Option Board Bracket Improved (PN 161378 replaces PN 161319)

The option board bracket has been improved (PN161378 replaces PN161319) to ensure that the option board closes firmly.

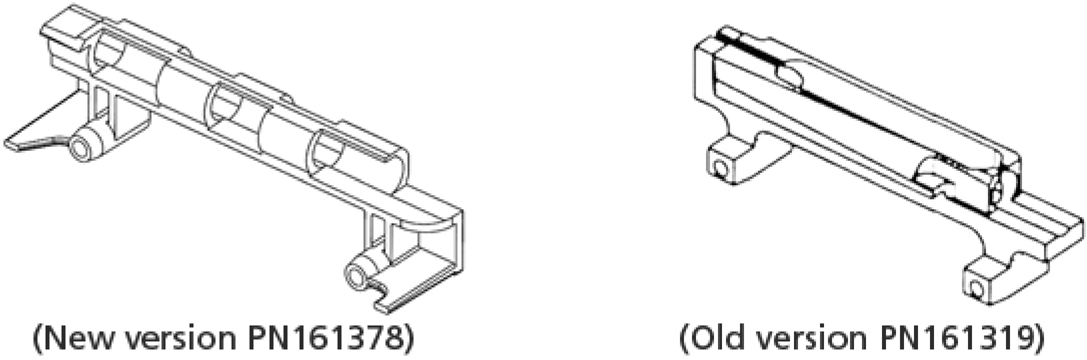


Fig. 270 Option board bracket

This improvement was introduced with HAMILTON-C1 SN3192.

16.7.2 Contact Spring (Driver Board) Modification (PN 161287)

The two hooks (A) on the contact spring (mounted on the driver board) can easily break off when reassembling the unit. The new contact spring uses indentations instead of hooks.

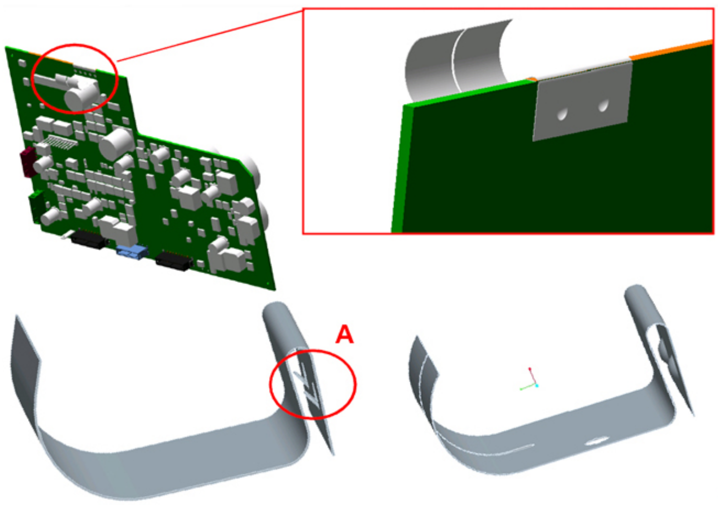


Fig. 271 Contact Spring

The new contact spring (left, PN 161795/02) was introduced with HAMILTON-C1 SN1927.

16.7.3 ESM Shield Housing (MSP161338)

To improve the robustness against ESD, the ESM shield housing was introduced.

This improvement is included with HAMILTON-C1 SN2743 and higher.

HAMILTON-C1 with lower serial numbers may be upgraded in areas with high electromagnetic fields (e.g. HAMILTON-C1 in closed vicinity to other electronic devices). The upgrade is not mandatory but recommended to be prepared for unexpected electromagnetic interferences.

This kit is available as **MSP161338** and is compatible with all HAMILTON-C1 units < SN2743.

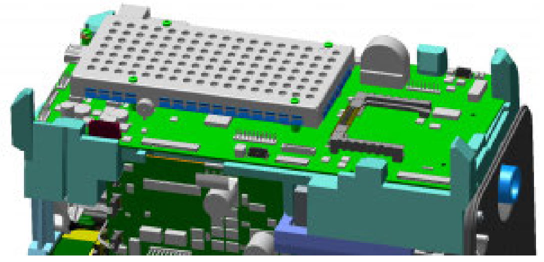


Fig. 272 ESM shield housing (MSP161338)

16.7.4 Display mounting system (PN 161916, PN 161917)

The display mounting system was improved by introducing two new display holders PN 161917 (A) and a new holder PN 161916 (B) for the display connector adapter (C).

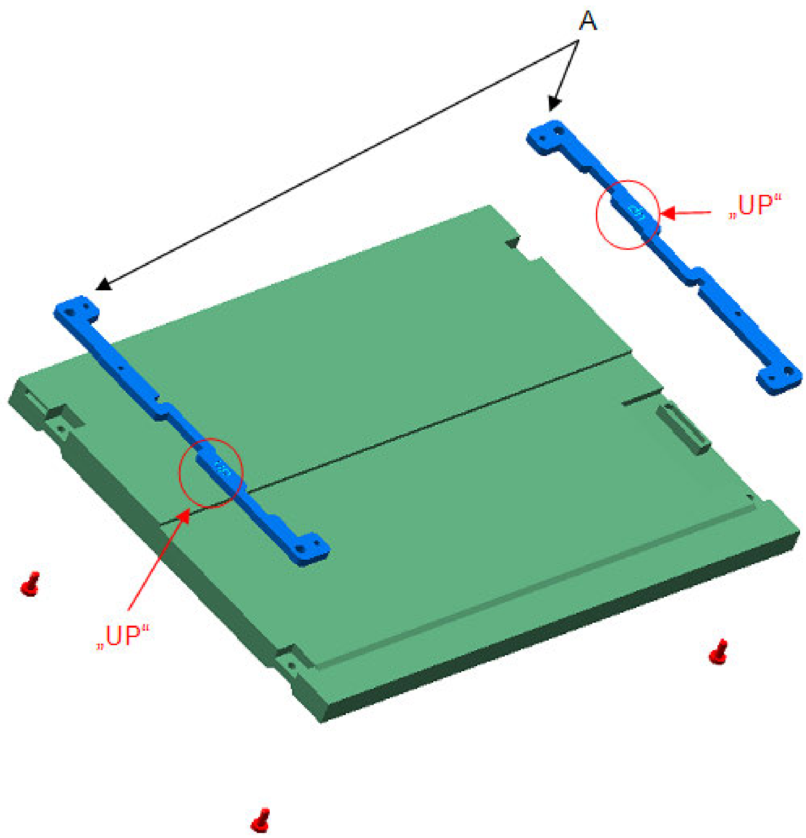


Fig. 273 Display holder (PN161917)

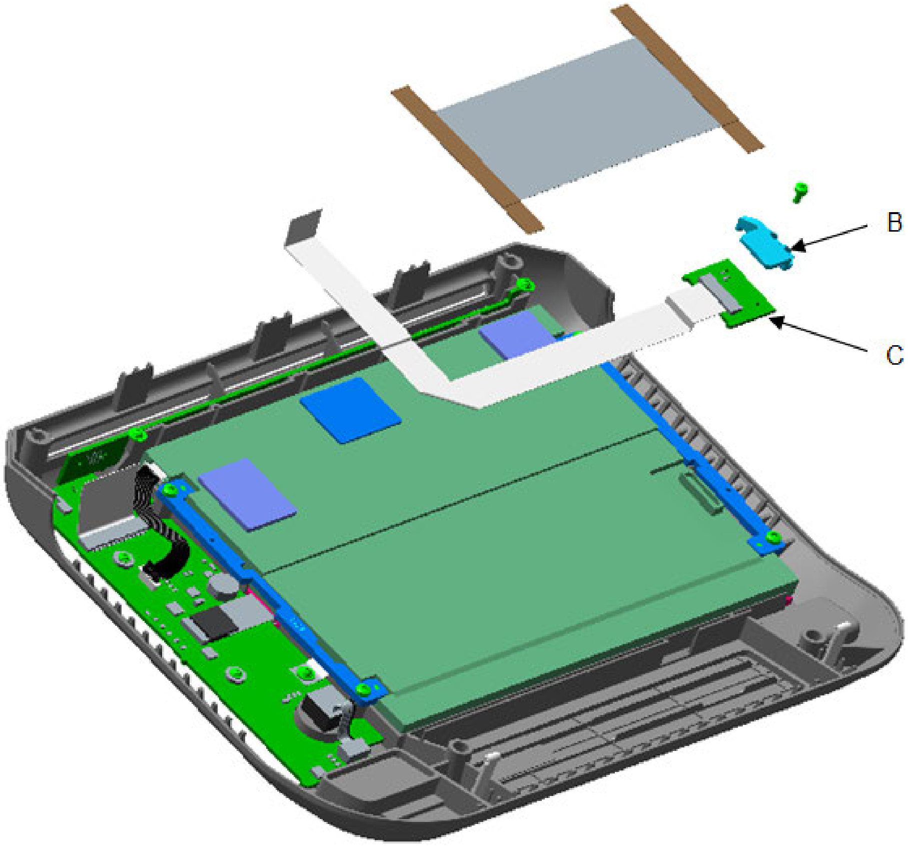


Fig. 274 Display connector adapter (PN161916)

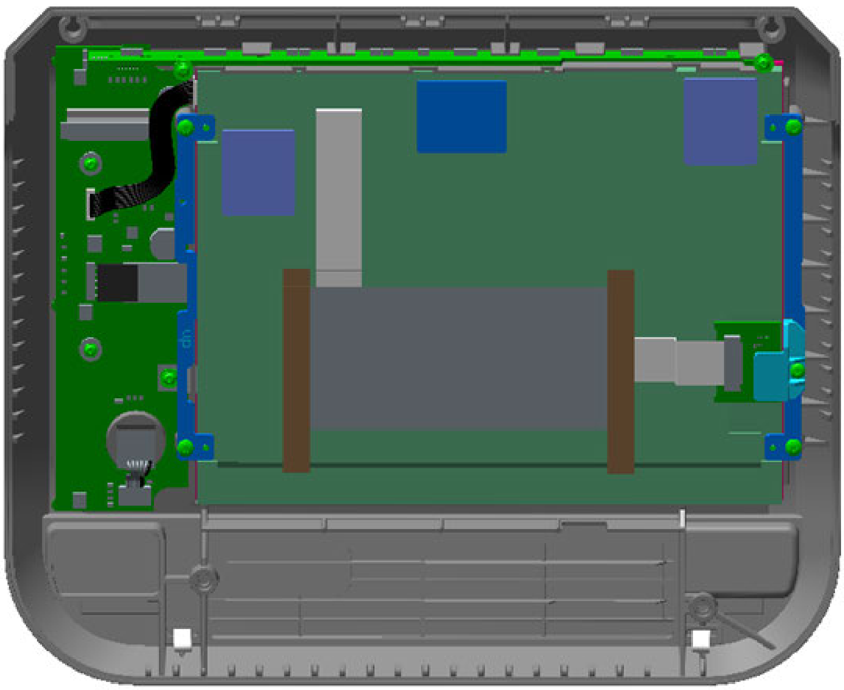
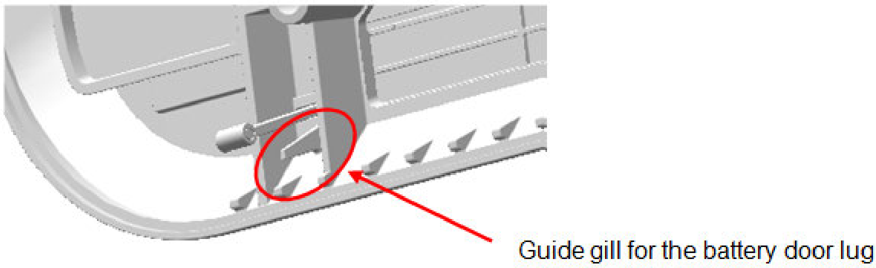


Fig. 275 Display mounting system

The new display mounting system wasintroduced with HAMILTON-C1 SN3663.

Compatibility:	
HAMILTON-C1 ≥SN3663 or with display front rev.07 or higher (identifiable with the guide gill)	

16.7.5 Contact Spring (Mounting Plate) (PN 161363 replaces PN 161332)

The contact force has been optimized by introducing a new contact spring PN 161363 to replace PN 161332.

This improvement is included with HAMILTON-C1 SN1933 and higher.

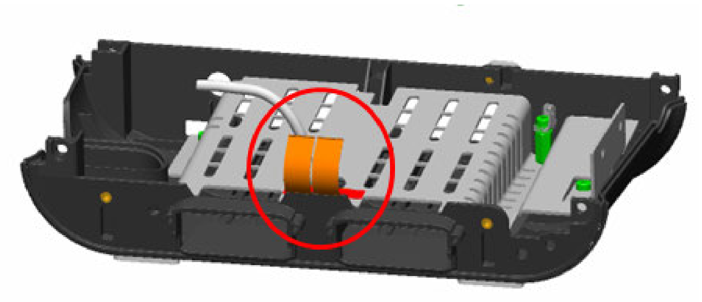


Fig. 276 Contact Spring (PN 161363)

16.7.6 ESD Protection Foil (PN 161365)

To improve the EMC robustness, the FFC cable to display has been secured with the ESD protection foil (PN 16135). The two Kapton tape stripes secure the ESD protection foil from unfolding.

This improvement is included with HAMILTON-C1 SN1721 and higher.

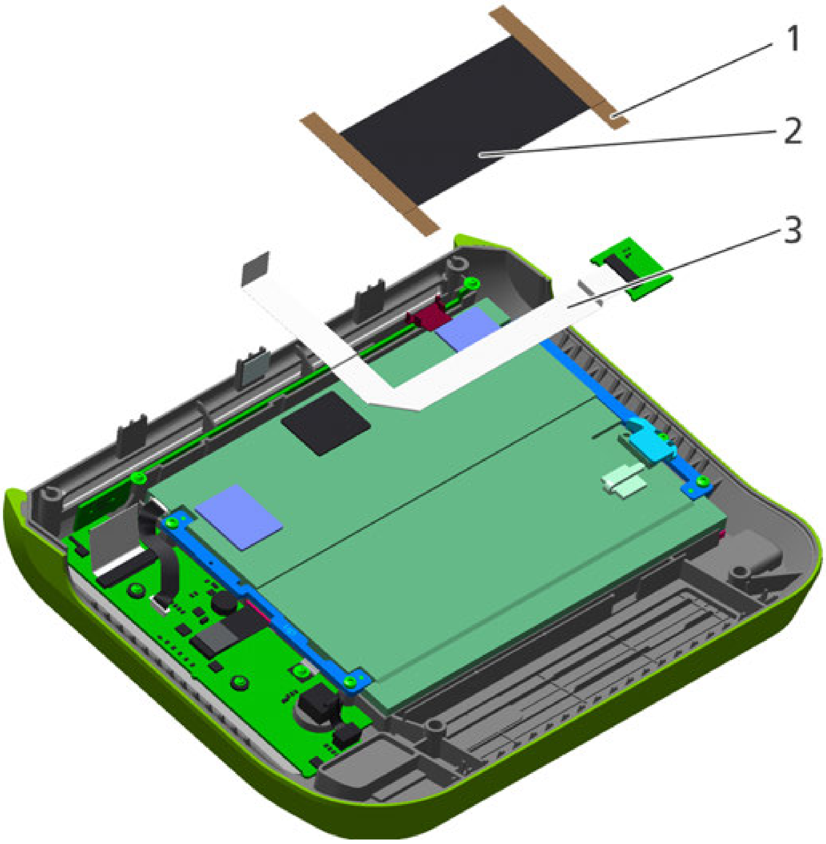


Fig. 277 ESD Protection Foil (PN 161365)

Legend:

1	Kapton Tape 9mm (PN 7279391)
2	ESD protection foil (PN 161365)
3	FFC cable to display (PN 161551)

16.7.7 Tubing to Pexpvalve pressure sensor improved

The tubing to Pexpvalve pressure sensor has been improved.

The tubing PN 7249089 (int. diameter 1.5, outer diameter 3.5mm) was replaced by PN 7249132 (int. diameter 1.0, outer diameter 4mm).

All HAMILTON-C1 units with SN2785 and higher have the new tubing included.

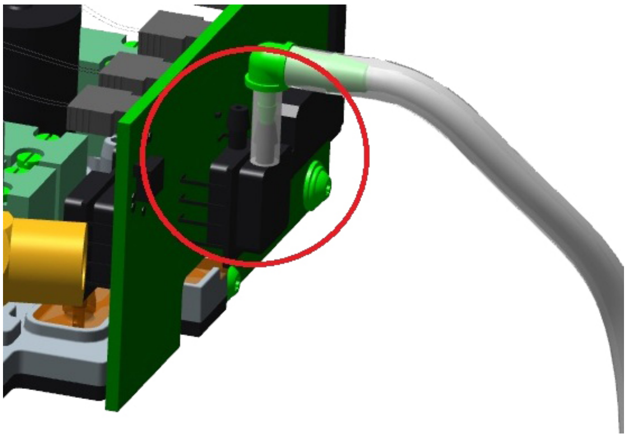


Fig. 278 Tubing to Pexpvalve pressure sensor

17 Ventilator Test Report

17.1 Ventilator Test Report

Customer Name:	....
Serial Number:	SN _ _ _ _
Date: (YYYY/MM/DD):	_ _ _ _ / _ _ / _ _
Service Manual Version:	624338/_ _

Installed SW Options		**Installed HW Options**
[ ] Trends/Loops	[ ] Neonatal	[ ] Communication board CO2, RS232, nurse call
[ ] NIV/NIV-ST	[ ] nCPAP/ nCPAP-PC	[ ] Communication board CO2, SPO2, nurse call
[ ] Intellisync	[ ]	[ ] Communication board CO2
[ ]	[ ]	[ ] ....

General Maintenance

[ ] Visual inspection of the device:

- All marks, symbols, and labels related to safety are complete and legible
- The device is not damaged or dirty (nor are the cables)

[ ] Fan filter cleaned or replaced?

[ ] O2 inlet filter replaced

[ ] HEPA filter replaced?

[ ] Blower module replaced (when blower timer =100%)

[ ] Battery replaced ? (whichever comes first):

- PN 369108 Rev. 00-03 when capacity < 3600mAh
- PN 369108 Rev. 04 when capacity < 5360mAh
- Battery age > 3Y
- Cycles > 400

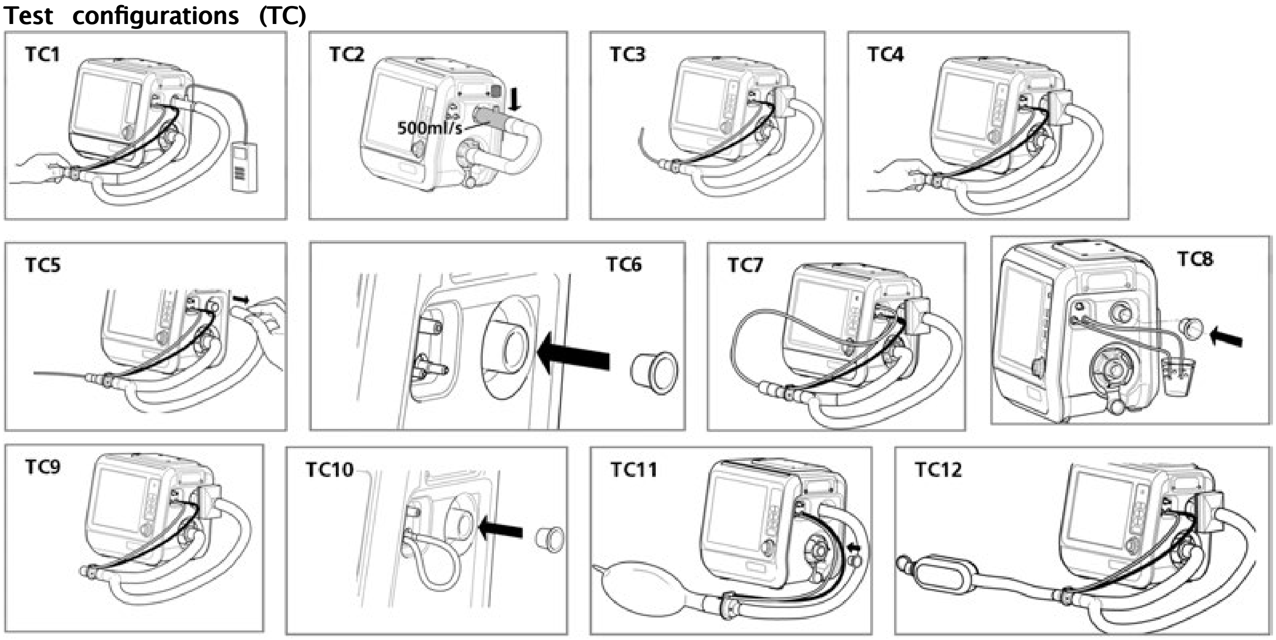
[ ] Battery calibrated (when cycles >100 OR %err >5)?

[ ] Oxygen cell replaced?

[ ] Air intake dust filter cleaned or replaced?

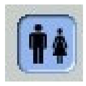
[ ] Technical state corresponds with components installed?

Test configurations (TC)



Special Tools		
Electrical Safety Tester	Device Type: ____________________	Serial Number: ______________
Flow Analyzer	Device Type: ____________________	Serial Number: ______________
Pressure Gauge	Device Type: ____________________	Serial Number: ______________

Ventilator Information		
Ventil. Info > RTC > **RTC** tab Chapter 9.7.8	**Page No 1401** Date and time **OK**? RTC status battery **OK**?	 OK [ ] OK [ ]
Ventil. Info > Technical State > **HW version** Chapter 9.7.4	**Page No 1102** HAMILTON-C1 O2 Cell Battery 1 (_ _ _cy._ _ _ _%err _ _ _ _ fcc.mAh)	**Revision** **Serial Number** _________ _________ _________ _________ _________ _________
Ventil. Info > Technical State > **SW version** Chapter 9.7.4	**Page No 1101** Software C1 OS (Operating System) FPGA menmon / Bootloader	**Revision** _________________________ _________________________ _________________________ _________________________
Ventilator Info > Service Timer > **Service Timer** Chapter 9.7.6	**Page No 1200** Operating hours (h) Service timer setting (h) Service timer reset	**Hours** _________ _________ Yes [ ] NO [ ]
Instrument State > Service Timer > **Blower Timer** Chapter 9.7.7	**Page No 1201** Blower timer (%)	 _________

Adjustments / Calibrations (ADULT/PED.)			
Tests/Calibration > Adjustment/Calibration > Calibration Tab > **Touchscreen** Chapter 9.8.4	**Page No 2321** Is the Touch Screen Calibration **OK**?	OK [ ]	
Tests/Calibration > Adjustment/Calibration > Calibration Tab > **Pressure** Chapter 9.8.5	**Page No 2341** Pressure sensor gain value	**Gain** _ _ _ _.	**TC1**
Tests/Calibration > Adjustment/Calibration > Calibration Tab > **Exp. valve** Chapter 9.8.6	**Page No 2343** Is 'Calibration completed' displayed on the screen?	OK [ ] Voffset: _ _ _ _ _	**TC2**
Tests/Calibration > Adjustment/Calibration > Calibration Tab > **O2 Cell Button** Chapter 9.8.7	**Page No 2346** Is 'Oxygen Cell Calibration OK' displayed on the screen?	OK [ ]	**TC9**
Tests/Calibration > Adjustment/Calibration > **Flow sensor** Chapter 9.8.8	**Page No 2347** Is 'flow sensor calib ended OK' displayed on the screen?	OK [ ]	**TC9**

Component Tests (ADULT/PED.)			
Tests/Calib > Comp test > Electronics > **Alarm system** Chapter 9.9.2.1	**Page No 2102** Is the loudspeaker **ON**? Is the yellow lamp **ON**? Is the red lamp **ON** (for HAMILTON-C1 <SN6000)? Is the red lamp **blinking** for (HAMILTON-C1 ≥SN6000)? Is the loudspeaker loudness (range 1-10) **OK**?	 OK [ ] OK [ ] OK [ ] OK [ ] OK [ ]	
Tests/Calib > Comp test > Electronics > **Alr. Mon. 1** (10/10) Chapter 9.9.2.2	**Page No 2113** Is 'Test completed' shown on the screen?	 OK [ ]	
Tests/Calib > Comp test > Electronics > **Alr. Mon. 2** Chapter 9.9.2.3	**Page No 2114** Did the alarm light blink? Did the buzzer sound?	 OK [ ] OK [ ]	
Tests/Calib > Comp test > **User I/F** Chapter 9.9.3	**Page No 2115** Is the P+T knob OK? Are the hardkeys + LED's OK? Are the hardkey combinations **OK**? Is the switching of Day/Night brightness **OK**?	 OK [ ] OK [ ] OK [ ] OK [ ]	
Tests/Calib > Comp test > Pneumatics 1 > **Binary valve** Chapter 9.9.4.1	**Page No 2106** 1) Is the autozero Pvent_monitor (Operation) **OK**? 2) Is the autozero Pvent_monitor (Autozero) **OK**? 3) Is the prox. autozero valve (Operation) **OK**? 4) Is the prox. autozero valve (Autozero) **OK**? 5) Is the dist. autozero valve (Operation) **OK**? 6) Is the dist. autozero valve (Autozero) **OK**?	 OK [ ] OK [ ] OK [ ] OK [ ] OK [ ] OK [ ]	**TC3**
Tests/Calib > Comp test > Pneumatics 1 > **Autozero** Chapter 9.9.4.2	**Page No 2109** Is the pressure sensor Paw and flow sensor Qaw **OK**? Is the Pvent_monitor and Pvent_control **OK**?	 OK [ ] OK [ ]	**TC4**

Component Tests (ADULT/PED.)			
Tests/Calib > Comp Test > Pneumatics 1 > **Blower flow** Chapter 9.9.4.3	**Page No 2104** Is the blower speed at 800 ml/s **OK**? Is the blower speed at 1500 ml/s **OK**? Is the blower speed at 2100 ml/s **OK**? Is the blower speed at 2800 ml/s **OK**? Is the blower speed at 3500 ml/s **OK**?	OK [ ] OK [ ] OK [ ] OK [ ] OK [ ]	**TC5**
Tests/Calib > Comp test > Pneumatics 1 > **Blower pressure**	**Page No 2105** Is the blower pressure at 15mbar **OK**? Is the blower pressure at 25mbar **OK**? Is the blower pressure at 35mbar **OK**? Is the blower pressure at 50mbar **OK**?	OK [ ] OK [ ] OK [ ] OK [ ]	**TC6**
Tests/Calib >Comp test >Pneumatics 1 > **Exp. valve**	**Page No 211** Is the Pexpvalve test **OK**? Is the Pressure test **OK**?	OK [ ] OK [ ]	**TC6** **TC4**
Tests/Calib > Comp test > Pneumatics 2 > **O2 input** Chapter 9.9.5.1	**Page No 2112** Is the flow test **OK**? Is the leakage test **OK**?	OK [ ] OK [ ]	**TC5** **HPO**
Tests/Calib > Comp test > Pneumatics 2 > **Neb. valve** Chapter 9.9.5.2	**Page No 2116** Is the nebulizer valve off test **OK**? Is the nebulizer valve on test **OK**?	OK [ ] OK [ ]	**TC7** **HPO**
Tests/Calib > Comp test > Pneumatics 2 > **Prox. Test** Chapter 9.9.5.3	**Page No 2110** Is the rinse flow test **OK**? Is the proximal pressure test **OK**? Is the proximal flow test **OK**? Is the rinse tank test **OK**?	OK [ ] OK [ ] OK [ ] OK [ ]	**TC8** **TC3** **TC9** **TC10**
Tests/Calib > Comp test > Pneumatics 2 > **Check valve** Chapter 9.9.5.4	**Page No 2118** for HAMILTON-C1 units < SN6000 Is the check valve test OK? for HAMILTON-C1 units ≥ SN6000 Is the Tightness test OK? Is the obstruction valve active test OK?	n/a [ ] OK [ ] n/a [ ] OK [ ] OK [ ]	**TC11**
Tests/Calib > Comp test > Pneumatics 2 > **Air entry** Chapter 9.9.5.5	**Page No 2117** Is the default HEPA filter test (Flow 0) **OK**? Is the default HEPA filter test (Flow 60) **OK**? Is the obstructed filter test **OK**?	OK [ ] OK [ ] OK [ ]	**TC5**

System Tests (ADULT/PED.)			
Tests/Calib > System test > **Pressure** Chapter 9.10.2	**Page No 2201** Pinsp=5mbar-> are all the values within tolerance Pinsp=25mbar-> are all the values within tolerance Pinsp=50mbar-> are all the values within tolerance	OK [ ] OK [ ] OK [ ]	**TC4**
Tests/Calib > System test > **Flow** Chapter 9.10.3	**Page No 2202** Qvent= 9 l/min -> are all the values within tolerance Qvent= 18 l/min -> are all the values within tolerance Qvent= 27 l/min -> are all the values within tolerance	OK [ ] OK [ ] OK [ ]	**TC12**
Tests/Calib > System test > **O2 mixer** Chapter 9.10.4	**Page No 2203** Qvent = 18 l/min FiO2 = 21% -> are all the values within tolerance FiO2 = 61% -> are all the values within tolerance FiO2 = 90% -> are all the values within tolerance	OK [ ] OK [ ] OK [ ] OK [ ]	**TC9** **HPO**
Tests/Calib > System test > **Tightness** Chapter 9.10.5	**Page No 2204** Is the tightness tubing test **OK**?	OK [ ]	**TC4**
Tests/Calib > System test > **Alarming** Chapter 9.10.6	**Page No 2205** Is the alarm High test **OK**? Is the alarm Medium test **OK**? Is the alarm Low test **OK**? Is the alarm priority test **OK**?	OK [ ] OK [ ] OK [ ] OK [ ]	

for HAMILTON-C1 units ≥ SN6000			
Adjustments / Calibrations (NEONATAL)			
Tests/Calibration > Adjustment/Calibration > Calibration Tab > **Exp. valve** Chapter 9.11.2	**Page No 2343** Is 'Calibration completed' displayed on the screen?	OK [ ] Voffset: _ _ _ _ _	**TC2**
Tests/Calibration > Adjustment/Calibration > **Flow sensor** Chapter 9.8.8	**Page No 2347** Is 'flow sensor calib ended OK' displayed on the screen?	OK [ ]	

for HAMILTON-C1 units ≥ SN6000			
Component Tests (NEONATAL)			
Tests/Calib > Comp test > Pneumatics 1 > **Exp. valve** Chapter 9.12.2	**Page No 2111** Is the Pexpvalve test **OK**? Is the Pressure test **OK**?	OK [ ] OK [ ]	**TC6** **TC4n**

General Tests Chapter 9.7.4			
Service Manual > General test's > **AC-Battery test**	Is the AC -Battery test **OK**?	OK [ ]	
Service Manual > General test's > **Power loss**	Is the power (battery) loss test **OK**?	OK [ ]	
Service Manual > General test's > **Fan Check**	Does the fan blow into the ventilator?	OK [ ] not required [ ] *	
Service Manual > General test's > **Exp. prop.valve exhaust tubing check**	Does the ventilator alarm with "Exhalation obstructed"?	OK [ ] not required [ ] *	
Service Manual > General test's > **Nebulizer tube / connection tightness check**	Is the nebulizer tube / connection tight?	OK [ ]	
Service Manual > General test's > **USB port check**	Is the USB port check test **OK**?	OK [ ]	
Service Manual > **CO2 Sensor Accuracy check** Chapter 9.17	Is the CO2 accuracy **OK**?	OK [ ] not available [ ]	
Service Manual > **SPO2 Sensor check** Chapter 9.18	for HAMILTON-C1 units ≥ SN6000 only Is the SPO2 check **OK**?	OK [ ] not available [ ]	
Service Manual > **Nurse call functional check** Chapter 9.20	Is the nurse call function **OK**?	OK [ ] not available [ ]	
Service Manual > Communication interface RS232 functional test Chapter 9.19	Is the RS232 test **OK**?	OK [ ] not available [ ]	

*Test required only after reassembly

Preoperational checks Chapter 9.21			
Operator's Manual Chapter 2.9 **About the batteries**	Is the battery charge indicator green **OK**?	OK [ ]	
Operator's Manual Chapter 3.2 **Running the preoperational check**	**Tests, calibrations, and utilities**		
	Is the tightness test **OK**?	OK [ ]	
	Is the flow sensor calibration **OK**?	OK [ ]	
	Is the O2 cell calibration **OK**?	OK [ ]	
Operator's Manual Chapter 3.5 **Alarm Tests**	**Alarm Tests**		
	Is the **High Pressure** alarm test OK?	OK [ ]	
	Is the **Low minute volume** alarm test OK?	OK [ ]	
	Is the **Low Oxygen / Oxygen supply failed** alarm test OK?	OK [ ]	
	Is the **Disconnection on patient side** alarm test OK?	OK [ ]	
	Is the **Loss of external power** alarm test OK?	OK [ ]	
	Is the **Exhalation obstructed** alarm test OK?	OK [ ]	
	Is the **Apnea** alarm test OK?	OK [ ]	

Electrical SafetyTest				
Service Manual Section 8 **Electrical Safety Test**	All measured values must be documented using the measurement process and are considered reference values. Should the measured values measured during the next maintenance cycle be within 90 to 100% of the permissible values, the reference values are to be used to evaluate the ventilators electrical safety.	**Results**		
Chapter 8.1	Electrical Safety Test **OK**?	OK [ ]	Not OK [ ]	

Remarks:

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Tests and calibrations performed:

Date: (YYYY/MM/DD):	First- and Surname:	Signature:
_ _ _ _ / _ _ / _ _	....	....

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18 Environmental requirements

18.1 Environmental requirements

Temperature	Operating: 5°C to 40°C (41°F to 104°F)	
	Storage: –20°C to 60°C (–4°F to 140°F), in original packaging –15°C to 60°C (5°F to 140°F) otherwise	
Altitude	–650 to 4000 (–2132 to 13,120 ft) above sea level	
Relative humidity	Operating/storage:10% to 95%, noncondensing	
Water protection	IP21	

19 Glossary

19.1 Definitions of Expression

This glossary offers definitions of expressions not included, or extended definitions of expressions briefly included, in the glossary of the HAMILTON-C1 Operator's Manual. It should be used together with the glossary in this guide.

Activate	An action on the touchscreen or the P+T knob to choose a function or action.
Air	Source used in the HAMILTON-C1
Alarm buffer	An area of memory containing details of the twenty most recent alarms. The most recent six of the twenty alarms can be accessed by activating the alarm symbol at the bottom left of the screen when the HAMILTON-C1 is in normal operating mode.
Alarm lamp	Indicates alarm conditions – Red - high priority alarms and technical faults – Yellow - Medium and Low Priority Alarms
Alarm status indicator	An area at the bottom of the touchscreen of the HAMILTON-C1 which displays the alarm status and power status.
Ambient state	A state that the HAMILTON-C1 uses when it cannot function normally because of an internal or external fault. The ambient state is often associated with *Technical Faults*, but can also be caused by such things as a air or oxygen supply. It is always accompanied by a high-priority patient alarm, sounded by the loudspeaker or *buzzer*.
Ambient state gas flow	If the HAMILTON-C1 is in Ambient State, the patient breathes unassisted.
Analog - digital conversion (ADC)	Converts an analog signal to a digitized signal.
Audible alarm	An alarm sounded when there is a Technical Fault or other error condition. An audible alarm is generated. A buzzer is used as a backup if the audible alarm through the loudspeaker does not function.
Autozero	A method to automatically adjust for electronic drift of a device or a sensor due to temperature and environmental conditions.
Autozero valves	See *flow sensor autozero valves*
Backlight	Lights used to help illuminate the screen.
Basic input output system (BIOS)	The basic input output system for the central processing unit (CPU). This is held on an EPROM or EEPROM mounted on the ESM.
Basket	An accessory located on the back of the HAMILTON-C1 trolley.
Battery charger	Circuits located in the driver board that resupply power to the primary and optional battery packs when mains power is available. – Primary battery pack - 14.4 VDC maximum charging voltage. – Optional battery pack - 14.4 VDC maximum charging voltage. Both battery packs can also be charged using an external charger.
Breathing circuit	A patient breathing circuit carries the Air/oxygen mixture to the patient and carries the expired (exhaust) air from the patient. It may include tubings, mask, Iinspiratory flow filter, slow sensor, nebulizer jar, expiration valve cover and membrane.
Buzzer	A piezoelectric device mounted on the control board, used by the HAMILTON-C1 to sound some alarms. It functions independently of the loudspeaker and the power supply, and typically indicates a high-priority Technical Fault that causes the HAMILTON-C1 to go into the ambient state.
Check valve	A valve used to restrict gas flow to only one direction.
Communication interface	The Ethernet port on the rear of the HAMILTON-C1.
Configuration menu	A screen used to select ventilation and other operation parameters of the HAMILTON-C1.
De-activate	An action on the touchscreen or the P+T knob to clear the selection of a function or action.

De-select	An action on the touchscreen or the P+T knob to clear the selection of a function or action.
Digital - Analog Converter (DAC)	Converts a digital signal to an analog signal.
DISS	Diameter index safety standard, a standard connector used for connection of oxygen to the HAMILTON-C1, designed so the oxygen supply cannot be connected incorrectly.
dP flow sensor	Measures the differential pressure (pressure difference) across the flow sensor. The measurement is performed by a pressure sensor inside the HAMILTON-C1, and is used to calculate airway gas flow.
EEPROM	Electrically Erasable Programmable Read Only Memory
Electrical Safety Tests	A set of electrical test's used to check the safety of a device.
Electrostatic discharge (ESD)	Electrostatic Discharge
Emergency Buzzer Alarm	**Note**: The buzzer makes a high frequency sound. It functions independently of the loudspeaker. An alarm that sounds when a Technical Fault occurs that is serious enough to cause the HAMILTON-C1 to switch to ambient mode. In ambient mode, all valves switch to their unpowered position, and the HAMILTON-C1 is completely passive.
ESM Board	**E**mbedded **S**ystem **M**odule. A PCB containing the processor
Event Log	A record of most activity in the HAMILTON-C1. This includes user actions and internal activity such as: – Alarms – Technical faults – Controls settings – Switch-on times The Event Log always holds a maximum of 1,000 events. Turning the HAMILTON-C1 OFF and ON, does not erase the storage of the Event Log. You can access a subset of the event log suited for clinical use by activating the Event Log symbol in the monitoring menu in normal operating mode.
Expiration	The act of the patient breathing out.
Expiratory valve	A valve controlling pressure in the patient circuit, enabling the patient to exhale and the HAMILTON-C1 to maintain PEEP.
Expiratory valve block connection	The plastic connector used to attach the patient breathing circuit on the side of the HAMILTON-C1.
Fan filter	A filter used to capture dust from the cooling fan.
Flow sensor AIR (Qvent)	Measures the flow of the air/oxygen mixture into the patient breathing circuit.
Flow restrictor	A device that restricts flow of a gas.
Front panel keys	Control buttons at the front panel.
Front panel	Part of the HAMILTON-C1 containing the user interface for interaction with the ventilator; LCD display and hard keys.
Galvanic oxygen cell	See *oxygen Cell*
Gas Inlet	Connection for the inlet of oxygen to the HAMILTON-C1.
Gold Caps	One provides power for emergency buzzer alarm for 2 minutes and one for the real time clock for 3 months when no power source is provided from mains power or battery.
Ground (GND)	Refers to the 0 electrical potential of a device.
HAMILTON-C1	Product name.
HEPA	High efficiency particle air filter
Hot Swappable	A term used to indicate a device can be disconnected without removing power.
HPO	High pressure oxygen
Inspiration	The act of the patient breathing in.

Instrument report	A record of the installed software and hardware. Includes: -Hardware state -Software state -Timer state -Technical state of components with part number, revision and serial number -Calibration values. The act of the patient breathing in.
Internal Temperature	The HAMILTON-C1 contains devices to measure the internal operating temperatures.
LED (Light Emitting Diode)	Light Emitting Diode
LPO	Low pressure oxygen
Loudspeaker	A speaker used to indicate alarm conditions from the ventilation unit.
Main Power Switch	Powers the HAMILTON-C1 ON and OFF.
Metron EST Tester	Automated device used to perform the electrical safety test.
Microphone	In the HAMILTON-C1, a microphone is positioned near the loudspeaker as a feedback circuit to determine that the loudspeaker is operating properly.
Nebulizer connection	Connection on the side of the HAMILTON-C1 to attach tubing for the Nebulizer output.
Nebulizer valve	Valve used to control the flow of oxygen to the nebulizer jar.
NIST	Noninterchangeable screw thread, a standard connector used for connection of oxygen to the HAMILTON-C1, designed so the oxygen supply cannot be connected incorrectly.
NVG	Night Vision Goggle Mode. A mode to dim the display and alarm lamp where night vision goggle is used.
O2 cell Calibration	A procedure, which supplies a controlled flow of Air, oxygen and Air/oxygen mixture to the oxygen cell for calibration.
Orifice flow restrictor	A device with an fixed opening which restricts the flow of a gas.
Orifice tube	Used in the test configuration to perform adjustments in the Service Software.
oxygen cell	A small, replaceable, plastic unit used by the HAMILTON-C1 to measure oxygen concentration. (Also known as an O2 Cell.) The oxygen cell reacts to the presence of oxygen, producing a voltage output in proportion to the oxygen concentration. The oxygen cell must be replaced after a period of service, when it can no longer be calibrated. Typically, about one year.
Pambient	A sensor, which measures the ambient pressure or the room pressure.
Patient alarms	An alarm indicating that there is a problem or potential problem in ventilating the patient. There are three levels of patient alarms: high, medium, and low. They are indicated by beeps on the loudspeaker, messages on the display and the alarm lamp.
Patient breathing circuit	See Breathing circuit
Paw	A sensor which measures the pressure at the proximal side of the flow sensor.
PCB	Printed Circuit Board
Pfilter	A sensor which measures the pressure after the HEPA filter; used to indicate if the HEPA filter needs to be replaced.
Pflowsensor	A sensor, which measures the differential pressure across the patient airway flow sensor.
Platform C	Product family (HAMILTON-C1,HAMILTON-C1, HAMILTON-MR1, HAMILTON-C2, HAMILTON-C3)
Portable tank	Oxygen tanks used for supply in a portable environment when the facility source is not available.
Press and Turn knob (P+T)	A button on the front of the front panel used to select and activate screen functions.

Press and Turn Encoder (P+T Encoder)	An electrical device, which provides input signals for control of screen functions.
Pressure gauge	A mechanical device used to measure gas pressure.
Pressure regulator	A device that regulates the pressure and restricts the flow of a gas.
Pressure sensor assembly	Provides components for pressure measurments used to monitor ventilation.
Preventive maintenance (PM)	A term used for periodic maintenance of a device with specific planned tasks and items to check, adjust and replace.
Principal gas flow	The main gas flow through the HAMILTON-C1 from the HEPA filter for air and the oxygen inlets to the patient, and then from the patient through the expiratory valve.
Pvent_control	A sensor, which measures the pressure at the patient outlet, used for controlling.
Pvent_monitor	A sensor, which measures the pressure at the patient outlet, used for monitoring.
Qvent flow sensor	Used to measure the Air/oxygen flow in the patient breathing circuit
Rinse flow	A very small, continuous flow of gas through both the blue (patient side) and clear (ventilator side) flow sensor tubes to the flow sensor. The flow minimizes the possibility of tube blockage, and hinders the potential migration of bacteria and viruses from the patient's expired gases through the tubes towards the pressure sensors inside the ventilator.
Safety mode	An emergency state that ensures a basic minute ventilation while giving the user time for corrective actions in case of some technical fault alarms. The default inspiratory pressure is maintained, the expiratory valve opens as needed to switch system pressure levels between PEEP and inspiratory pressure, and patient sensing is nonfunctional.
Select	An action on the touchscreen or the P+T knob to choose a function or action.
Smart battery pack	Li-Ion battery, hot swappable, which monitors and communicates the battery condition.
SOC	State of charge
Service Software	The software used to perform test's, adjustments and calibrations of the HAMILTON-C1. Also enables viewing and exporting data from the Event Log.
	 The HAMILTON-C1 cannot be used for patient ventilation when in Service Software Mode.
Service Software Mode	The operational status of the HAMILTON-C1 when in the Service Software.
T-Fitting	A type of tubing connector in the shape of a T.
Technical Events	A very minor fault or event recorded by the HAMILTON-C1 in the *Event Log* for use only by software developers.
Technical Faults	An alarm condition indicating a major malfunction of the HAMILTON-C1. (This contrasts with an alarm, that indicates a problem with the status of a patient.) Technical Faults are intended to alert users and engineers of the need for intervention, and are recorded in the *Event Log*.
Test configuration (TC)	A particular configuration of devices and tubings use to perform the test's/calibrations in the service software.
Touchscreen	An interaction method where the LCD display screen can be touched with a finger to activate or select a function.
Trolley	A part of the HAMILTON-C1 on which the ventilator is mounted for transport within the customer location.
Update	An update is an improvement to an existing function. An update normally involves only software. A software update is generally a revision number increment in a digit after the decimal point: for example, from 3.2 to 3.3.
Upgrade	An upgrade is the addition of new functions to a device. There are three ways to perform an upgrade: – Add a hardware item that offers additional functions – Upgrade to a higher software revision indicated by a higher value before the decimal point: for example 01.03 to 02.00 – Upgrade to a higher type of software

Variable orifice membrance	A variable flow restrictor as used in the patient flow sensor.
Ventilation unit control board	The HAMILTON-C1 main processor. An assembly containing the microprocessor that controls both the user interface and high-level aspects of ventilation, such as tidal volume, minute volume and rate.
Y-Fitting	A type of tubing connector in the shape of a Y.

19.2 Alarm Code 100 000

19.2.1 100000 Alarm Code - Patient alarms

id number	CSystemConfiguration id	enGB text value
132001	paBM_pawPressureLow	Loss of PEEP
132002	paBM_pawTubing	Check flow sensor tubing
132003	paBM_qawFlowSensorTubing	Check flow sensor
132004	paBM_qawFlowSensorn/a	Check flow sensor
132005	paBM_O2SensorDefect	O2 cell defective
132006	paBM_O2Sensorn/a	O2 cell n/a
132007	paBM_O2SensorInvalid	O2 cell not system compatible
132008	paBM_O2SensorCalibrationNeeded	O2 cell calibration needed
132010	paBM_CO2Sensorn/a	CO2 sensor disconnected
132011	paBM_CO2SensorDefect	CO2 sensor defect
132012	paBM_CO2SensorOverTemperature	CO2 sensor over temperature
132013	paBM_CO2SensorWarmUp	CO2 sensor warmup
132014	paBM_wrongFlowsensor	Wrong flow sensor
132015	paBM_FlowSensorCalibrationNeeded	Flow sensor calibration needed
132016	paBM_CO2CheckAirwayAdapter	Check CO2 airway adapter
132017	paBM_CO2CheckSamplingLine	Check CO2 sampling line
132018	paBM_SpO2SensorPatientDisconnect	SpO2: patient disconnected
132019	paBM_SpO2SensorProben/a	SpO2: probe n/a
132020	paBM_SpO2SensorLowPerfusionIndex	SpO2: low perfusion index
132021	paBM_SpO2SensorLightInterference	SpO2: light interference
132022	paBM_SpO2SensorAdapterError	SpO2: sensor error
132023	paBM_SpO2SensorAdaptern/a	SpO2: adapter n/a
132024	paBM_CircuitCalibrationNeeded	Circuit calibration needed
133001	paBPG_apnea	n/a
133002	paBPG_volumeLimitReached	Inspiratory volume limitation
133003	paBPG_pressureLimitReached	High pressure
141001	paVMC_pressureLimitation	Pressure limitation
141002	paVMC_VThigh	Vt high
141003	paVMC_VTlow	Vt low
141004	paVMC_expMinVolHigh	High minute volume
141005	paVMC_expMinVolLow	Low minute volume
141006	paVMC_fTotalHigh	High frequency
141007	paVMC_fTotalLow	Low frequency
141008	paVMC_oxygenHigh	High oxygen
141009	paVMC_oxygenLow	Low oxygen
141010	paVMC_apnea	Apnea
141011	paVMC_apneaVentilationEnd	Apnea ventilation ended
141012	paVMC_apneaVentilation	Apnea ventilation
141013	paVMC_highPressureDuringSigh	High pressure during sigh
141014	paVMC_turnFlowSensor	Turn the flow sensor
141016	paVMC_disconnectionVentilator	Disconnection on ventilator side
141017	paVMC_disconnectionPatient	Disconnection on patient side
141018	paVMC_exhalationObstructed	Exhalation obstructed
141019	paVMC_IRV	IRV
141020	paVMC_ASVunableToReachTarget	ASV: Cannot meet target
141021	paVMC_ASVplimitChanged	Pressure limit has changed
141022	paVMC_instrumentMaybeContaminated	Instrument may be contaminated

141023	paVMC_sensorFailMode	External flow sensor failed
141024	paVMC_pressureLow	Low pressure
141025	paVMC_PetCO2High	PetCO2 high
141026	paVMC_PetCO2Low	PetCO2 low
141027	paVMC_suctioningManoeuvre	Suctioning maneuver
141028	paVMC_performanceLimitedByHighAltitude	Performance limited by high altitude
141029	paVMC_SpO2High	High SpO2
141030	paVMC_SpO2Low_MediumPrio	Low SpO2
141031	paVMC_PulseRateHigh	High pulse
141032	paVMC_PulseRateLow	Low pulse
141033	paVMC_PerfusionIndexHigh	High PI
141034	paVMC_PerfusionIndexLow	Low PI
141035	paVMC_SpHbHigh	High SpHb
141036	paVMC_SpHbLow	Low SpHb
141037	paVMC_SpCOHigh	High SpCO
141038	paVMC_SpCOLow	Low SpCO
141039	paVMC_SpMetHigh	High SpMet
141040	paVMC_SpMetLow	Low SpMet
141041	paVMC_SpO2Low_HighPrio	Low SpO2
141043	paVMC_VentilationAdjustmentOff	Ventilation adjustment OFF
141044	paVMC_OxygenationAdjustmentOff	Oxygenation adjustment OFF
141045	paVMC_VentilationControllerUpperLimitReached	Ventilation Controller at limit
141046	paVMC_OxygenationControllerUpperLimitReached	Oxygenation Controller at limit
141047	paVMC_nCPAP_HighFlow	High flow
141048	paVMC_Obstruction	Obstruction
141049	paVMC_flowHigh	High flow
141050	paVMC_SimulationActive	Sensor simulation active
141051	paVMC_PEEPHigh	High PEEP

19.3 Alarm Code 200 000

19.3.1 200000 Alarm Code - Technical events

id number	CSystemConfiguration id	enGB text value
231001	taGD_pressureControllerPressureLow	Technical event:
231002	taGD_pressureControllerPressureHigh	Technical event:
231003	taGD_flowControllerFlowLow	Technical event:
231004	taGD_flowControllerFlowHigh	Technical event:
231005	taGD_inspirationValveLeak	Technical event:
231006	taGD_O2ControllerFlowLow	Oxygen supply failed
231007	taGD_O2ControllerFlowHigh	Technical event:
231008	taGD_O2ValveLeak	Technical event:
231009	taGD_blowerControllerSpeedLow	Technical event:
231010	taGD_blowerControllerSpeedHigh	Technical event:
231011	taGD_ventOutputTemperatureHigh	Vent outlet temperature high
231012	taGD_qventFlowSensorDefect	Technical event:
231013	taGD_qO2FlowSensorDefect	Technical event:
231014	taGD_ambientValveError	Technical event:
231015	taGD_autozeroPventControlOK	n/a
231016	taGD_autozeroPventControlOutOfRange	n/a
231017	taGD_blowerServiceRequired	Blower service required
231018	taGD_selftestWithError	Technical event:
231019	taGD_iInspValveSensorDefect	Technical event:
231020	taGD_regulatorDataLogOn	Technical event:
231021	taGD_o2PresenceCheckFailed	n/a
231022	taGD_pExpValveSensorDefect	Technical event:
231023	taGD_invalidFlowSensor	Technical event:
231024	taGD_expValveCoverAdult	n/a
231025	taGD_expValveCoverNeo	n/a
231026	taGD_expValveCoverInvalid	n/a
231027	taGD_expValveCoverMismatch	Wrong expiratory valve
231028	taGD_pressureControllerFlowHigh	n/a
231029	taGD_autozeroPExpValveOK	n/a
231030	taGD_autozeroPExpValveError	n/a
231040	taGD_calibratePVentControlOK	n/a
231041	taGD_calibratePVentControlError	n/a
231044	taGD_calibrateExpValveOK	n/a
231045	taGD_calibrateExpValveError	n/a
231046	taGD_calibrateIExpValveOK	n/a
231047	taGD_calibrateIExpValveError	n/a
231099	taGD_communicationCheck	n/a
232001	taBM_pressureSensorTolerance	n/a
232002	taBM_pventMonitorSensorDefect	Technical event:
232003	taBM_pawSensorDefect	Technical event:
232004	taBM_pressureNotReleased	Pressure not released
232005	taBM_blowerHot	Technical event:
232006	taBM_blowerTemperatureSensorDefect	Technical event:
232007	taBM_qawFlowSensorDefect	Check flow sensor tubing
232008	taBM_pambientSensorDefect	Technical event:
232009	taBM_pventAutozeroValveError	n/a
232010	taBM_pventAutozeroValven/a	n/a

232011	taBM_proximalAutozeroValveError	n/a
232012	taBM_proximalAutozeroValven/a	n/a
232013	taBM_distalAutozeroValveError	n/a
232014	taBM_distalAutozeroValven/a	n/a
232015	taBM_proximalDistalAutozeroValven/a	n/a
232016	taBM_proximalDistalAutozeroValveError	n/a
232017	taBM_autozeroPventMonitorOK	n/a
232018	taBM_autozeroPventMonitorOutOfRange	n/a
232019	taBM_autozeroPventControlOK	n/a
232020	taBM_autozeroPventControlOutOfRange	n/a
232022	taBM_autozeroPawOutOfRange	n/a
232024	taBM_autozeroQawOutOfRange	n/a
232025	taBM_autozeroPawQawOK	n/a
232026	taBM_autozeroPawQawOutOfRange	n/a
232027	taBM_instrumentTemperatureHigh	Device temperature high
232028	taBM_pFilterPressureHigh	Technical event:
232029	taBM_tinstSensorDefect	Technical event:
232030	taBM_clockError	Technical event:
232031	taBM_fiO2CalibrationError	n/a
232032	taBM_fiO2CalibrationOK	n/a
232034	taBM_O2SensorError	Replace O2 cell
232035	taBM_pfilterSensorDefect	Technical event:
232036	taBM_co2CalibrationError	n/a
232037	taBM_co2CalibrationOK	n/a
232038	taBM_co2CalibrationNeeded	CO2 calibration needed
232040	taBM_disconnectionQuick	n/a
232041	taBM_co2CalibrationStartError	n/a
232042	taBM_co2CalibrationStartOK	n/a
232043	taBM_reconnectionQuick	n/a
232044	taBM_SpO2SensorError	n/a
232045	taBM_SpO2SensorSettingsError	Technical event:
232046	taBM_autozeroPExpValveOK	n/a
232047	taBM_autozeroPExpValveError	n/a
232048	taBM_autozeroProxValveLeak	n/a
232049	taBM_autozeroDistValveLeak	n/a
232050	taBM_pventMonitorCalibrationError	n/a
232051	taBM_pventMonitorCalibrationOK	n/a
232052	taBM_pawCalibrationError	n/a
232053	taBM_pawCalibrationOK	n/a
232054	taBM_qawCalibrationError	n/a
232055	taBM_qawCalibrationOK	n/a
232056	taBM_pAmbientPfilterMismatch	Technical event:
232099	taBM_communicationCheck	n/a
233001	taBPG_autozeroPventMonitorFail	Technical event:
233002	taBPG_autozeroPventControlFail	Technical event:
233003	taBPG_autozeroPawFail	Technical event:
233004	taBPG_autozeroQawFail	Technical event:
233005	taBPG_pressureSensorTolerance	Technical event:
233006	taBPG_nebulizerValveError	Technical event:
233020	taBPG_autozeroPventOK	n/a
233021	taBPG_autozeroPawQawOK	n/a
233022	taBPG_autozeroVentValveOK	n/a
233023	taBPG_autozeroVentValven/a	n/a

233024	taBPG_autozeroVentValveError	n/a
233025	taBPG_autozeroProxValveOK	n/a
233026	taBPG_autozeroProxValven/a	n/a
233027	taBPG_autozeroProxValveError	n/a
233028	taBPG_autozeroDistValveOK	n/a
233029	taBPG_autozeroDistValven/a	n/a
233030	taBPG_autozeroDistValveError	n/a
233031	taBPG_autozeroPventMonitorTimeout	n/a
233032	taBPG_autozeroPventControlTimeout	n/a
233033	taBPG_autozeroPawQawTimeout	n/a
233034	taBPG_autozeroPventMonitorOutOfRange	n/a
233035	taBPG_autozeroPventControlOutOfRange	n/a
233036	taBPG_autozeroPawOutOfRange	n/a
233037	taBPG_autozeroQawOutOfRange	n/a
233038	taBPG_proximalDistalAutozeroValven/a	n/a
233039	taBPG_proximalDistalAutozeroValveError	n/a
233040	taBPG_autozeroPExpValveOK	n/a
233041	taBPG_autozeroPExpValveError	n/a
233042	taBPG_autozeroPExpValveTimeout	n/a
233043	taBPG_autozeroPExpValveFail	n/a
234099	taSND_communicationCheck	n/a
241001	taVMC_replaceHEPAfilter	Replace HEPA filter
243001	taALR_alarmSilenceError	Technical event:
243002	taALR_alarmUnknown	Technical event:
243003	taALR_loudspeakerDefect	Loudspeaker defective
243004	taALR_buzzerDefectAtStartup	Buzzer defective
243006	taALR_developSound	Technical event:
243007	taALR_rtcReset	Realtime clock failure
244001	taPM_externalPowerLoss	Loss of external power
244002	taPM_batteryCalibrationRequiredBat1	Battery 1: Calibration required
244003	taPM_batteryCalibrationRequiredBat2	Battery 2: Calibration required
244004	taPM_batteryTemperatureHighBat1	Battery 1: Temperature high
244005	taPM_batteryTemperatureHighBat2	Battery 2: Temperature high
244006	taPM_batteryPowerLowPriorityHigh	Battery low
244007	taPM_batteryPowerLoss	Battery power loss
244008	taPM_battery1WrongBattery	Battery 1: Wrong battery
244009	taPM_battery2WrongBattery	Battery 2: Wrong battery
244010	taPM_batteryPowerLowPriorityLow	Battery low
244011	taPM_batterySystemManagerBusError	Battery communication error
244012	taPM_battery1PermanentFailure	Battery 1: Defective
244013	taPM_battery2PermanentFailure	Battery 2: Defective
244014	taPM_batteryTaskLifeSignTimeout	Technical event:
244015	taPM_batteryPowerLowPriorityMedium	Battery low
244016	taPM_batteryReplacementRequiredBat1	Battery 1: Replacement required
244017	taPM_batteryReplacementRequiredBat2	Battery 2: Replacement required
244099	taPM_communicationCheck	n/a
246001	taLLS_serviceNeeded	Preventive maintenance required
246002	taLLS_cpuTemperatureHigh	Technical event:
246003	taLLS_fanError	Fan failure
246004	taLLS_processorOverload	Technical event:
246005	taLLS_alarmMonitorDefect	Technical event:
246006	taLLS_eepromDefaults	Technical event:
246007	taLLS_eepromWriteFailed	Technical event:

246008	taLLS_cpuTemperatureDefect	Technical event:
246009	taLLS_devWatchdogDisabled	Technical event:
246010	taLLS_hardwareParameterError	Technical event:
246011	taLLS_postMemoryError	Technical event:
246012	taLLS_postEthernetError	Technical event:
246013	taLLS_postI2CError	Technical event:
246014	taLLS_postBootloaderError	Technical event:
246015	taLLS_postHarddriveError	Technical event:
246016	taLLS_postTouchError	Touch not functional
246017	taLLS_externalDisplayError	Technical event:
249001	taCFG_OhOptionFileNotRead	Options not found
249002	taCFG_OhOptionFileNotWritten	Technical event:
249003	taCFG_OhOptionFileWrongVersion	Technical event:
249004	taCFG_OhOptionFileDefaultGenerated	Technical event:
249010	taCFG_DscDeviceConfigFileError	Technical event:
249011	taCFG_DscSetupConfigFileError	Technical event:
249012	taCFG_DscLastSettingConfigFileError	Technical event:
249020	taCFG_InvalidOptionBoard	Invalid option board
249099	taCFG_communicationCheck	n/a
255001	taIVS_PercentageMinVolHighFailed	n/a
255002	taIVS_PercentageMinVolHighLimitWrong	n/a
255003	taIVS_PercentageMinVolLowFailed	n/a
255004	taIVS_PercentageMinVolLowLimitWrong	n/a
255005	taIVS_PeepHighLimitWrong	n/a
255006	taIVS_PeepHighFailed	n/a
255007	taIVS_PeepLowLimitWrong	n/a
255008	taIVS_PeepLowFailed	n/a
255009	taIVS_OxygenLowFailed	n/a
255010	taIVS_OxygenHighFailed	n/a
255011	taIVS_PercentageMinVolChangePosFailed	n/a
255012	taIVS_PercentageMinVolChangeNegFailed	n/a
255013	taIVS_PeepChangePosFailed	n/a
255014	taIVS_PeepChangeNegFailed	n/a
255015	taIVS_OxygenChangePosFailed	n/a
255016	taIVS_OxygenChangeNegFailed	n/a
255017	taIVS_RecruitmentRunningTime	n/a
255018	taIVS_SimulationSuperviseFailed	n/a
255019	taIVS_PercentageMinVolHighFineFailed	n/a
255020	taIVS_PercentageMinVolHighLimitFineWrong	n/a
255021	taIVS_PercentageMinVolLowFineFailed	n/a
255022	taIVS_PercentageMinVolLowLimitFineWrong	n/a
255023	taIVS_CtrlOszillationFiO2	n/a
255024	taIVS_CtrlOszillationPEEP	n/a
255025	taIVS_CtrlOszillationPercMinVol	n/a
255026	taIVS_DataMismatch	Technical event:
283001	taVGUI_StartupFailed	Technical event:
283003	taVGUI_languageNotLoaded	Technical event:
283004	taVGUI_deviceConfigFileError	Technical event:
283005	taVGUI_setupConfigFileError	Technical event:
283007	taVGUI_lastSettingError	Technical event:
283008	taVGUI_checkSetting	Check settings
283009	taVGUI_selftestFailed	Self test failed
284001	taSGUI_StartupFailed	n/a

284002	taSGUI_alarmServiceHigh	Technical event:
284003	taSGUI_alarmServiceMedium	Technical event:
284004	taSGUI_alarmServiceLow	Technical event:
285001	taAGL_alarmLampsErrorDefect	Technical event:
285002	taAGL_alarmLampsWarningDefect	Technical event:
285003	taAGL_BacklightDefect	Technical event:
285004	taAGL_HardkeyDefect	Function key not operational

19.4 Alarm Code 300 000

19.4.1 300000 Alarm Code - Technical failure ending in safety mode

id number	CSystemConfiguration id	enGB text value
331001	tfsGD_pventPressureSensorDefect	Safety ventilation:
332001	tfsBM_qawFlowSensorError	Safety ventilation:
341001	tfsVMC_breathSettingsNotAccepted	Safety ventilation:
341002	tfsVMC_returnedBreathSettingsIncorrect	Safety ventilation:
341003	tfsVMC_adaptiveSettingsInvalid	Safety ventilation:
341004	tfsVMC_breathSettingsTimeout	Safety ventilation:
341005	tfsVMC_controllerSettingsInvalid	Safety ventilation:
343001	tfsALR_communicationTimeout	Safety ventilation:
346002	tfsLLS_watchdogFailedALR	Safety ventilation:
346003	tfsLLS_watchdogFailedALR_MFmeasure	Safety ventilation:
346004	tfsLLS_watchdogFailedESL	Safety ventilation:
346005	tfsLLS_watchdogFailedESL_MMILog	Safety ventilation:
346006	tfsLLS_watchdogFailedESL_ControlLog	Safety ventilation:
346007	tfsLLS_watchdogFailedESL_BreathLog	Safety ventilation:
346008	tfsLLS_watchdogFailedESL_EventSDRReader	Safety ventilation:
346009	tfsLLS_watchdogFailedESL_ServiceSDRReader	Safety ventilation:
346010	tfsLLS_watchdogFailedESL_EventSDRWriter	Safety ventilation:
346011	tfsLLS_watchdogFailedESL_ServiceSDRWriter	Safety ventilation:
346012	tfsLLS_watchdogFailedESL_MFmeasure	Safety ventilation:
346013	tfsLLS_watchdogFailedGUIL_Touch	Safety ventilation:
346014	tfsLLS_watchdogFailedGUIL_PTKnob	Safety ventilation:
346015	tfsLLS_watchdogFailedGUIL_Hardkeys	Safety ventilation:
346016	tfsLLS_watchdogFailedGUIL_ScreenShot	Safety ventilation:
346017	tfsLLS_watchdogFailedLM	Safety ventilation:
346019	tfsLLS_watchdogFailedLLS_HWException	Safety ventilation:
346020	tfsLLS_watchdogFailedLLS_CommonServer	Safety ventilation:
346022	tfsLLS_watchdogFailedLLS_AlarmStatus	Safety ventilation:
346023	tfsLLS_watchdogFailedLLS_MFmeasure	Safety ventilation:
346024	tfsLLS_watchdogFailedPM	Safety ventilation:
346025	tfsLLS_watchdogFailedPM_MFmeasure	Safety ventilation:
346026	tfsLLS_watchdogFailedQSPI	Safety ventilation:
346027	tfsLLS_watchdogFailedQSPI_MMI_Server	Safety ventilation:
346028	tfsLLS_watchdogFailedQSPI_BM_Server	Safety ventilation:
346029	tfsLLS_watchdogFailedQSPI_BPG_Server	Safety ventilation:
346030	tfsLLS_watchdogFailedQSPI_LLS_Server	Safety ventilation:
346031	tfsLLS_watchdogFailedQSPI_QuadSPI	Safety ventilation:
346032	tfsLLS_watchdogFailedQSPI_MFmeasure	Safety ventilation:
346033	tfsLLS_watchdogFailedRTC_RealTimeClock	Safety ventilation:
346034	tfsLLS_watchdogFailedRTC_AlarmClock	Safety ventilation:
346035	tfsLLS_watchdogFailedSC	Safety ventilation:
346036	tfsLLS_watchdogFailedSGUI	Safety ventilation:
346037	tfsLLS_watchdogFailedSTU	Safety ventilation:
346038	tfsLLS_watchdogFailedVMC	Safety ventilation:
346039	tfsLLS_watchdogFailedVMC_VentAlarming	Safety ventilation:
346040	tfsLLS_watchdogFailedVMC_VentControl	Safety ventilation:
346041	tfsLLS_watchdogFailedVMC_VentMonitoring	Safety ventilation:
346042	tfsLLS_watchdogFailedVMC_MFmeasure	Safety ventilation:

346043	tfsLLS_watchdogFailedVGUI	Safety ventilation:
346044	tfsLLS_watchdogFailedVGUI_ModeControl	Safety ventilation:
346045	tfsLLS_watchdogFailedVGUI_MFmeasure	Safety ventilation:
346046	tfsLLS_watchdogFailedLLS_eepromWrite	Safety ventilation:
346047	tfsLLS_watchdogFailedBM_AlarmingSlow	Safety ventilation:
346048	tfsLLS_watchdogFailedSND_SoundControl	Safety ventilation:
346049	tfsLLS_watchdogFailedSND_Sound	Safety ventilation:
346050	tfsLLS_watchdogFailedVT	Safety ventilation:
346051	tfsLLS_watchdogFailedCFG_Configuration	Safety ventilation:
346052	tfsLLS_watchdogFailedEXM_ComBase	Safety ventilation:
346053	tfsLLS_watchdogFailedIVS	n/a
346054	tfsLLS_safetyFailureDetected	Safety ventilation:
383001	tfsVGUI_settingsNotAccepted	Safety ventilation:
383002	tfsVGUI_returnedSettingsIncorrect	Safety ventilation:
383003	tfsVGUI_settingsValidation	Safety ventilation:
383004	tfsVGUI_monitoringChannelObservationFailed	Safety ventilation:
383005	tfsVGUI_VMCTimeout	Safety ventilation:
383006	tfsVGUI_returnedDeviceSettingsIncorrect	Safety ventilation:
383007	tfsVGUI_trendingChannelObservationFailed	Safety ventilation:
385001	tfsAGL_alarmingChannelObservationFailed	Safety ventilation:
385002	tfsAGL_safetyFailureDetected	Safety ventilation:
385003	tfsAGL_PMChannelObservationFailed	Safety ventilation:
386001	tfsGUIL_bitmapNotLoaded	Safety ventilation:

19.5 Alarm Code 400 000

19.5.1 400000 Alarm Code - Technical failure ending in ambient mode

Tab. 14 Alarm Code

id number	CSystemConfiguration id	enGB text value
431001	tfaGD_blowerFault	Blower fault
431002	tfaGD_blowerDisconnected	Technical fault:
431004	tfaGD_inspirationValveOverCurrent	Technical fault:
431005	tfaGD_expiratoryValveDisconnected	Technical fault:
431006	tfaGD_expiratoryValveOverCurrent	Technical fault:
431007	tfaGD_ventOutputOverTemperature	Technical fault:
431008	tfaGD_qventFlowSensorError	Technical fault:
431009	tfaGD_qO2FlowSensorError	Technical fault:
431010	tfaGD_controlREGSPITimeout	Technical fault:
431011	tfaGD_monitorREGSPITimeout	Technical fault:
431012	tfaGD_flowSensorMeasurementImprecise	Technical fault:
431013	tfaGD_calibrationReadFailed	Technical fault:
431014	tfaGD_iExpValveSensorDefect	Technical fault:
431015	tfaGD_emergencyOffFailed	Technical fault:
432001	tfaBM_blowerOverTemperature	Technical fault:
432002	tfaBM_instrumentOverTemperature	Technical fault:
432003	tfaBM_pressureNotReleasedAmbient	n/a
433001	tfaBPG_breathMonitoringTickTimeout	Technical fault:
433002	tfaBPG_controlTickTimingError	n/a
443001	tfaALR_watchdogFailedLLS	Technical fault:
444001	tfaPM_batteriesTotalDischarge	Battery totally discharged
444004	tfaPM_voltageOutOfTolerance	Technical fault:
444005	tfaPM_shutdownFailed	Technical fault:
446001	tfaLLS_cpuTemperatureCritical	Technical fault:
446002	tfaLLS_safetyFailed	Technical fault:
446003	tfaLLS_watchdogFailedGD	Technical fault:
446004	tfaLLS_watchdogFailedGD_ValveRegulator	Technical fault:
446005	tfaLLS_watchdogFailedGD_BlowerRegulator	Technical fault:
446006	tfaLLS_watchdogFailedGD_Monitoring	Technical fault:
446007	tfaLLS_watchdogFailedGD_ValveLog	Technical fault:
446008	tfaLLS_watchdogFailedGD_BlowerLog	Technical fault:
446009	tfaLLS_watchdogFailedGD_MFmeasure	Technical fault:
446010	tfaLLS_watchdogFailedGD_GPIOFaultInput	Technical fault:
446011	tfaLLS_watchdogFailedBM	Technical fault:
446012	tfaLLS_watchdogFailedBM_GasDeliveryCom	Technical fault:
446013	tfaLLS_watchdogFailedBM_Hardwarecontrol	Technical fault:
446014	tfaLLS_watchdogFailedBM_BPGclientReceiver	Technical fault:
446015	tfaLLS_watchdogFailedBM_BPGserverReceiver	Technical fault:
446016	tfaLLS_watchdogFailedBM_BreathDataCalc	Technical fault:
446017	tfaLLS_watchdogFailedBM_MFmeasure	Technical fault:
446018	tfaLLS_watchdogFailedBPG	Technical fault:
446019	tfaLLS_watchdogFailedBPG_GDclientReceiver	Technical fault:
446020	tfaLLS_watchdogFailedBPG_MFmeasure	Technical fault:
446021	tfaLLS_exceptionHappened	Technical fault:
446022	tfaLLS_voltageError	Technical fault:

446023	tfaLLS_watchdogFailedLLS_Workload	Technical fault:
446024	tfaLLS_Am3v3Error	Technical fault:
446025	tfaLLS_AmAdcError	Technical fault:
446026	tfaLLS_AmVrefError	Technical fault:
446028	tfaLLS_clockError	Technical fault:
446029	tfsLLS_ambientFailureDetected	Technical fault:
446030	tfaLLS_AmWatchdogOccurred	Technical fault:
446031	tfaLLS_restartVentilationFailed	Self test failed
481001	tfaSTU_firstRunMigrationError	Technical fault:
481002	tfaSTU_crcError	Technical fault:
481003	tfaSTU_unknownPartNumber	Unknown part number
481004	tfaSTU_technicalStateError	Technical state failed
483001	tfaVGUI_StartupBasicStartupFailure	Technical fault:
483002	tfaVGUI_StartupScreenFailure	Technical fault:
483003	tfaVGUI_StartupLoadGuiBasicsFailure	Technical fault:
483004	tfaVGUI_StartupSelftestPrologFailure	Technical fault:
483005	tfaVGUI_StartupSelftestFailure	Technical fault:
483006	tfaVGUI_StartupSelftestEpilogFailure	Technical fault:
483007	tfaVGUI_StartupLoadingBitmapsFailure	Technical fault:
483008	tfaVGUI_StartupInitializationFailure	Technical fault:
484001	tfaSGUI_StartupBasicStartupFailure	Technical fault:
484002	tfaSGUI_StartupScreenFailure	Technical fault:
484003	tfaSGUI_StartupLoadGuiBasicsFailure	Technical fault:
484004	tfaSGUI_StartupSelftestPrologFailure	Technical fault:
484005	tfaSGUI_StartupSelftestFailure	Technical fault:
484007	tfaSGUI_StartupLoadingBitmapsFailure	Technical fault:
484008	tfaSGUI_StartupInitializationFailure	Technical fault:
485001	tfaAGL_ambientFailureDetected	Technical fault:

20 Document History

20.1 Document History

Re-vi-sion	Date	Description
01	March 2011	First release of the HAMILTON-C1 Service Manual
02	Septem-ber 2014	**Chapter 3 HAMILTON-C1 Overview** -Content revised **Chapter 4 Pneumatics: Overview and Theory of Operation** -Content added **Chapter 5 Electronics: Component Functions Overview** -Content added **Chapter 6 Lithium Ion Battery** -Lithium Ion Battery Maintenance added **Chapter 7 Preventive Maintenance and Testing** -Engineer Preventive Maintenance revised **Chapter 8 Electrical Safety** -Engineer Preventive Maintenance revised **Chapter 9 Service Software** -Totally revised for SW version 2.1.x -Neonatal relevant test's and calib. added **Chapter 10 Technical Faults** -Content revised **Chapter 11 Components Removal/Assembly** -Content revised due to new HW **Chapter 12 Maintenance Tools and Test Equipment** -Equipment for CO2, SpO2 check and neonatal added. -Electrical safety test cable for option board added **Chapter 13 Spare Parts** -Revised and some new added (2nd generation HW) **Chapter 14 Schematics** -Revised and pneumatic diagrams added (2nd generation HW) **Chapter 15 Software Revisions, Features and Compatibilty** -Content added for SW version 2.1.1 **Chapter 16 Hardware Revisions, Features and Compatibilty** -Content added **Chapter 17 Ventilator Test Report** -Revised **Chapter 18 Environmental requirements** -Content added **Chapter 19 Glossary** -Alarm code list updated