Respiratory Modules E-sCAiOVX, E-sCAiOV, E-sCAiO, E-sCOVX, E-sCOV, E-sCO

Service Manual

Host software version 3
Module hardware version 00

Respiratory Modules E-sCAiOVX,
E-sCAiOV, E-sCAiO, E-sCOVX, E-sCOV,
E-sCO
English
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Due to continuing product innovation, specifications in this manual are subject to change without notice.

For technical documentation purposes, the abbreviation GE is used for the legal entity names, GE Medical Systems *Information Technologies*, Inc. and GE Healthcare Finland Oy.

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About this manual

Intended use of this manual

This manual contains instructions for the planned and corrective maintenance of the acquisition module. This manual must be used together with the monitor's service manual for important safety and installation information.

Use the manual as a guide for maintenance procedures and repairs considered field repairable. Where necessary the manual identifies additional sources of relevant information and technical assistance.

See the monitor's service manual for an overview of the patient monitoring system, information needed for system installation and for planned and corrective maintenance of the monitor.

See the monitor's supplemental information manual for the technical specifications, default settings and compatibility information, including electromagnetic compatibility.

See the monitor's user manual for the instructions necessary to operate the device safely in accordance with its function and intended use.

Intended audience of this manual

This manual is intended for service representatives and technical personnel who maintain, troubleshoot, or repair this device.

Manual conventions

This manual uses the following styles to emphasize text or indicate an action. Also note the terminology conventions.

Item	Description
bold	Indicates hardware keys and connectors.
bold italic	Indicates menu options, software keys and messages.
italic	Indicates terms for emphasis.
>	Indicates menu options to select consecutively.
select	The word select means choosing and confirming.
supplemental information	In this manual, the phrase supplemental information refers to information that appears in the Supplemental Information Manual or supplements provided.
NOTE	Note statements provide application tips or other useful information.

In this manual, the following product names are used as generic terms:

- D-lite when referring to D-lite, D-lite+, and D-lite++
- Pedi-lite when referring Pedi-lite and Pedi-lite+
- D-fend Pro when referring to D-fend Pro and D-fend Pro+

Illustrations and names

This manual uses illustrations as examples only. Illustrations in this manual may not necessarily reflect all system settings, features, configurations, or displayed data.

Names of persons, institutions, and places and related information are fictitious; any similarity to actual persons, entities, or places is purely coincidental.

Related documents

- CARESCAPE monitor's service manual
- CARESCAPE monitor's user manual
- CARESCAPE monitor's supplemental information manual
- Cleaning and Disinfecting Supplement
- Supplies and Accessories Supplement

Product availability

NOTE Due to continual product innovation, design and specifications for these products are subject to change without notice.

Some of the products mentioned in this manual may not be available in all countries. Please consult your local representative for the availability.

Trademarks

GE, GE Monogram, and CARESCAPE are trademarks of General Electric Company.

Third party trademarks

All third party product and company names are the property of their respective owners.

Manufacturer responsibility

GE is responsible for the effects on safety, reliability, and performance of the equipment only if:

- Assembly operations, extensions, readjustments, modifications, servicing, or repairs are carried out by authorized service personnel.
- The electrical installation of the relevant room complies with the requirements of the appropriate regulations.
- The equipment is used in accordance with the instructions for use.
- The equipment is installed, maintained and serviced in accordance with the instructions provided in the related service manuals.

WARNING SAFETY HAZARD. To avoid risks to personnel and patient, or damage to the equipment, only perform maintenance procedures described in this manual. Unauthorized modifications can lead to safety hazards.

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Module introduction

Respiratory module introduction

This document provides information for the maintenance and service of the CARESCAPE respiratory modules, E-sCO, E-sCOV, E-sCOVX, E-sCAiO, E-sCAiOV, and E-sCAiOVX. The CARESCAPE Respiratory modules are single width plug-in modules.

The CARESCAPE Respiratory modules provide airway and respiratory measurements

Letters in the module name stand for:

C = CO_2 and N_2O, O = patient O_2, V = spirometry, X = gas exchange, A = anesthetic agents, and i = agent identification

Options for CARESCAPE respiratory modules

Modules	**Parameters / measurements**						
	CO_2	N_2O	O_2	Anes-thetic agents	Agent ID	Spirome-try	Gas ex-change
E-sCOVX	X	*	X			X	X
E-sCOV	X	*	X			X	
E-sCO	X	*	X				
E-sCAiO-VX	X	X	X	X	X	X	X
E-sCAiOV	X	X	X	X	X	X	
E-sCAiO	X	X	X	X	X		
* The E-sCO, E-sCOV, and E-sCOVX modules automatically compensate for N_2O in realtime although N_2O values are not displayed on screen.							

Module compatibility

For detailed information regarding module, monitor, and accessory compatibility, see the supplemental information provided.

About unpacking the module

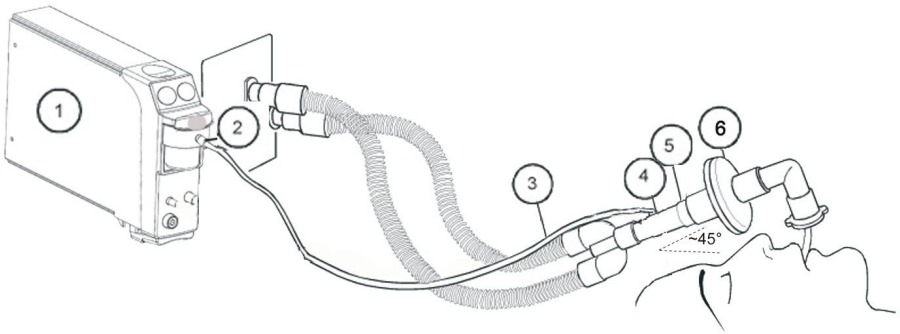
When receiving a new or recently serviced module from transport, remove the module from the package and let it remain in ambient air for 48 to 72 hours, if possible. Do not calibrate the module while waiting.

The module is ready for use sooner if it successfully passes the calibration check.

If the calibration check fails, CO_2 may have been trapped inside the module during transport. In this case, do not try to calibrate the module until at least 72 hours have passed.

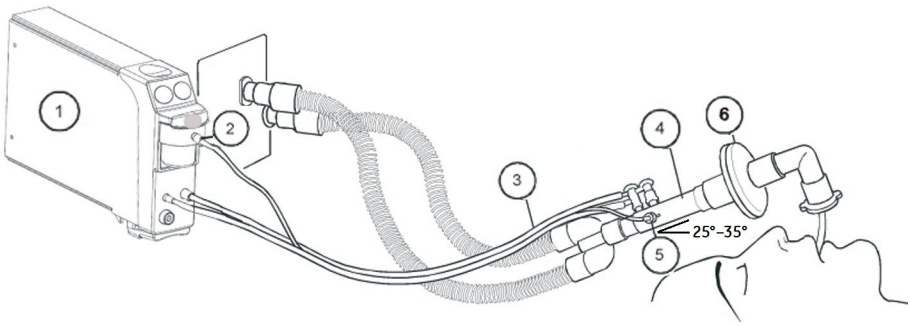
NOTE Typically, gas calibration is not required for received modules. They have already been calibrated either at the factory or at the service depot before shipping.

Airway gases equipment to patient connections with CARESCAPE respiratory modules



1. CARESCAPE respiratory module
2. Gas sample, gas sampling line connector on the water trap
3. Gas sampling line
4. Gas sampling line connector on the airway adapter; place the connector upwards
5. Airway adapter with sampling line connector
6. Heat and moisture exchanger with filter (HMEF) (optional when sampled gas is directed to the scavenging system)

Spirometry equipment to patient connection



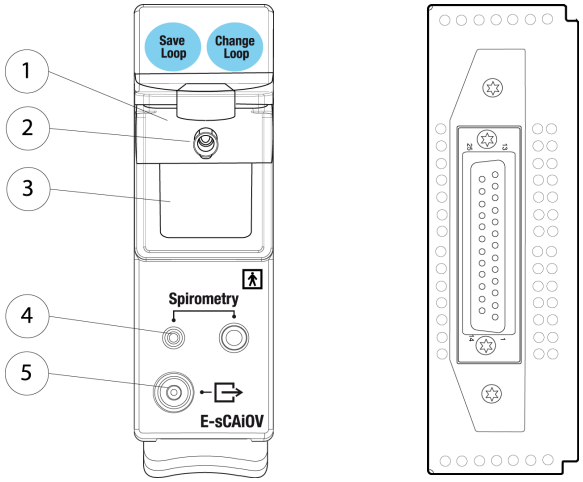
1. E-sCOV, E-sCOVX, E-sCAiOV, E-sCAiOVX, or E-sCAiOVE module
2. Gas sample, gas sampling line connector on the water trap
3. Gas sampling and spirometry tubes
4. D-lite/Pedi-lite sensor
   With D-lite++: the sensor design and position of the gas sampling line differ from the above figure.

5. Gas sampling line connector
6. Heat and moisture exchanger with filter (HMEF)

NOTE Place all D-lite ports upwards with a 25° to 35° tilt to prevent condensed water from entering the sensor interior and the tubings.

Controls and connectors

Front of CARESCAPE Respiratory Module, E-sCAiOV, and the back of the module:



1. D-fend Pro water trap
2. Gas sample, sampling line connector on the water trap
3. Water trap container
4. Connectors for spirometry
5. Gas exhaust, connector for the gas exhaust line (sampling gas out)
   There are two types of connectors as indicated in the following figure:

a. Module with Luer exhaust connector: use Luer gas exhaust lines.

b. Module with GE custom exhaust connector: use GE gas exhaust lines.

Module keys	Module	Description
Save Loop	E-sCOV, E-sCAiOV, E-sCOVX, and E-sCAiOVX	**Save Loop** saves a reference loop
Change Loop	E-sCOV, E-sCAiOV, E-sCOVX, and E-sCAiOVX	**Change Loop** changes a pressure/volume loop to a flow/volume loop or vice versa.

Connector	Module	Description
D25 connector	all modules	Module bus connector

Spirometry module keys

There are two keys on the CARESCAPE respiratory modules E-sCAiOV, E-sCAiOVX, E-sCAiOVE, E-sCOV, and E-sCOVX:

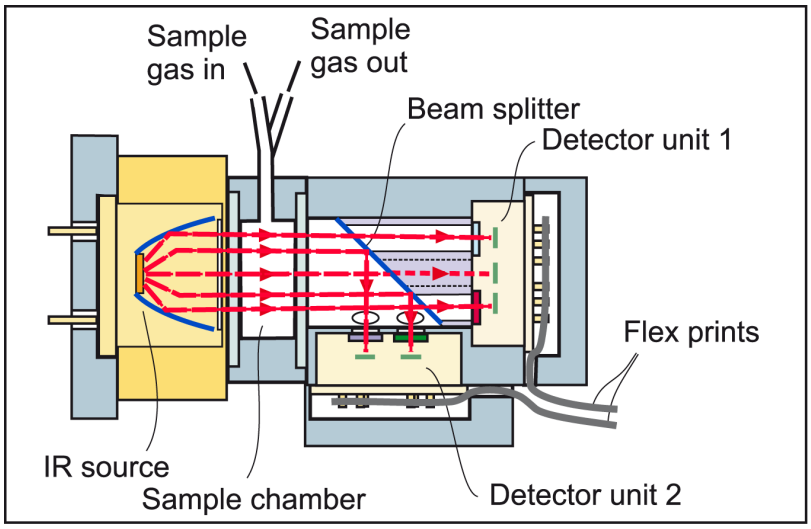
Save Loop	Saves the currently active loop with corresponding numeric data.
Change Loop	Toggles between a Paw-Vol and a Flow-Vol loop.

Measurement principle

CO_2, N_2O, and agent measurement

MiniTPX is a side stream gas analyzer, measuring real time concentrations of CO_2, N_2O, and anesthetic agents (Halothane, Enflurane, Isoflurane, Desflurane, and Sevoflurane).

The following illustrates the MiniTPX sensor principle:



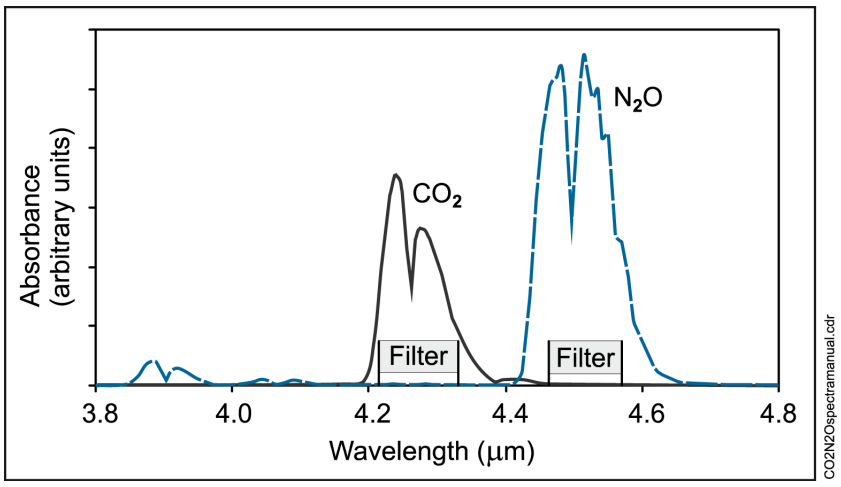
Anesthetic agents or mixtures of two anesthetic agents are automatically identified, and concentrations of the identified agents are measured. MiniTPX also detects mixtures of more than two agents and issues an alarm.

MiniTPX is a non-dispersive infrared analyzer, measuring absorption of the gas sample at seven infrared wavelengths, which are selected using optical narrow band filters.

The infrared radiation detectors are thermopiles.

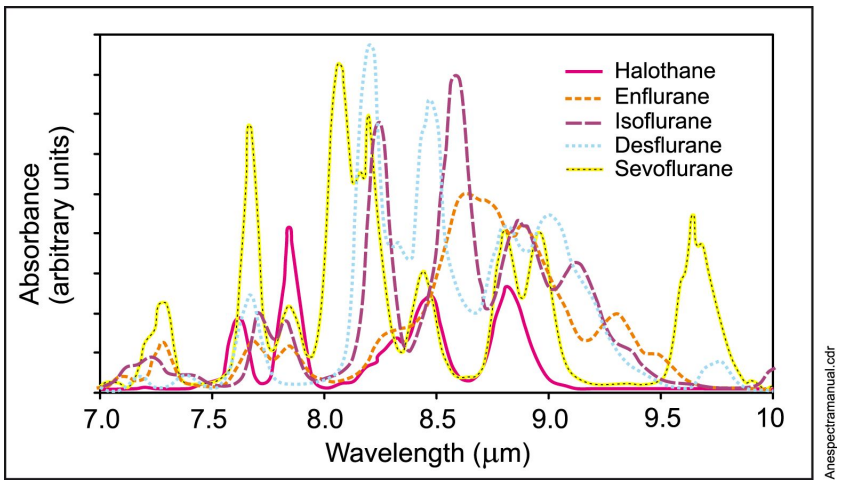
Concentrations of CO_2 and N_2O are calculated from absorption measured at 3-5 µm.

The following illustrates the absorbance of N_2O and CO_2:



Identification of anesthetic agents and calculation of their concentrations is performed by measuring absorptions at five wavelengths in the 8-9 µm band and solving the concentrations from a set of equations.

The following illustrates the infrared absorbance of AAs:

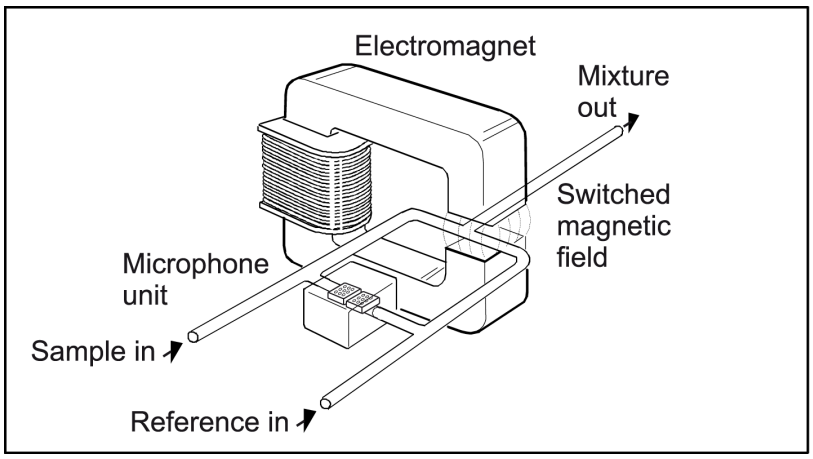


The measuring accuracy is achieved utilizing numerous software compensations. The compensation parameters are determined individually for each MiniTPX during the factory calibration.

O_2 measurement

The differential oxygen measuring unit uses the paramagnetic principle in a pneumatic bridge configuration. The signal picked up with a differential pressure transducer is generated in a measuring cell with a strong magnetic field that is switched on and off at a main frequency of 164 Hz. The output signal is a DC voltage proportional to the O2 concentration difference between the gas to be measured and the air reference.

The following illustrates the O_2 measurement principle:



Spirometry measurement

In mechanical ventilation, breaths are delivered to the patient by a ventilator with a proper tidal volume (TV), respiration rate (RR), and inspiration / expiration ratio in time (I:E) determined by the settings of the ventilator.

Spirometry monitors patient ventilation.

Displayed volume parameters

- Expiratory and inspiratory tidal volume (TV) in ml
- Expiratory and inspiratory minute volume (MV) in l/min
- Expiratory spontaneous minute volume in l/min
- Inspiration/expiration ratio (I:E)

Displayed airway pressure parameters

- Peak pressure (P_{peak})
- Mean airway pressure (P_{mean}); available with ICU, NICU and ED software packages
- End inspiratory plateu pressure (P_{plat})
- $PEEP_i$, $PEEP_e$; available with ICU, NICU and ED software packages
- Total positive end expiratory pressure ($PEEP_{tot}$); available with OR and PACU software packages
- Real time airway pressure waveform (P_{aw})
- Static Positive End Expiratory Pressures (Static $PEEP_i$ and Static $PEEP_e$); available with ICU, NICU and ED software packages
- Static Plateau pressure (Static P_{plat}); available with ICU, NICU and ED software packages
- Static Compliance (Static Compl); available with ICU, NICU and ED software packages

PEEP, P_{peak}, P_{mean}, and P_{plat} are measured by a pressure transducer on the MiniPVX board.

Ambient pressure is used as a reference in measurement. The pressure measurement is made from the airway part that is closest to the patient between the patient circuit and intubation tube.

$PEEP_i$=intrinsic PEEP, $PEEP_{tot}$-$PEEP_e$

Static pressure measurement maneuvers are automatically identified based on an increased zero flow period at the end of the inspiration or expiration.

Static Compliance is calculated, if Static PEEP and Static P_{plat} measurements were made within a 2 minute period.

Displayed airway flow parameters

- Real time flow waveform (V')
- Compliance (Compl)
- Airway resistance (Raw)
- Pressure volume loop
- Flow volume loop

The measurement is based on measuring the kinetic gas pressure and is performed using the Pitot effect. A pressure transducer is used to measure the Pitot pressure. The pressure signal obtained is linearized and corrected according to the density of the gas. Speed of flow is calculated from these pressure values and the TV value is then integrated. The MV value is calculated and averaged using TV and RR (respiratory rate) values.

D-lite

Spirometry uses specific sensors called D-lite and Pedi-lite flow sensors. Different types of sensors are available: adult sensor for measuring adults and pediatric sensor for children. Both are available as reusable and disposable versions.

D-lite and Pedi-lite adapters are designed to measure kinetic pressure by a two-sided Pitot tube. Velocity is calculated from pressure difference according to Bernoulli's equation. Flow is then determined using the calculated velocity.

$$v = \sqrt{\frac{2 \times dP}{\rho}}$$ (from Bernoulli's equation) Formula 1

$$V' = v \times A$$

where:

V'= flow (l/min)	v = velocity (m/s)	A = cross area (m^2)	dP = pressure difference (cmH_2O	ρ = density (kg/m^3)

Finally the volume information is obtained by integrating the flow signal.

Compliance and airway resistance

Compliance is calculated for each breath from the equation

$$Compl = \frac{TV_{exp}}{P_{plat} - (PEEP_i + PEEP_e)}$$ Formula 2

Compliance describes how large a pressure difference is needed to deliver a certain amount of gas to the patient.

The airway resistance, Raw, is calculated using an equation that describes the kinetics of the gas flow between the lungs and the D-lite. The equation states that the pressure at the D-lite can at any moment of the breath be approximated using the equation

$$P(t) = Raw \times V'(t) + \frac{V(t)}{Compl} + PEEP_i + PEEP_e$$ Formula 3

where P(t), V'(t) and V(t) are the pressure, flow and volume measured at the D-lite at a time t, Raw is the airway resistance, Compl is the compliance and $PEEP_e$+$PEEP_i$ is the total positive end expiratory pressure ($PEEP_{tot}$).

Gas exchange measurement

The gas exchange measurement uses the D-lite flow sensor and the gas sampling system.

The basic data which is needed to obtain O_2 consumption and CO_2 production are volumes and concentrations.

Concentrations have been corrected for delay and deformation during the transport of the gas sample in a sidestream gas measurement sensor.

To obtain the amount of O_2 consumed in ml/min, the amount which is exhaled is subtracted from the amount that is inhaled.

To obtain the amount of CO_2 produced in ml/min, the amount which is inhaled is subtracted from the amount that is exhaled.

These amounts can be obtained by multiplying each measured volume piece (dv) by the corresponding gas concentration:

$$VO_2 = \int_{insp} f_{O_2} dv - \int_{exp} f_{O_2} dv$$ Formula 4

and

$$VCO_2 = \int_{exp} f_{CO_2} dv - \int_{insp} f_{CO_2} dv$$ Formula 5

Using inspiratory and expiratory minute volumes MV_i and MV_e and volume-weighted inspiratory concentrations fi and fe, these equations can be rewritten as:

$$VO_2 = fi_{O_2} \times MV_i - fe_{O_2} \times MV_e \quad [ml/min]$$ Formula 6

$$VCO_2 = fe_{CO_2} \times MV_e - fi_{CO_2} \times MV_i \quad [ml/min]$$ Formula 7

To obtain results which are less sensitive to errors in volume measurements, the so-called *Haldane transformation* is used. This means taking advantage of the fact that the patient is not consuming nor producing nitrogen: the amount of nitrogen inhaled is equal to the amount exhaled $fi_{N2} \times MV_i = fe_{N2} \times MV_e$

VO_2 and VCO_2 can then be written as:

$$VO_2 = (fi_{O_2} - f_{Hald} \times fe_{O_2}) MV_i \quad [ml/min]$$ Formula 8

$$VCO_2 = (f_{Hald} \times fe_{CO_2} - fi_{CO_2}) MV_i \quad [ml/min]$$ Formula 9

with

$f_{Hald} = (1\text{-}fi_{CO2} - fi_{O2} - fi_{N2O} - fi_{Ane1} - fi_{Ane2}) / (1\text{-}fe_{CO2} - fe_{O2} - fe_{N2O} - fe_{Ane1} - fe_{Ane2})$

Main components of respiratory modules

The respiratory modules consist of:

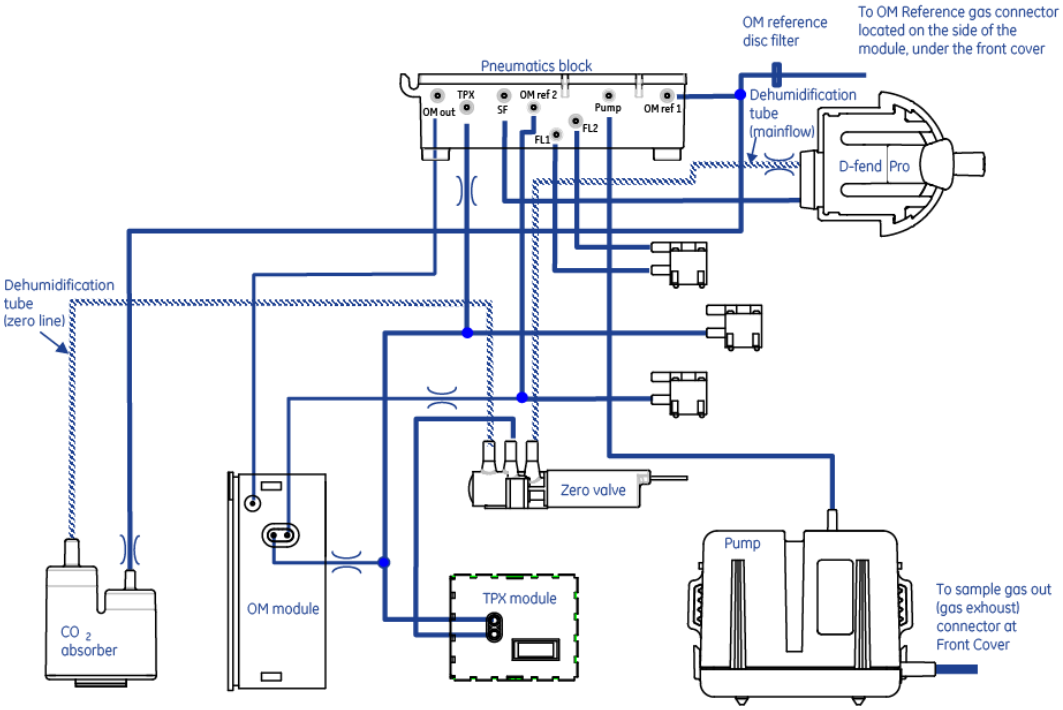
- Gas sampling system
- MiniTPX measuring unit
- MiniOM measuring unit
- MiniPVX measuring unit
- CPU board

Gas sampling system

The gas sampling system draws a 120ml/min sample from the patient's airway to the module. The sampling system also takes about 30ml/min flow of room air to the oxygen sensor. When the gas sensors are zeroed, room air is taken through the CO_2 absorber to the gas sensors instead of the sampled gas from the patient's breathing.

The gas sampling line is connected between the patient circuit and the Gas Sample port on the water trap. The water trap protects the sampling system and gas sensors from liquids and dust.

The following diagram illustrates the gas sampling system:



The sampling system has a self diagnostics that detects disturbances in the gas flow, reveals the most common reasons for disturbances, such as occluded sampling line or blocked gas exhaust line, and communicates relevant status messages to the patient monitor.

The system is designed so that the sampled gas will not flow from the sampling line back to the patient circuit. The parts and connections of the sampling system are streamlined for minimal dead spaces and turbulences in gas flows.

All gas inputs of the module have dust filters protecting the sampling system and gas sensors. The water trap acts as a dust filter for the sampled gas and the module should always have the water trap connected.

NOTE It is very important to prevent dust from entering the open gas connections during service operations.

D-fend Pro water trap

The gas sampling line is connected to the input of the water trap where a special membrane passes gases and vapors but stops liquids. The gas flowing through the membrane continues via the main flow connector of the water trap to the module. The main flow is about 90% of the sample flow.

Liquids stopped below the membrane are moved to the water container by a side flow that goes through the water container and the water separation membrane before entering the side flow connector of the water trap. Thus, the side flow also is free of liquids when it gets into the module. In the module, the side flow is connected directly to the pump input and it does not enter the gas sensors.

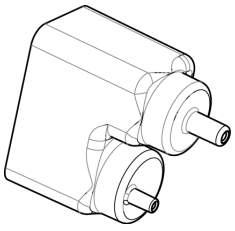
NOTE The water trap acts as a dust filter for the sampling system and gas sensors. Thus, the module should always have the water trap connected.

Zero valve and CO_2 absorber

The zero valve is activated during gas sensor zeroing. Room air is drawn through the CO_2 absorber and the zero valve to the gas sensors, and the main flow of sample gas is stopped. The zero gas comes to the sensors through the CO2-absorber that chemically absorbs CO_2. The side flow of the water trap flows in the gas sampling line even during zeroing.

During normal monitoring, the zero valve is not activated and the sampled gas gets through the zero valve to the gas sensors.

The following illustrates the CO_2 absorber:



Dehumidification tubes

The dehumidification tube between the water trap and the zero valve equalizes the humidity of the sampled gas to ambient level. This will prevent calibration errors caused by the difference in humidities in the sampled breathing gas and the totally dry calibration gas.

Another dehumidification tube is used between the CO_2 absorber and the zero valve to prevent condensation of water generated in the CO_2 absorber as by-product of CO_2 absorption.

Gas sensors

After the zero valve, the gas flows trough the MiniTPX sensor that measures the concentrations of all gases but oxygen.

The oxygen concentration is measured in the MiniOM sensor that has two inputs. One input draws in a part of the main flow and the other draws in room air as reference gas for the O_2 measurement.

Sample flow differential pressure transducer

The module measures total flow at the input of the gas pump and reference flow at the OM reference line. The sample flow is the difference of these two flows.

Working pressure transducer

The working pressure transducer measures absolute working pressure near the MiniTPX unit and MiniOM unit.

It is used for messages: ***Sample line blocked***, ***Check Water Trap***, ***Replace Water Trap***, and ***Check sample gas out***.

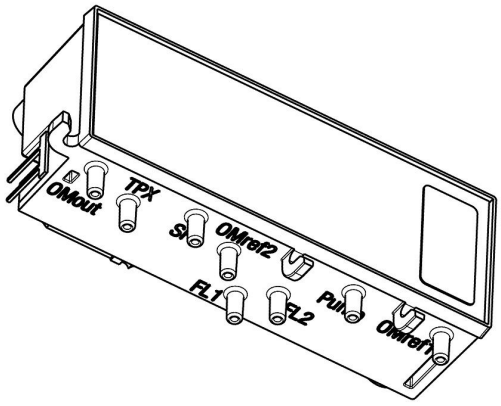
Pneumatics unit

The pneumatics unit contains the zero valve, occlusion valve and pneumatics block with tubing connections.

The zero valve is activated during the zero level calibrations of gas sensors. The occlusion and zero valves are activated when the sampling line or water trap is occluded. With the activated valves, the gas pump generates maximal suction trough the “side flow” connector of the water trap, thus maximizing the transfer of liquids from the wet side of the water trap to the container.

The pneumatics block contains a network of constrictions to divide the sampled gas in correct proportions to different parts in the module. The first branching takes place in the water trap where incoming flow is divided to the “main flow” and “side flow”. The second branching takes place before the MiniOM sensor.

The pneumatics block also contains a pneumatic low pass filter between gas sensors and gas pump. The filter consists of constrictions (resistors) and volumes (capacitors) and it attenuates the pressure pulsation generated in the gas pump so that they do not disturb the operation of the gas sensors.



Gas pump unit

The gas pump is a membrane pump run by a brushless DC-motor. The pump is adjusted so that the sample gas flow is kept close to its nominal value even when the flow resistances in the sampling line of water trap change.

The pump is in a plastic enclosure to minimize the operating noise and mechanical vibration of the pump unit. A pneumatic damping chamber is integrated to the enclosure to attenuate the pressure pulsation and noise conducted to the gas exhaust port.

Pressure measurements

The four pressure sensors on the CPU board are used to measure ambient pressure, working pressure of the MiniTPX and MiniOM sensors and pressure of the reference gas flow to the MiniOM sensor.

Sample flow control

The gas flow in the sampling line is monitored by measuring the gas flow at the input of the gas pump and the reference flow to the oxygen sensor is estimated by measuring the pressure in the reference gas flow branch. The sample flow is calculated by subtracting the reference flow from the total gas flow. A control loop adjusts the rotation speed of the pump motor so that the gas flow is kept close to 120 ml/min.

Gas sampling self-diagnostics

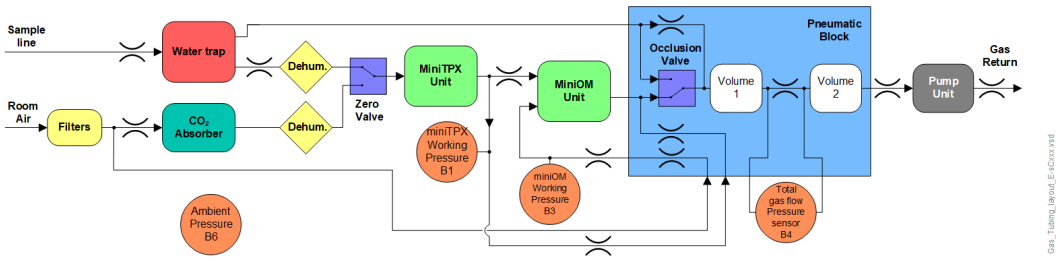
The sample flow and the vacuum in the sampling system are used for continuous monitoring of the gas sampling system. The vacuum is calculated in real time as difference of the measured ambient and working pressures.

The self-diagnostics of the gas sampling system sends the following status data to the patient monitor when specific triggering conditions are met: ***Check water trap***, ***Check sample gas out***, ***Replace water trap***, ***Sample line blocked***, ***Continuous blockage***.

The gas pump is stopped when the ***Sample line blocked*** has lasted for more than 1 minute. The module automatically restarts the pump to check whether the abnormal situation has been resolved so that normal gas sampling operation is possible.

The gas pump repeats 1 minute full pump, 30 seconds pump off when the ***Continuous blockage*** message is shown.

The following diagram illustrates gas tubing layout:



MiniTPX measuring unit

The MiniTPX unit is a non dispersive infrared analyzer, measuring the absorption of the gas sample at seven infrared wavelengths, which are selected using optical narrow band filters. The IR source is a micro-machined heating element with an integrated collimator. From the output of the source, the radiation is passed to a flow optimized measuring chamber.

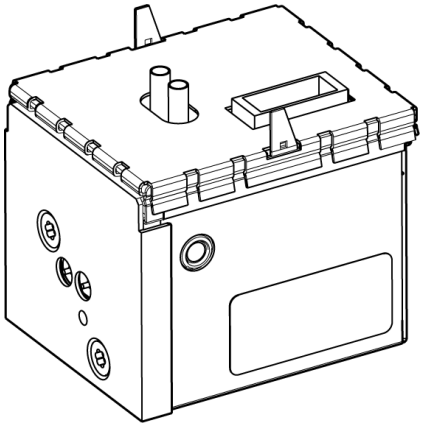
From the sample chamber, radiation goes via a specially designed beam splitter to two detector units, each with four thermopile detectors and integrated optical filters. The miniTPX measuring unit has two detector units for redundancy purposes.

Each detector unit also measures the unit's temperature. The module CPU uses it for further processing and temperature compensation of the measured raw signals.

The miniTPX unit includes an amplifier board with the following functions:

- On-board 5V regulator and 2.5V reference source.
- Preamplifiers for the eight thermopile detectors and for the two temperature sensors. A 16 channel buffered multiplexer is used to transfer the signals to the CPU board.
- PWM controlled power for the IR source.
- An EEPROM memory for storing factory calibration coefficients of the sensor.

The input to the amplifier board comprises a 7V DC feed and CPU control signals for the PWM, multiplexer and EEPROM. When the module starts up, the calibration coefficients are read to the module CPU and then used for calculating the gas concentrations from the raw data received from the sensor multiplexer.



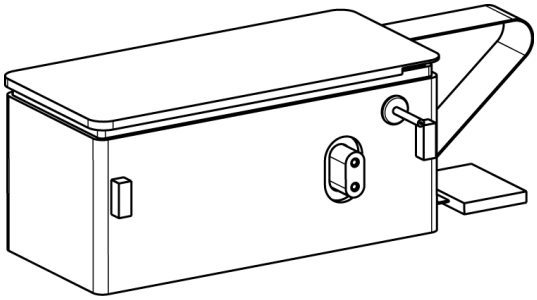
MiniOM oxygen sensor

The miniOM sensor measures the concentration of oxygen in the gas sample.

The measurement is based on the magnetic properties of oxygen. The sensor measures the sound pressure generated in the air gap of the magnet at the 164 Hz operating frequency. Two microphones are used for detection and the oxygen concentration is calculated from the RMS value of the difference of the microphone outputs.

The sensor consists of the following functional parts:

- Pneumatic system
- Amplifier board
- MiniOM board
- Magnet



NOTE The sensor is assembled in the module using flexible suspension to prevent mechanical vibrations of the gas pump and cooling fan from disturbing the oxygen measurement. All gas lines to the sensor must also be carefully assembled so that they do not pick up mechanical vibrations of the module mechanics.

Pneumatic system

The pneumatic system, together with the gas sampling system of the module creates the gas flows and pressures needed for the oxygen measurement and protection of the microphones from excessive pressure. About 30 ml/min flow of sampled gas comes to the In connector on the MiniOM sensor. Room air is drawn to the Ref input of MiniOM also at 30 ml/min rate. About 75% of these flows are conducted to a pressure equalization chamber so that only about a 8 ml/min flow of the two gas streams continue into the air gap of the magnet. All the internal gas flows finally get to a volume enclosed by the sensor board and the sensor body, and then flow out through the Out connection of the sensor. Some of the gas channels and flow restrictors are integrated into the preamplifier electronics board utilizing the multi-layer structure of the LTCC (Low Temperature Co-fired Ceramics) circuit board technology.

NOTE It is very important to prevent dust or liquids from getting into the pneumatic circuit of MiniOM. Thus, the gas connections should always be closed with a protecting cap when the sensor is not connected to the module pneumatics.

Amplifier board

The amplifier board located in the sensor has two electric microphones for the differential detection of pressure pulses generated in the magnet's air gap. The

microphone signals are fed to two identical signal conditioning channels with a band-pass filter and a digitally controlled amplifier. The voltage gains of the amplifiers are set during factory calibration so that the responses of the microphone channels match in spite of differences in the microphone's sensitivities. The amplifier board also has an amplifier for the thermistor measuring the temperature of the magnet.

MiniOM board

The MiniOM board has five functions:

- Drive the magnet coil.
- Convert the microphone and temperature signals into digital format.
- Filter digitally the microphone signals and perform the RMS conversion.
- Communicate digitally with the module CPU.
- Store factory calibration data in permanent memory and communicate them to the module CPU.

The module CPU provides the coil drive and communication enabling signals and also clock signal for MiniOM board. The FPGA takes care of the coil drive and also has a back-up clock in case the CPU clock does not work. The FPGA takes care of the A/D conversions which are performed with a serial controlled SAR A/D-converter.

The digital band pass filtering and RMS conversion of the microphone signals are made with the FPGA circuit controlled by a VHDL code stored in the circuit. In order to filter out the disturbances caused by acoustic noise, mechanical vibration and amplifier noise, the band pass filters are designed to have as narrow a pass band as possible without slowing down the filter's response to changes in the amplitude of the 164 Hz signal.

The FPGA circuit takes care of the digital communication between the miniOM sensor and the module CPU.

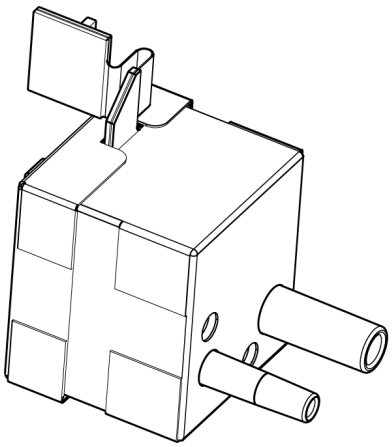
The factory calibration coefficients of the sensor are stored in an EEPROM memory on the miniOM board. When the module starts up, the calibration coefficients are read to the module CPU and then used for calculating the O_2 concentration from the oxygen raw data received from the sensor.

MiniPVX measuring unit

NOTE Never apply overpressure or negative pressure of more than 300 cmH_2O to the flow and volume tubing. Differential pressure max 25 cmH_2O is allowed on one port at a time e.g. when connecting tubes.

When spirometry is used, a special sensor, D-lite, replaces the normal airway adapter in the patient circuit. A double lumen tubing is attached to the two connectors on the adapter and on the module front panel.

Spirometry provides patient respiration monitoring capabilities using the D-lite and Pedi-lite flow sensors.



The measurement is based on measuring the kinetic gas pressure and is performed using the Pitot effect. A pressure transducer is used to measuring the Pitot pressure. The signal is then linearized and corrected according to the density of the gas. The speed of the flow is calculated from the pressure and TV is integrated from it.

Spirometry consists of airway connections, two pressure transducers, valves, and preamplifiers. The preamplifiers are connected to the A/D converter on the module main CPU.

The patient's breathing flow passing through the D-lite adapter creates a pressure difference. This pressure difference is measured by a pressure transducer, B1. Overpressure and negative pressure in airways are measured by another pressure transducer, B2.

Gas exchange

The gas exchange measurement uses the concentrations measured by the TPX measurement unit and the O_2 measurement unit, in combination with the flow from the PVX measurement unit. The gas exchange calculation is done by software.

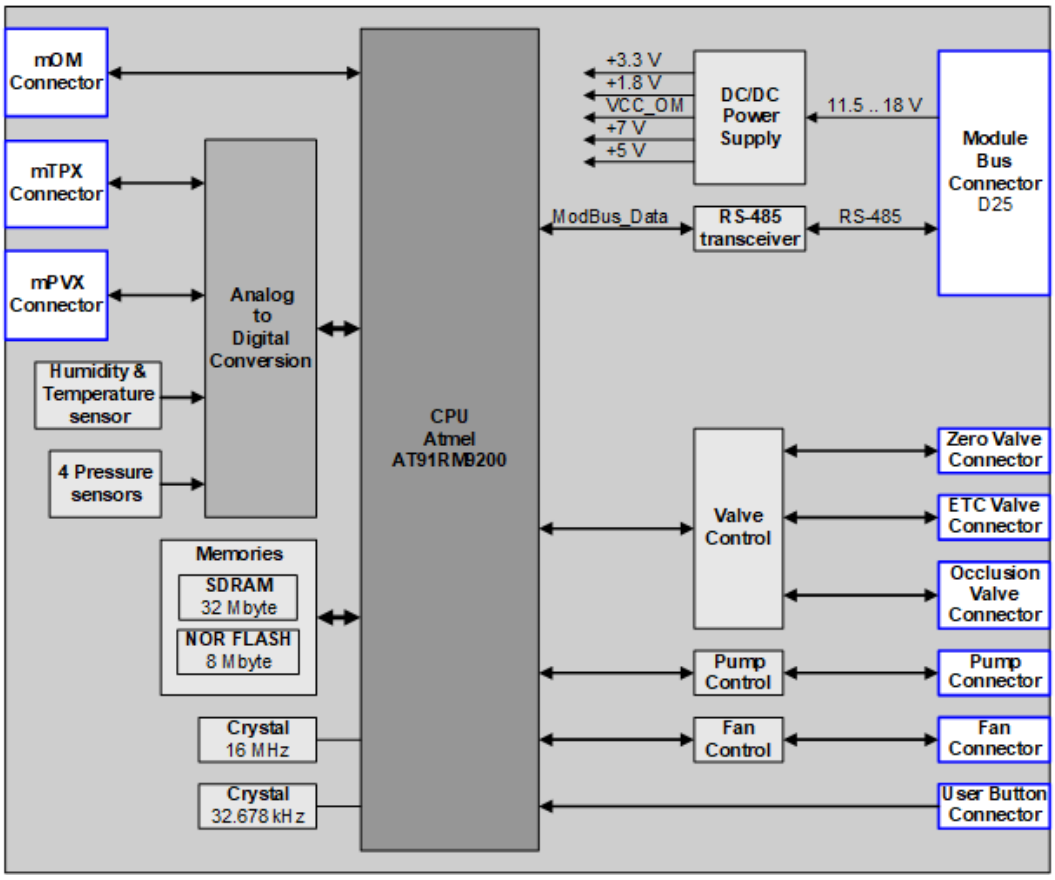
NOTE The gas exchange measurement in the E-CAiOVX and E-COVX modules works accurately only with 2-meter (7 ft) gas sampling lines.

CPU board

The CPU board contains a processor, memories and an A/D converter that is common to the whole module.

The CPU board also contains sensors for pressure, temperature and humidity as well as drivers for the valves, fan and pump. The module is connected to the module bus through an RS-485 serial channel.

The following diagram illustrates signal processing on the CPU board:



MiniOM board

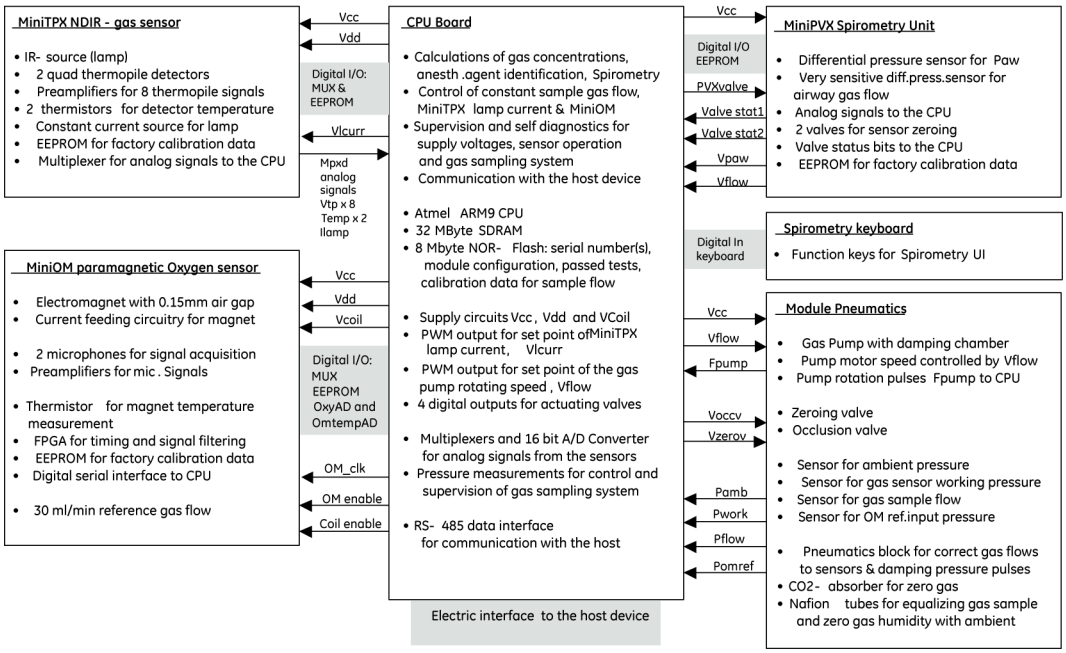
The miniOM board contains electronics specific to the MiniOM sensor: FPGA circuit, coil drive, A/D converter, etc. It also contains an EEPROM memory that stores calibration data of the oxygen measurement.

MiniPVX board

The MiniPVX board contains pressure sensors for airway pressure and flow measurement and preamplifiers for those. It also contains EEPROM memory that stores calibration data of the spirometry measurement.

Main component interactions

The following block diagram illustrates the functionality of the module and the division of tasks between different components:


MiniTPX NDIR - gas sensor
• IR- source (lamp)
• 2 quad thermopile detectors
• Preamplifiers for 8 thermopile signals
• 2 thermistors for detector temperature
• Constant current source for lamp
• EEPROM for factory calibration data
• Multiplexer for analog signals to the CPU
Vcc
Vdd
Digital I/O: MUX & EEPROM
Vlcurr
Mpxd analog signals Vtp x 8 Temp x 2 Ilamp
MiniOM paramagnetic Oxygen sensor
• Electromagnet with 0.15mm air gap
• Current feeding circuitry for magnet
• 2 microphones for signal acquisition
• Preamplifiers for mic . Signals
• Thermistor for magnet temperature measurement
• FPGA for timing and signal filtering
• EEPROM for factory calibration data
• Digital serial interface to CPU
• 30 ml/min reference gas flow
Vcc
Vdd
Vcoil
Digital I/O: MUX EEPROM OxyAD and OmtempAD
OM_clk
OM enable
Coil enable
CPU Board
• Calculations of gas concentrations, anesth .agent identification, Spirometry
• Control of constant sample gas flow, MiniTPX lamp current & MiniOM
• Supervision and self diagnostics for supply voltages, sensor operation and gas sampling system
• Communication with the host device
• Atmel ARM9 CPU
• 32 MByte SDRAM
• 8 Mbyte NOR- Flash: serial number(s), module configuration, passed tests, calibration data for sample flow
• Supply circuits Vcc , Vdd and VCoil
• PWM output for set point ofMiniTPX lamp current, Vlcurr
• PWM output for set point of the gas pump rotating speed , Vflow
• 4 digital outputs for actuating valves
• Multiplexers and 16 bit A/D Converter for analog signals from the sensors
• Pressure measurements for control and supervision of gas sampling system
• RS- 485 data interface for communication with the host
Electric interface to the host device
Vcc
Digital I/O EEPROM
PVXvalve
Valve stat1
Valve stat2
Vpaw
Vflow
Digital In keyboard
Vcc
Vflow
Fpump
Voccv
Vzerov
Pamb
Pwork
Pflow
Pomref
MiniPVX Spirometry Unit
• Differential pressure sensor for Paw
• Very sensitive diff.press.sensor for airway gas flow
• Analog signals to the CPU
• 2 valves for sensor zeroing
• Valve status bits to the CPU
• EEPROM for factory calibration data
Spirometry keyboard
• Function keys for Spirometry UI
Module Pneumatics
• Gas Pump with damping chamber
• Pump motor speed controlled by Vflow
• Pump rotation pulses Fpump to CPU
• Zeroing valve
• Occlusion valve
• Sensor for ambient pressure
• Sensor for gas sensor working pressure
• Sensor for gas sample flow
• Sensor for OM ref.input pressure
• Pneumatics block for correct gas flows to sensors & damping pressure pulses
• CO2- absorber for zero gas
• Nafion tubes for equalizing gas sample and zero gas humidity with ambient

3

Planned and corrective maintenance

About the maintenance check procedures

This chapter describes the planned and corrective maintenance check procedures for the product. To help ensure the equipment remains in proper operational and functional order and maintains its essential performance and basic safety, follow the corrective and planned maintenance instructions. The tests and the replacement of planned maintenance parts that are related to the essential performance and basic safety are marked with the *.

The cleaning precautions, cleaning requirements, cleaning procedures, and recommended cleaning solutions are described in the monitor's user manual or supplemental information provided.

For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

Record the results of the planned and the corrective maintenance check procedures to the eCheckforms delivered in the electronic manual media.

WARNING	SAFETY HAZARD. To avoid risks to personnel and patient, or damage to the equipment, only perform maintenance procedures described in this manual. Unauthorized modifications can lead to safety hazards.
CAUTION	EQUIPMENT DAMAGE. Do not apply pressurized air or gas to any outlet or tubing connected to the monitor. Pressure may destroy sensitive elements.

Corrective maintenance

Perform the following check procedure after any corrective maintenance, before taking the product back into clinical use:

Performed service activity	Required checkout procedure	
	Visual inspection	Functional check
Front panel replacement	All steps	Check module keys only.
OM reference gas filter assembly or OM reference disc filter	All steps	Check sample flow rate. *
Module case opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps

Planned maintenance

WARNING PATIENT SAFETY. Planned maintenance must be carried out at the specified interval. Failure to implement the maintenance schedule may cause equipment failure and possible health hazards.

Perform the planned maintenance procedure completely every 12 months after installation. Perform the procedure in the following order:

1. Replacement of planned maintenance parts *
2. Visual inspections
3. Functional check

Replacement of planned maintenance parts*

Replace the following parts that wear in use at the following interval.

Description	Pieces	Replacement interval
Dehumidification tube, 230 mm (main flow)	1	Once a year
OM reference gas filter assembly including O-ring	1	Once a year
OM reference disc filter	1	Once a year
PM sticker	1	Once a year
Dehumidification tube, 85 mm (zero line)	1	Once every 4 years
CO_2 absorber	1	Once every 4 years

GE Healthcare recommends that you replace the D-fend Pro water trap, the gas sampling line and the spirometry tube as part of the planned maintenance procedure.

NOTE: See the supplemental information provided for compatible accessories.

Planned maintenance kits

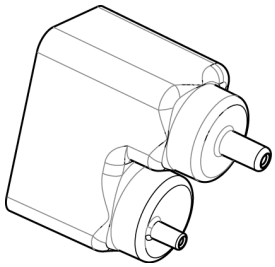
The required planned maintenance parts are included in PM kits.

Part number	Description
2093610-001	One year Planned Maintenance Kit for CARESCAPE Respiratory modules. The PM kit includes the required dehumidification tube, 230 mm (mainflow), the OM reference gas filter assembly with an O-ring, OM reference disc filter, and a PM sticker. NOTE: The one year PM kit does not include the CO_2 absorber and dehumidification tube, 85 mm (zero line).
2093594-001	Four year Planned Maintenance Kit for CARESCAPE Respiratory modules. NOTE: The four year PM kit contains all required PM parts.

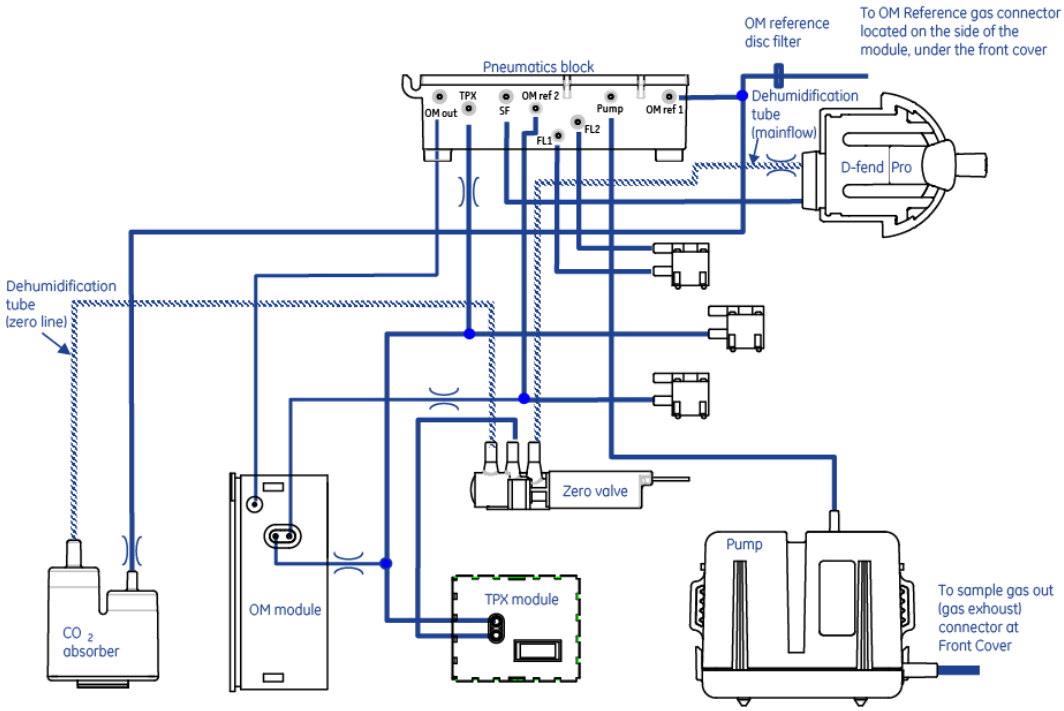
Replacing planned maintenance parts*

Replace the specified planned maintenance parts according to the chapter Disassembly and reassembly.

1. Replace the CO_2 absorber every 4 years.



2. Replace the dehumidification tubes and check the condition of the internal tubing.
   a. Check that the tubing inside the module is not contaminated. Any contamination inside the tubing may indicate that the valves or sensors are contaminated, too. This can increase a risk of faulty operation in valves or sensors. The valves or gas sensors are not possible to clean in the field. Therefore, if you noticed any contamination in the module tubing, send the module to GE for factory service.



NOTE: The dehumidification tubes do not include the silicon fittings they connect to. Use the original silicon fittings unless they are damaged or leaking.

3. Replace the OM reference gas filter assembly.
4. Replace the OM reference disc filter.

   NOTE: If the module does not have the disc filter, install it to the OM reference line according to the instructions in the Disassembly and reassembly chapter.
5. Check that the fan and ventilation hole are not covered in dust.

Performing visual inspection

1. Remove the module from the host device and check that:
   a. The front cover is intact.
   b. All connectors are intact, clean and attached properly.
   c. The module casing and the latch are clean and intact.
   d. The module and gas sampling and spirometry tubes are clean and intact.
2. Check that the D-fend Pro and its connectors are clean and intact.

Performing functional check

Required tools for the functional check

For a list of compatible accessories, see the supplemental information provided.

- Barometer

- Mass flowmeter for measuring air flow, minimum measurement range from 0 to 200ml/min, accuracy 5% or better in the 0 to 200 ml/min range.
- P/N: 755534-HEL Calibration Gas Regulator
- P/N: 755583-HEL Calibration gas, CO2, O2, N2O, DESF, package of 1 can (with E-sCAiO, E-sCAiOV, and E-sCAiOVX modules)
- P/N: 755581-HEL QUICK CAL calibration gas, CO2, O2, N2O, package of 4 cans (with sCO, E-sCOV, and E-sCOVX modules)
- P/N: M1006864, Calibration Gas Regulator, US only
- P/N: 755571-HEL, Calibration Gas, 5% CO2, 54.5% O2, 36.0% N2O, 2.0% DESFLURANE, BAL N2 (with E-sCAiO, E-sCAiOV, and E-sCAiOVX modules) US only
- P/N: 755587, Calibration Gas, CO2, O2, Balance, 4 cans/pkg (with E-sCO, E-sCOV, and sCOVX modules) US only
- D-fend Pro water trap
- 3 m / 10 ft GE anesthesia gas sampling line
- Spirometry tube, 3 m/10 ft (with E-sCOV, E-sCOVX, E-sCAiOV, and E-sCAiOVX modules)
- Adult D-lite sensor
- Pressure manometer with either an integrated or a separate pressure pump
- Tubing for spirometry leak tests
- Forceps

Making connections for the functional check

1. Disconnect the module from the monitor for the first two tests:
   - gas sampling system leak test
   - spirometry system leak test

   For the rest of the functional check steps:
2. Turn on or restart the monitor and wait until the normal screen appears.
3. Ensure that the module is connected to the monitor.
4. Let the module warm up for at least 5 minutes.

Configuring monitor for functional check

1. Configure the CO2, O2, AA, and Flow waveform fields to the monitor screen with adequate priority.
2. Configure the Spiro 1 split screen to the monitor screen.
3. Select the ***Setup*** tab in the ***Spirometry & Gas Exchange*** menu and configure:
   a. ***Scaling***: Auto
   b. ***Sensor Type***: Adult
   c. ***Show Volume***: TV

Testing respiratory module features

Mark each task as complete on the checkout form.

1. Gas sampling system leak test *

   NOTE: Disconnect the gas module from the monitor during the leak test.

   Check the gas sampling system for possible leakages.

   a. Disconnect the module from the monitor.

   b. Detach the module front cover and casing.

   c. Block the OM reference tube with the forceps. Correct positioning of the forceps is indicated by the figure below.

      NOTE: Be careful when attaching the forceps to the tube and avoid stretching the tube. Short pieces of silicone tubing on the forcep jaws can be used to protect the tube from breaks that may appear when the tube is compressed between the jaws.

   d. Connect a new D-fend Pro water trap to the module.

   e. Connect a new gas sampling line to the sampling line connector in the water trap.

   f. Connect the other end of the gas sampling line to a pressure manometer and a pressure pump.

   g. Block the sample gas out (gas exhaust) connector.

   h. Carefully pump 80 mmHg ± 20 mmHg pressure to the gas sampling system. Let the pressure stabilize for 10 - 20 seconds.

   i. Check that the pressure reading does not drop more than 2 mmHg during 25 seconds.

   j. Release the forceps, and attach the module casing. Make sure that the tubing fits nicely into the module casing.

2. Spirometry system leak test

   NOTE: Perform this test only for E-sCOV, E-sCOVX, E-sCAiOV, and E-sCAiOVX modules.

   NOTE: Disconnect the gas module from the monitor during the leak test.

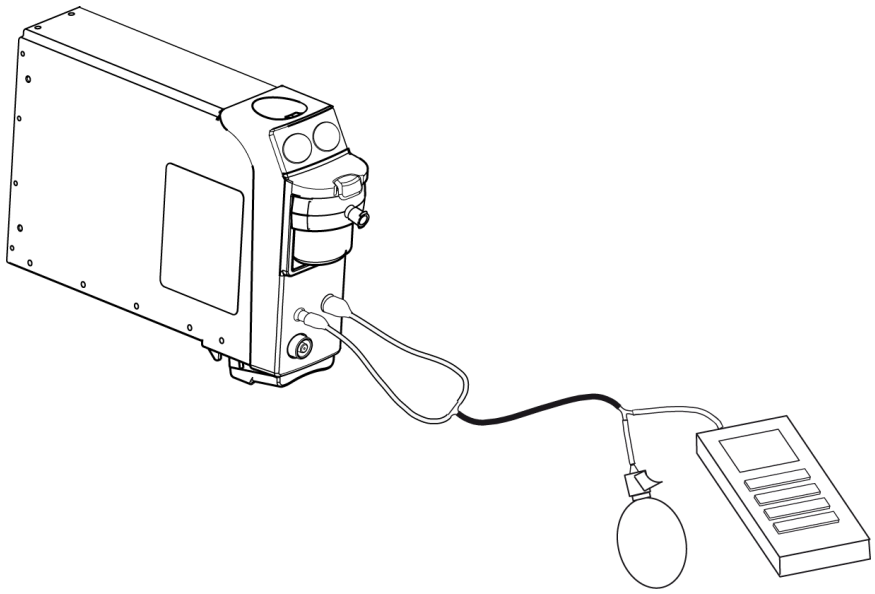
   NOTE: The spirometry pressure transducers are very sensitive for differential overpressure. A momentary differential pressure between the two spirometry connectors exceeding 25 cmH_2O (18 mmHg) may damage the pressure sensors. To ensure that both pressure channels are equally pressurized, make sure that the tubing between the manometer and the two spirometry connectors is connected tightly, the tubes are equally long and thick and not kinked.

   NOTE: Do not overpressure the spirometry sampling system. A static pressure exceeding 300 cmH_2O (220 mmHg) may damage the pressure sensor.

   Check the spirometry sampling system for possible leakages.

   a. Disconnect the module from the monitor.

   b. Connect a pressure manometer to the spirometry connectors.



   c. Pump ~68 cmH_2O (50 mmHg ±10 mmHg) pressure to the Spirometry sampling system. Let the pressure stabilize for approximately 10 seconds.

   d. Verify that the pressure reading does not drop more than 4 cmH_2O (3 mmHg) during one minute.

3. Sample flow rate check *

   Check the sample flow rate.

   Connect the module to the monitor.

   NOTE: Anesthetic gas measurement is not available during the first 1 to 5 minutes after the module is connected due to warming up. A message '***Calibrating Gas Sensor***' is shown in the waveform field. Wait until warm-up is completed before proceeding with the next steps.

   NOTE: The ambient temperature and air pressure influence the flow rate measured by the flow meter. A flow meter, which has been calibrated at 21.11°C (70°F) and 760 mmHg (1013 mbar), measures the flow rate correctly under the same conditions, i.e. in room temperature at sea level. A flow rate correction as instructed by the manufacturer of the flow meter needs to be performed when measuring flow rate under other conditions, for example in high altitude.

   a. Connect the gas sampling line to the sampling line connector.
   b. Connect the other end of the gas sampling line to a flowmeter.
   c. Check the sample flow rate reading from the flowmeter. The flow rate should be within the specification limit 120 ± 20 ml/min.

   NOTE: Readjustment is needed, if the measured value is not within the specification limit.

4. Reference gas flow rate check *

   Check the flow rate in reference gas inlet:

   a. Connect the gas sampling line to the sampling line connector.
   b. Leave the other end of the gas sampling line open to room air.
   c. Connect the flowmeter to the OM reference gas inlet on the side of the module with a piece of tubing.
   d. Check that the ***Reference Flow*** is within the following range: 10 - 50 ml/min.
   e. Detach the water trap.
   f. Attach the front cover.

5. Fan *

   a. Check that the gas module's fan is running behind the D-fend Pro water trap.
   b. Attach the water trap.

6. Module keys

   NOTE: Perform this test only for E-sCOV, E-sCOVX, E-sCAiOV, and E-sCAiOVX modules.

   a. Press the **Change Loop** module key.
   b. Check that the spirometry loop is changed from ***Flow / Vol*** loop to ***Paw/Vol*** loop, or vice versa.
   c. Leave the ***Flow / Vol*** loop on the screen.

7. Zero valve operation *

   Select the calibration gas according to the module type and region. For more information, see the Required tools for the functional check section.

   Test the zero valve functionality:

   a. Connect the gas regulator to the calibration gas container.

   b. Connect the gas sampling line to the sampling line connector.

   c. Connect the end of the gas sampling line to the regulator on the gas container. Leave the regulator overflow port open to room air.

   d. Select ***Monitor Setup*** > ***Main Setup*** > ***Parameter Setup*** > ***Gases***.

   e. Select ***CO2*** > ***Setup*** and check that ***Gas Module (Mod)*** has been selected as ***Measurement Source***.

   f. Select ***Monitor Setup*** > ***Defaults & Service*** >***Service Calibrations***.

   g. Enter the ***Username*** and the ***Password*** and press **Enter** to get into the ***Service / Calibrations*** menu.

   h. Select ***Gases***.

   i. Start feeding the specified calibration gas. Wait until the gas values shown in the ***Gases Calibration*** menu rise approximately to the level indicated in the labelling of the calibration gas container.

      NOTE: The gas values in the ***Gases Calibration*** menu is in percentages (%).

   j. Open the zero air valve to room air by selecting ***Zero valve*** : ***Off*** button (zero position).

   k. Check that the ***CO2***, ***N2O*** and anesthesia agent values drop back near 0% and the O2 reading near 21% (room air).

   l. Stop feeding the calibration gas.

   m. Turn the zero valve back to the normal measurement position by selecting ***Zero valve*** : ***On*** button.

8. Gas calibration *

   Perform gas calibration according to the instructions in section Gas Calibration.

9. Agent identification *

   NOTE: Perform this test only for E-sCAiO, E-sCAiOV, and E-sCAiOVX modules.

   Check agent ID unreliability:

   a. Feed the specified calibration gas for at least 30 seconds.

   b. Select ***Monitor Setup*** > ***Defaults & Service*** > ***Service Calibrations*** > ***Gases*** > ***Main***, and check that anesthesia agent is identified as Desflurane and the IDu value (=agent ID unreliability) is lower than 75.

      If the value is higher, repeat the gas calibration and check the value again.

10. Ambient pressure *

    Use a barometer to check the operation of the absolute pressure sensor.

    Select ***Monitor Setup*** > ***Defaults & Service*** > ***Service Calibrations*** > ***Gases*** > ***Main***, and check that that the ambient pressure value does not differ more than ± 10 mmHg from the value shown by the barometer.

    NOTE: The ambient pressure value in the ***Gases Calibration*** menu is in mmHg.

11. Occlusion detection *
    a. Block the tip of the sampling line by your finger.
    b. Check that the ***Sample line blocked*** message appears in the parameter window within 30 seconds.
12. Air leak detection *
    a. Detach the D-fend Pro water trap.
    b. Check that the ***Check Water Trap*** message appears in the parameter window within 30 seconds.
    c. Attach the water trap.
13. Gas exhaust blockage *
    a. Block the gas exhaust connector with your finger.
    b. Check that the ***Sample gas out*** message appears in the parameter window within 30 seconds.
14. Airway gases *
    a. Breathe a minimum of 5 times to the tip of the sampling line.
    b. Check that a normal ***CO2*** waveform appears in the waveform field and the ***EtCO2*** and ***FiCO2*** values are updated in the parameter window.
15. Apnea detection
    a. Stop breathing to the gas sampling line.
    b. Check that the ***Apnea (CO2)*** alarm appears in the message field within 30 seconds.
16. Flow waveform

    NOTE: Perform this test only for E-sCOV, E-sCOVX, E-sCAiOV, and E-sCAiOVX modules.
    a. Connect a clean spirometry tube and D-lite to the module.
    b. Breathe through the wider side of the D-lite.
    c. Check that the flow waveform responds when you breathe in and out. The setting of the inspiratory flow may be positive or negative.

Completing the functional check

1. Select ***Discharge Patient*** or ***Reset Case*** to discard any changes made to the monitor configuration during the functional check.
2. Disconnect the test setup.

4

Configuration and calibration

Configuration

There is no service configuration for this module.

Software update

The module software can be updated in two ways:

- using the software installation kit and the service interface
- using InSite RSvP

To update the software from the software installation kit, connect a service laptop to the host monitor and transfer the new software to the monitor.

When the transfer is complete, activate the software through the service interface.

For more detailed information on updating the software, see the host monitor's service manual.

Calibration and adjustments

Sample flow rate adjustment

Sample flow rate shall be adjusted:

- if the sample flow rate check failed.

Required tools

- A mass flowmeter for measuring air flow, minimum measurement range from 0 to 200ml/min, accuracy 5% or better in the 0 to 200 ml/min range.
- 3 m / 10 ft GE anesthesia gas sampling line.

NOTE See the supplemental information provided for compatible accessories.

NOTE Use only accurate, properly maintained, calibrated, and traceable calibration tools for the parameter calibration to ensure measurement accuracy.

NOTE If the flowmeter unit is not ml/min, it shall be converted to ml/min according to the instructions of the flow meter manufacturer.

NOTE Refer to the flowmeter documentation for user instructions.

Making connections

1. Ensure that the module is connected to the monitor.
2. Ensure that you have a new D-fend Pro water trap in use.
3. Connect a new gas sampling line to the sampling line connector in the water trap.
4. Connect the other end of the gas sampling line to the flow meter.

NOTE Before checking or adjusting the sample flow, make sure there is no leakage in the sampling system.

Adjusting sample flow rate

1. Select ***Monitor Setup*** > ***Main Setup*** > ***Parameter Setup*** > ***Gases***.
2. Select ***CO2*** > ***Setup*** and check that ***Gas Module (Mod)*** has been selected as ***Measurement Source***.
3. Select ***Monitor Setup*** > ***Defaults & Service*** > ***Service Calibrations***.
4. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
5. Select ***Gases***.
6. Select the ***Sample Flow Adjustment***: ***Start*** button.

7. Adjust the sample flow to the nominal value 120 ml/min by using the ***Sample Flow Gain*** up-down spinner controls:
   a. To decrease the sample flow rate measured by the flow meter by approximately 7.5 ml / min, add gain value by 0.05.
   b. To increase the sample flow rate measured by the flow meter by approximately 7.5 ml / min, lower the gain value by 0.05.
8. Press ***Confirm*** to check the effect of the gain adjustment. Wait until the sample flow value shown in the calibration menu returns near to the nominal value 120 ml/min and then check the actual measured flow rate from the flow meter.
9. Repeat steps 7 and 8 until the flow meter shows a 120 ± 20 ml /min flow rate.
10. Select the ***Sample Flow Adjustment***: ***Stop*** button to save the new gain value to the permanent memory of the module.

NOTE Adjust the flow rate according to the reading in the flow meter. The flow rate reading in the calibration menu is measured by the internal electronics and settles always back to the nominal 120 ml /min independent on the real flow rate.

Gas calibration

WARNING ERRONEOUS READINGS. A failure in zeroing or calibrating airway gases may cause inaccurate readings.

WARNING EXPOSURE TO ANESTHETIC AGENTS. Since calibration gas contains anesthetic agents, always ensure sufficient ventilation of the room during calibration.

Gas calibration shall be performed:

- each time planned maintenance is performed.
- each time corrective maintenance is performed.
- each time calibration check (performed by the clinical user) fails.

Required tools

- P/N: 755534-HEL Calibration Gas Regulator
- P/N: 755583-HEL Calibration gas, CO2, O2, N2O, DESF, package of 1 can (with E-sCAiO, E-sCAiOV modules)
- P/N: 755581-HEL QUICK CAL calibration gas, CO2, O2, N2O, package of 4 cans (with E-sCO, E-sCOV modules)
- P/N: M1006864, Calibration Gas Regulator, US only
- P/N: 755571-HEL, Calibration Gas, 5% CO2, 54.5% O2, 36.0% N2O, 2.0% DESFLURANE, BAL N2 (with E-sCAiO, E-sCAiOV modules) US only
- P/N: 755587, Calibration Gas, CO2, O2, Balance, 4 cans/pkg (with E-sCO, E-sCOV modules) US only
- 3 m / 10 ft GE anesthesia gas sampling line

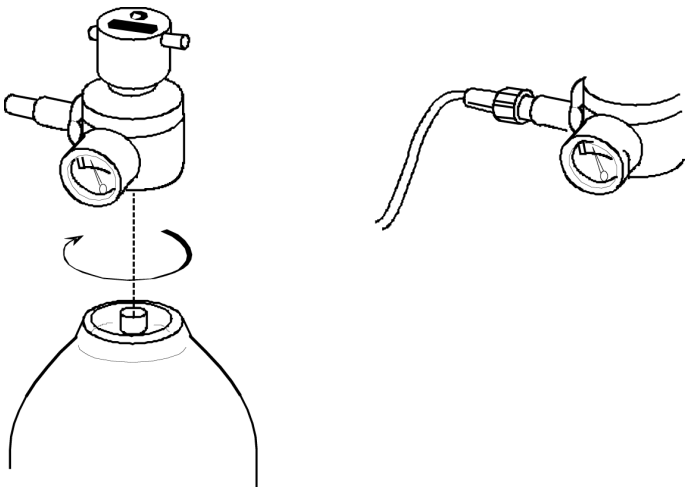
NOTE Use only the specified GE Healthcare calibration gas for the gas calibration to ensure measurement accuracy. Do not use any other calibration gases. Check the calibration gas container's labeling to ensure that the calibration gas has not expired.

NOTE Ensure that the gas regulator is functioning properly before gas calibration. Refer to the gas regulator's Instructions for Use letter for the annual maintenance instructions.

Making connections

1. Ensure that the module is connected to the monitor.
2. Ensure that you have a new D-fend Pro water trap in use.
3. Connect the gas regulator to the calibration gas container.
4. Connect a new gas sampling line to the sampling line connector in the water trap.
5. Connect the other end of the gas sampling line to the regulator on the gas container. Leave the regulator overflow port open to room air.

The following illustrates how to connect a gas regulator to the calibration gas container and a sampling line to the gas regulator:



Calibrating gases

NOTE Gas calibration is not available during the first five minutes after the module is connected. The message ***Gas calibration is not available during first 5 minutes*** is shown in the lower left corner of the gases calibration main menu. For maximum accuracy, let the monitor warm up for 30 minutes before starting calibration.

NOTE Gas calibration is not available during a ***Sample line blocked***, ***Check Water Trap*** and ***Check sample gas out*** alarm condition. The message ***Gas calibration is not available due to alarm condition*** is shown in the lower left corner of the calibration menu. Resolve the alarm condition before starting calibration.

1. Select ***Monitor Setup*** > ***Main Setup*** > ***Parameter Setup*** > ***Gases***.

2. Select ***CO2*** > ***Setup*** and check that ***Gas Module (Mod)*** has been selected as ***Measurement Source***.
3. Select ***Monitor Setup*** > ***Defaults & Service*** > ***Service Calibrations***.
4. Enter the User Name and the Password and press **Enter** to get into the ***Calibrations*** menu.
5. Select ***Gases***.
6. Select the ***Gases Calibration*** tab.

7. The monitor will start automatic zeroing of the gas sensors. Wait until the message ***Zeroing*** is replaced by the message ***Zero OK*** for all the measured gases.
8. Wait until the message ***Feed gas*** appears.
9. Open the regulator and feed the gas. The measured gas concentrations are displayed in real-time in the gas calibration menu. Wait until the measured gas concentrations are stabilized and the ***Adjust*** message appears for all the measured gases, then close the regulator.
10. Use the up-down spinner controls to adjust the gas value displayed in the calibration menu until they match the values on the calibration gas container.
11. Confirm by selecting ***Accept***.
12. If the calibration is successful, the message ***Calibration OK*** is displayed for a few seconds. If the calibration fails, the message ***Calibration error*** appears instead. In this case, start a new calibration by selecting ***Recalibrate***.

NOTE The message ***Zero error*** is shown in case the zeroing fails.

NOTE The message ***Calibration error*** is shown, if you do not start feeding gas within one minute after the automatic zeroing is completed, or if the calibration fails due to too large gain adjustment.

Spirometry calibration

Spirometry does not require regular service calibration during planned maintenance, or after the MiniPVX unit has been replaced. Calibration is only needed if there is a permanent difference between the measured inspiratory and expiratory volumes.

The MiniPVX measuring unit is calibrated at the factory and due to the unit's design, spirometry calibration is not regularly needed in the field. The calibration data is saved into the board's EEPROM.

If calibration is desired, it is recommended to perform the calibration both with adult values using the D-lite, and with pediatric values using the Pedi-lite.

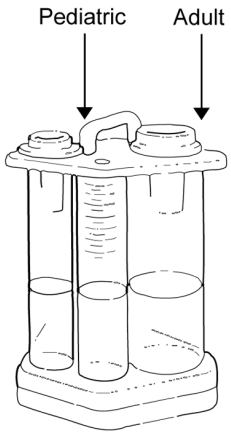
Required tools

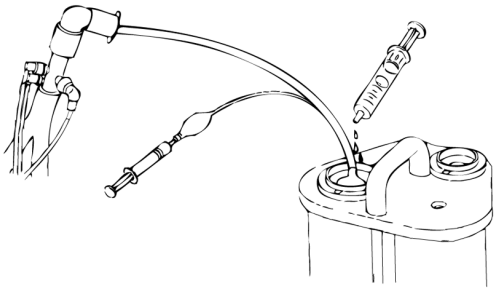
- P/N 884202-HEL Spirometry tester
- D-lite and Pedi-lite sensors
- Spirometry tube
- Ventilator

NOTE See the supplemental information provided for compatible accessories.

Making connections

1. Refer to the instructions for use of the spirometry tester for the setup.





Configuring the monitor

1. Configure the ***Flow*** waveform field to the monitor screen with adequate priority.

2. Select the ***Setup*** tab in the ***Spirometry & Gas Exchange*** or ***Spirometry*** (NICU software package) menu and configure:
   a. ***Scaling***: Auto
   b. ***Sensor Type***: Adult
   c. ***Show Volume***: TV

Configuring the ventilator

1. Configure the ventilator to use air as fresh gas.
2. Set the Tidal Volume (***TV***) to 500 ml/min when doing calibration check and calibration with adult sensor and 100 ml/min with pediatric sensor.
3. Set the ***RR*** =15, ***I/E*** =1/2 and ***PEEP*** 0cmH2O.

Checking ventilator calibration

1. Perform the calibration check according to the steps 1 through 12 a in the instructions for use of the spirometry tester.

   NOTE: Let the gas module to warm up at least for 10 minutes before performing the calibration check or flow calibration.
2. The measured flow values are shown in real-time in the ***TV Insp*** and ***TV Exp*** fields in the ***Flow*** parameter window. Compare these measured values to the TV value reading (highest water level) in the spirometry tester.

Acceptance criteria:

- If the ***TV Insp*** and ***TV Exp*** values differ less than ± 6% of the value read from the spirometry tester, flow calibration is not needed.
- If the ***TV Insp*** and ***TV Exp*** values differ more than ± 6% of the value read from the spirometry tester, perform flow calibration.

Calibrating flow

1. Select ***Monitor Setup*** > ***Main Setup*** > ***Parameter Setup*** > ***Gases***.
2. Select ***CO2*** > ***Setup*** and check that ***Gas Module (Mod)*** has been selected as ***Measurement Source***.
3. Select ***Monitor Setup*** > ***Defaults & Service*** > ***Service Calibrations***.
4. Enter the User Name and the Password and press **Enter** to access the ***Calibrations*** menu.
5. Select ***Gases***.
6. Select ***Spirometry Calibration***.
7. Ensure that the ***Sensor Type*** is correct and that ***Spirometry Zeroing*** is Enabled.
8. Wait until the MiniPVX sensor performs an automatic zeroing. It shows a message ***zeroing*** in the Flow parameter window when zeroing takes place.

9. Adjust the ***Exp Flow Gain*** and/or ***Insp Flow Gain*** separately by using the related up-down spinner controls to calibrate the measured ***TV Exp ml*** and ***TV Insp ml*** values:
   - To increase the ***TV Exp ml*** flow value, increase the ***Exp Flow Gain***.
   - To decrease the ***TV Exp ml*** flow value, lower the ***Exp Flow Gain***.
   - To increase the ***TV Insp ml*** flow value, increase the ***TV Flow Gain***.
   - To decrease the ***TV Insp ml*** flow value, lower the ***TV Flow Gain***.
10. Press ***Confirm*** to check the effect of the gain adjustment to the flow readings.
11. Repeat steps 9 and 10 until the flow values are within the specification.

5

Troubleshooting

Troubleshooting guidelines

This chapter focuses on troubleshooting technical problems. Refer to the user manual for troubleshooting monitoring problems and clinical configuration issues.

If a problem remains, contact technical support for service. To ensure accurate problem solving, please be prepared to provide the following information:

- Product name and serial number or UDI
- Hardware and software versions
- Detailed problem description
- Error messages, if any
- Configuration information (or settings file)
- Service Logs
- The troubleshooting you have done so far

Perform the specified corrective maintenance check after any corrective maintenance to the product.

Performing visual inspection

Before any detailed troubleshooting, complete a thorough visual inspection for the module.

1. Remove the module and check that:
   a. The front cover is intact.
   b. All the connectors are intact, clean, and attached properly.
   c. The module casing and the latch are clean and intact.
   d. The water trap connection and disconnection function properly.
   e. The patient cables are clean and intact.
   f. The metal D-fend Pro connectors and the D-fend O-rings are clean and intact.

2. If you suspect that there are loose parts or cable connections inside the module, remove the four screws from the back of the module to detach the module box, and check that:
   a. All the screws are tightened properly.
   b. All the cables are connected properly.
   c. The tubes are not pinched, and there are no sharp bends on them.
   d. All the tubes are connected properly.
   e. There are no loose objects inside the module.

Troubleshooting checklist

The following simple troubleshooting hints may help you to localize and isolate a functional problem to the correct unit. Ensure that the monitor is turned on and the module is connected:

- Check if there are any messages shown in the display message field. Find the possible cause and solution from the 'Messages' section later in the chapter.
- Check that the connected modules are compatible with the monitor system. Compatibility information can be found from the CARESCAPE monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.
- Connect the accessories to the module. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (***Monitor Setup*** > ***Screen Setup*** > ***Upper Parameter Area***).
- Do a visual check to the accessories used with the module. If in doubt, replace the accessories with known good ones.

Gas sampling system troubleshooting

- Faults which can occur in the sampling system are: leaks or blockages in the tubing, failure of the sampling pump or the magnetic valves, or diminishing of the flow rates because of dirt or other matter accumulating in the internal tubing or failure of pressure sensors.
- Whenever you inspect the sampling system and always after having done any work on the sampling system, check the sampling system for leakages and check the flow rate.
- The D-fend Pro water trap should be replaced when the ***Replace Water Trap*** message appears.
- If any liquid has entered the MiniTPX measuring unit due to water trap filter failure, contact GE Healthcare service.
- Check that the tubing inside the module is not contaminated.
  Any contamination inside the tubing may indicate that the valves or sensors are contaminated, too. This can increase the risk of faulty operation in valves or sensors. You cannot clean the valves or gas sensors in the field. Therefore, if you noticed any contamination in the module tubing, replace the entire module and send the module to GE Healthcare for factory service.

NOTE: All internal tubes are mechanically fragile. Sharp bends may cause leaks and occlusions.

MiniOM measuring unit troubleshooting

- Due to the complicated and sensitive mechanical construction of the oxygen measuring unit, you should not attempt any repairs inside the unit. Instead, if the fault has been found in the measuring unit itself, replace the entire module and send the faulty module to GE Healthcare for repair.
- In cases of no response to O_2 or strong drift, check the tubing for loose connections, blockages, and leaks.
- Check also the OM reference gas filter assembly, and replace if needed.
- If the O_2 signal is noisy, check the measurement unit suspension and if the MiniOM tubing has tension.

NOTE: Never apply overpressure to the O_2 measuring unit, as the pressure transducer may be permanently damaged.

MiniTPX measuring unit troubleshooting

The MiniTPX measuring unit can only be repaired at the factory. In case of failure, replace the entire module and send the faulty module to GE Healthcare for repair.

MiniPVX measuring unit troubleshooting

In case of failure, replace the MiniPVX unit. Perform spirometry system leak test to check if there is any leakages in the internal or external spirometry tubing.

CPU board troubleshooting

- Due to the complexity of the large scale integrated circuitry, there are few faults in the CPU digital electronics that can be located without special equipment.
- Check that all connectors and screws are properly installed.
- In case of failure, replace the entire module and send the faulty module to GE Healthcare for repair.

Viewing device information

To view the hardware, software and configuration information of the monitor, modules and/or connected devices:

1. Ensure that the module is connected to the monitor.
2. Log in to the service interface.
3. Select ***Information***.
4. Select an item on the side navigation menu or scroll down the page to view the information.

Service log files

The monitor collects information about different system events, errors and alarms to log files to help troubleshoot equipment problems. The following service logs may contain related useful information:

- ***System Logs*** records different system events, messages, clinical alarms, user interactions and internal communication events.
- ***EMBC Logs*** records module communication events and errors for E-series acquisition modules.

Viewing log files

1. Log in to the service interface.
2. Select ***Diagnostics*** > ***View Logs***.
3. Select the log you want to view. The contents of the selected log file are shown on the screen.

Downloading log files

For security reasons, the contents of the log file(s) will be encrypted with a user-selectable password before the download. Provide the password in a secure way only for the authorized receiver of the log file. Use 7-Zip open-source file archiver (http://7-zip.org/) and the password to decrypt the downloaded log file.

1. Log in to the service interface.
2. Select ***Diagnostics*** > ***Download Logs***.
3. Select the log(s) you want to download.
4. Provide a password to encrypt the contents of the log file. This password is user-selectable.
5. Depending on your access to the service interface:
   a. If you are using a service PC, you can save the log file to any storage device connected to the service PC.
      i. Select ***Download***.
      ii. Save the log file according to the instructions provided by the web browser.

      The steps to download the log file to a service PC depend on the web browser used. The web browser may also notify you about security issues. Refer to the web browser documentation for details.
   b. If you are using the local, integrated service interface, you can save the log file to a USB flash drive that is connected to one of the monitor's USB ports:
      i. Select ***Save to USB storage*** to save the log file to the USB flash drive.

      The log file is saved always to the root directory of the USB flash drive.

      NOTE Do not disconnect the USB flash drive until downloading is complete.
6. Send the log file and the password in a secure way to GE Service for further investigation.

Messages related to gases measurement

Message	Location	Possible causes	Suggested actions
• ***Apnea deactivated***	• param.	Apnea alarm start-up conditions are not reached.	• Apnea alarm detection is activated after three breaths are detected.
• ***Auto detecting source***	• wavef.	Automatic gas measurement source detection is ongoing.	• Wait until the message disappears.
• ***Calibrating***	• param.	Calibration is in progress.	• Wait until the calibration is successfully completed.
• ***Calibrating gas sensor***	• wavef.	Due to the module warm-up, O_2, CO_2, N_2O, and anesthetic agent measurements are not available immediately after the module has been connected.	• Wait until the warm-up has been completed.
• ***Calibration error***	• param.	Feeding the calibration gas was not started within one minute after the automatic zeroing was completed. CO_2 has been trapped inside the sensor during transport. Calibration failed due to too large a gain adjustment. Wrong calibration gas was used.	• Recalibrate. • Use the specified calibration gas. • Wait for up to 72 hours for possible trapped CO_2 to dissolve.
• ***Check sample gas out*** • ***Sample gas out***	• al. area • param.	The sample gas outflow is blocked. Internal tubing is blocked. Pump failure.	• Check the sample gas out connector in the front panel and the exhaust line for gas return or scavenging for blockages. ▪ If the sample gas is returned to the patient circuit, check that there is no occlusion in the tubing. ▪ If the sample gas outlet is connected to a scavenging system, make sure that such an open system is used where gas is removed in room pressure. • Check the internal tubing for blockages. • Check sample pump operation by measuring the sample gas flow rate. Replace the pump if needed.
• ***Check Water Trap Check water trap and sample gas out. Press Normal Screen to continue.***	• al.area, param. • wavef.	Water trap is not connected. There is a leak inside the internal tubing.	• Connect the water trap and sampling line to the module. • Check the tubing for leakages.

Message	Location	Possible causes	Suggested actions
• ***Continuous blockage. Check sample line and water trap.***	• wavef.	Gas sampling line is blocked. Water trap container is full. Water trap is occluded. Internal tubing is blocked.	• Check the external gas sampling line for blockages. Replace if needed. • Empty the water trap container. • Replace the water trap. • Check the tubing for leakages.
• ***Failure in Agent ID***	• al. area, param.	Agent ID has failed.	• Perform gas calibration. • Check agent ID unreliability according to the functional check instructions. If this does not help, send the module to GE for factory repair.
• ***Gas measurements removed***	• al. area	Acquisition module has been removed.	• Connect the module if you want to restart the measurement.
• ***Gas module standby*** • ***Standby*** • ***Gas module standby. Touch any button/key to activate.*** • ***Gas Module standby. Start Gas Module pump from CO2 setup menu to activate.***	• al. area • param. • wavef.	Acquisition module has shut down the module pump, or the user has stopped the pump through the menu.	• No action required. • To exit the standby mode, touch any button or key. • If needed, you can also turn on the pump by selecting ***Start Gas Module pump***.
• ***Identical gas modules***	• al. area	There are two or more identical gas modules in the system.	• Remove all but one gas modules.
• ***Low gas sample flow***	• al. area	Sample flow deviates to less than 80% of the module's specific nominal flow value. Gas sampling line, gas output, water trap, or internal tubing is blocked. Pump failure.	• Check sample flow rate. Adjust if needed. • Check or replace the gas sampling line, water trap, or internal tubing. • Replace the pump unit.
• ***Over range***	• param.	Measured FiO_2 is more than 103%.	• Calibrate airway gases.
• ***Over scale***	• wavef.	Incorrect waveform scale for the parameter. Depending on the scale selection, the waveform can be clipped because gas concentration exceeds the upper limit for the current scale.	• Change to an appropriate waveform scale, see the user manual.

Message	Location	Possible causes	Suggested actions
• ***Replace Water Trap***	• al. area, param.	Defective or contaminated D-Fend Pro. Occlusion in internal tubing.	• Replace the water trap. • Check sample and reference flows. Perform a visual check for the internal tubing. Remove the cause for occlusion.
• ***Sample line blocked***	• al. area, param.	Gas sampling line is blocked. Water trap container is full. Water trap is occluded. Internal tubing is blocked.	• Check the external gas sampling line for blockages. Replace if needed. • Empty the water trap container. • Replace the water trap. • Check the tubing for leakages.
• ***Zero error***	• param.	Autozeroing during the measurement or in the beginning of the gas calibration has failed.	• Check the zero valve operation. • Replace the zero absorber and dehumidification tube in the zero line. • If this does not help, send the module to GE for factory repair.
• ***Zeroing***	• param., wavef.	Zeroing is in progress.	• Wait until the zeroing is completed.

Messages related to spirometry measurement

For information regarding alarm priorities and escalation times, see the supplemental information provided.

Make sure you are familiar with the generic layout of the screen. This will help you identify where on screen the following messages appear. The message location is indicated with the following abbreviations:

- al. area = alarm area
- param. = parameter window
- wavef. = waveform area

Message	Location	Possible causes	Suggested actions
• ***Low volumes***	• param.	I:E detection does not work. The water trap may not be properly connected, or there may be a leak in the breathing circuit. All of the following conditions are true for 20 seconds: ***No apnea***;	• Check the water trap and its connection. • Check the breathing circuit for leaks. • Check the loops on screen to locate the problem.

Message	Location	Possible causes	Suggested actions
		Ppeak - ***PEEP*** < 2cmH2O; ***TVinsp*** and ***TVexp*** are DATA_INVALID.	
• ***MVexp << MVinsp***	• param.	Expired volume is much smaller (70% or less) than the inspired volume due to a leak in the spirometry system. A leaking tube or occluded spirometry tube. Water in the tubing.	• Replace the spirometry tube. • Perform a spirometry leak test. • Replace the MiniPVX if needed. • Clean the tubing.
• ***Over scale***	• wavef.	***Flow*** or ***Paw*** waveform signal exceeds the upper limit of the current scale.	• Change the ***Paw-Flow*** waveform scale or use autoscaling. For more information, see the user manual.
• ***Saving Loop***	• al. area	A loop is being saved.	• Wait until the message disappears.
• ***Scale changed***	• wavef.	Displayed for 10 seconds after the ***Auto*** scaling mode has changed the ***Flow*** or ***Paw*** scale.	• Wait until the message disappears.
• ***Zeroing***	• param.	Zeroing is in progress.	• Wait until the zeroing is completed.
• ***Zeroing error***	• param.	Zero valve leaking or internal damage in the flow sensor.	• Perform a spirometry leakage test. • Replace the MiniPVX sensor if needed • Check the MiniPVX flex cable.

Messages related to gas exchange measurement

For information regarding alarm priorities and escalation times, see the supplemental information provided.

Make sure you are familiar with the generic layout of the screen. This will help you identify where on screen the following messages appear. The message location is indicated with the following abbreviations:

- al. area = alarm area
- param. = parameter window
- wavef. = waveform area

Message	Location	Possible causes	Suggested actions
• ***Artifact***	• param.	Module is unable to synchronize flow and CO_2 due to a wrong sample line length (> 4 meters).	• Check that the sample line length is 4 meters or less.
• ***Bypass flow high***	• param.	Module is unable to synchronize flow and CO_2 due to a bypass flow.	• Reduce fresh gas flow.

Message	Location	Possible causes	Suggested actions
• ***FiN2O detected***	• param.	Module has detected N_2O.	• Gas exchange cannot be measured if N_2O is used. If you wish to measure gas exchange, use another anesthetic. If the measurement is not used, you may consider removing gas exchange numbers from the screen.
• ***No VO2, FiO2 >85%***	• param.	Unable to measure gas VO_2 because the measured FiO_2 is out of gas exchange specification (>85%).	• Use lower O_2 concentrations.
• ***Out of range***	• param.	VO_2 or VCO_2 is <0 or > 999 ml/min and therefore outside the measurement range.	• Check that the gas sampling line and spirometry lines are correctly connected to the patient airway and to the gas module. • Check that the correct sensor type (D-lite/Pedi-lite) has been selected from the monitor menu.

Messages related to servicing gas modules

For information regarding alarm priorities and escalation times, see the supplemental information provided.

Make sure you are familiar with the generic layout of the screen. This will help you identify where on screen the following messages appear. The message location is indicated with the following abbreviations:

- al. area = alarm area
- param. = parameter window
- report = report view
- wavef. = waveform area

Message	Location	Possible causes	Suggested actions
• ***Service Gas Module Error Code 0xGAS0001*** • ***Service gas module. CO2, N2O, AA sensor failed*** • ***Service gas module***	• al. area. • wavef. • param.	MiniTPX unit failure.	• Return the module to GE for service.
• ***Service Gas Module Error Code 0xGAS0010*** • ***Service gas module. O2 sensor failed***	• al. area. • wavef. • param.	MiniOM oxygen sensor failure.	• Return the module to GE for service.

Message	Location	Possible causes	Suggested actions
• ***Service gas module***			
• ***Service Gas Module Error Code 0xGAS0011*** • ***Service gas module. CO2, N2O, AA sensor failed*** • ***Service gas module. O2 sensor failed*** • ***Service gas module***	• al. area. • wavef. • wavef. • param.	Simultaneous MiniTPX measuring unit and MiniOM oxygen sensor failure.	• Return the module to GE for service.
• ***Service Gas Module Error Code 0xGAS0100*** • ***Service gas module. Spirometry sensor failed*** • ***Service gas module***	• al. area. • wavef. • param.	Spirometry sensor failure.	• Replace the spirometry sensor.
• ***Service Gas Module Error Code 0xGAS0101*** • ***Service gas module. CO2, N2O, AA sensor failed*** • ***Service gas module. Spirometry sensor failed*** • ***Service gas module***	• al. area. • wavef. • wavef. • param.	Simultaneous MiniTPX measuring unit and spirometry sensor failure.	• Return the module to GE for service.
• ***Service Gas Module Error Code 0xGAS0110*** • ***Service gas module. O2 sensor failed*** • ***Service gas module. Spirometry sensor failed*** • ***Service gas module***	• al. area. • wavef. • wavef. • param.	Simultaneous MiniOM oxygen sensor and spirometry sensor failure.	• Return the module to GE for service.
• ***Service Gas Module Error Code 0xGAS0111*** • ***Service gas module. CO2, N2O, AA sensor failed*** • ***Service gas module. O2 sensor failed*** • ***Service gas module. Spirometry sensor failed*** • ***Service gas module***	• al. area. • wavef. • wavef. • wavef. • param.	Simultaneous MiniTPX measuring unit, MiniOM oxygen sensor, and spirometry sensor failure.	• Return the module to GE for service.

Message	Location	Possible causes	Suggested actions
• ***Service Gas Module Error Code 0xGAS1000*** • ***Service gas module. Gas measurement failed*** • ***Service gas module***	• al. area • wavef. • param.	General gas measurement failure.	• Return the module to GE for service.
• ***Service Gas Module Error Code 0xGAS1001*** • ***Service gas module. Gas measurement failed*** • ***Service gas module***	• al. area • wavef. • param.	Simultaneous MiniTPX unit and general gas measurement failure.	• Return the module to GE for service.
• ***Service Gas Module Error Code 0xGAS1010*** • ***Service gas module. Gas measurement failed*** • ***Service gas module***	• al. area • wavef. • param.	Simultaneous MiniOM oxygen sensor and general gas measurement failure.	• Return the module to GE for service.
• ***Service Gas Module Error Code 0xGAS1011*** • ***Service gas module. Gas measurement failed*** • ***Service gas module***	• al. area • wavef. • param.	Simultaneous MiniTPX measuring unit, MiniOM oxygen sensor, and general gas measurement failure.	• Return the module to GE for service.
• ***Service Gas Module Error Code 0xGAS1100*** • ***Service gas module. Gas measurement failed*** • ***Service gas module***	• al. area • wavef. • param.	Simultaneous spirometry sensor and general gas measurement failure.	• Return the module to GE for service.
• ***Service Gas Module Error Code 0xGAS1101*** • ***Service gas module. Gas measurement failed*** • ***Service gas module***	• al. area • wavef. • param.	Simultaneous MiniTPX measuring unit, spirometry sensor, and general gas measurement sensor failure.	• Return the module to GE for service.

Message	Location	Possible causes	Suggested actions
• ***Service Gas Module Error Code 0xGAS1110*** • ***Service gas module. Gas measurement failed*** • ***Service gas module***	• al. area • wavef. • param.	Simultaneous MiniOM oxygen sensor, spirometry sensor, and general gas measurement failure.	• Return the module to GE for service.
• ***Service Gas Module Error Code 0xGAS1111*** • ***Service gas module. Gas measurement failed*** • ***Service gas module***	• al. area • wavef. • param.	Simultaneous MiniTPX measuring unit, MiniOM oxygen sensor, spirometry sensor, and general gas measurement failure.	• Return the module to GE for service.

Troubleshooting charts

Troubleshooting CO_2 measurement

Problem	Possible clinical cause	Possible technical cause	What to do
Too low $EtCO_2$ value	• sudden decrease in circulation • pulmonary embolism • hyperventilation • very large dead-space • large shunting	• leak in sampling system • calibration error • high by-pass flow from ventilator • incorrect humidity compensation • CO_2 trapped inside the sensor during transport	• Check all connections. • Check calibration. • Check the host device's humidity compensation type: ***Wet***(BTPS) / ***Dry***(ATPD). • Wait for up to 72 hours for possible trapped CO_2 to dissolve. Do not calibrate the module while waiting. When the module passes the calibration check, it is ready for use.
Too high $EtCO_2$	• hypoventilation • increased metabolism	• Water trap contamination • calibration error • incorrect humidity compensation	• Change D-fend Pro. • Check calibration. • Check the host device's humidity compensation type: ***Wet***(BTPS) / ***Dry*** (ATPD).
No response to breathing	• apnea • gas sample line disconnected	• sampling line or water trap loose or blocked (air leak) • sample gas out blocked	• Check all connections. • Check that the outlet is open.

Problem	Possible clinical cause	Possible technical cause	What to do
$EtCO_2$ over scale >15% Shown until 15.5%, specified range 0...15%.	• abnormally high $EtCO_2$ (permissive hypercapnia)	• CO_2 sensor contaminated • Water trap malfunction	• Contact your local service representative. • Change D-fend Pro.
$EtCO_2$>$PaCO_2$	• unit is mmHg or kPa and $EtCO_2$ is close to arterial PCO_2	• ***Dry gas*** as default	• Change to ***Wet gas*** from the ***Default Setup*** > ***Care unit Settings*** > ***Parameters*** menu.

Troubleshooting spirometry measurement

Problem	Possible clinical cause	Possible technical cause	What to do
insp TV>exp TV	• leak in lungs • ET tube cuff leak	• spirometry tube leak • water inside D-lite or tubings • another side stream gas sampling between D-lite and patient • D-fend Pro leaks	• Check leakages – perform leak test. • Change tubings and D-lite. • Do not use active humidification. • Connect gas sampling only and always to D-lite. • Check D-fend Pro.
exp TV>insp TV		• spirometry tube leak • water inside D-lite or tubings	• Check leakages – perform leak test. • Change tubings and D-lite. • Do not use active humidification.
Loop overscale Monitored volumes < set volumes		• wrong scale selected • wrong TV base selected • leak between ventilator and D-lite	• Change scaling. • Select correct TV base (ATPD / BTPS / NTPD / STPD). • Check ventilator connections.
Strongly vibrating loop Too large or too small volumes	• mucus in ET tube	• water or secretions in hoses or D-lite • wrong mode vs. sensor selection • incorrect sensor type selection	• Check the patient status. • Change dry D-lite and/or empty the water from hoses. • Check mode and sensor: ▪ D-lite for adult ▪ Pedi-lite for pediatric

Problem	Possible clinical cause	Possible technical cause	What to do
Fluctuating Raw	• mucus in airways or tubings • breathing effort against the ventilator • patient triggered breaths	• ventilator exp. valve causes fluctuations during exp. flow	• Check the tubings and D-fend Pro. • Check the patient status.
Too high Raw Raw value invalid	• kink in tubing • mucus • asthmatic patient • bronchospasm • spontaneous breaths • breathing efforts against the ventilator • patient triggered breaths		• Check the tubing. • Check the patient status.
Too high Ppeak	• bronchospasm • patient is coughing • patient breathes against the ventilator • obstruction in airways • HME obstructed		• Check the patient status. • Check the patient circuit status.
Compl value invalid	• spontaneous breaths		• Compliance cannot be calculated.

Troubleshooting gas exchange measurement

Problem	Possible clinical cause	Possible technical cause	What to do
"Strange" values	• ventilation mode: BiPaP, CPAP with high continuous by-pass flow • presence of N_2O or anesthetic agents in ICU applications		• Gas exchange not measurable. • Do not use N_2O or AA in ICU, or use a E-sCAiOVX module.
Nonphysiological VO_2 readings	• unstable O_2 delivery • gas mixer • RR over 35/min	• reference gas inlet port blocked • gas sampling line longer than 2 m • dead space of Y-piece > 8 ml • gas sampling line connected to HME	• Select oxygram and verify the stableness of the curve. • Check reference port. • Change 2 m sampling line. • Check the dead space of Y-piece.

Problem	Possible clinical cause	Possible technical cause	What to do
		• D-lite incorrectly placed	• Gas sampling line should always be connected to D-lite. • Always connect the D-lite between HME and Y-piece.
VO_2 value invalid, no VO_2 FiO_2 > 85%, (FiO_2+FiN_2O > 85%	• over range • no VO_2 value • 0 ml/min > VO_2 > 999 ml/min	• after changing the FiO_2 setting on the ventilator, VO_2 may be out of the specified range for several minutes	• VO_2 cannot be calculated without significant presence of N_2.

6

Disassembly and reassembly

Disassembly guidelines

Field repair of the device is limited to replacing field replaceable units (FRUs) and planned maintenance parts.

WARNING ERRONEOUS READINGS. To prevent erroneous readings, always perform gas sampling system leak test after the module cover is reassembled.

WARNING ERRONEOUS READINGS. To prevent erroneous readings, always perform gas calibration after any planned or corrective maintenance.

NOTE Only qualified service personnel should perform field replacement procedures.

NOTE Perform the specified corrective maintenance check after any corrective maintenance to the product.

Serviceable parts

- CO_2 absorber
- D-fend Pro
- Dehumidification tubes
- Front chassis unit
- MiniPVX unit
- Pump
- OM reference filter
- OM reference disc filter
- Latch and spring
- Mechanical parts listed in the Service parts chapter

Service limitations

The following parts are not serviceable:

- CPU board
- MiniOM measuring unit
- MiniTPX measuring unit

NOTE: Due to the complicated and sensitive mechanical construction of the oxygen measuring unit, do not attempt any repairs inside the unit. Instead, if the fault has been found in the measuring unit itself, replace the entire module and send the faulty module to GE for repair.

NOTE: The MiniTPX measuring unit can only be repaired and calibrated at the factory. In case of failure, replace the entire module and send the faulty module to GE for repair.

ESD precautions

WARNING EQUIPMENT DAMAGE AND LOSS OF MONITORING. To avoid the risk of the module getting damaged and the loss of monitoring, protect the module from electrostatic discharge.

All external connectors of the device are designed with protection from ESD damage. However, if the device requires service, exposed components and assemblies inside are susceptible to ESD damage. This includes human hands, non-ESD protected work stations or improperly grounded test equipment. The following guidelines may not guarantee a 100% static-free workstation, but can greatly reduce the potential for failure of any electronic assemblies being serviced:

- Discharge any static charge you may have built up before handling semiconductors or assemblies containing semiconductors.
- Wear a grounded, antistatic wristband or heel strap at all times while handling or repairing assemblies containing semiconductors.
- Use properly grounded test equipment.
- Use a static-free work surface while handling or working on assemblies containing semiconductors.
- Do not remove semiconductors or assemblies containing semiconductors from antistatic containers until absolutely necessary.
- Do not slide semiconductors or electrical/electronic assemblies across any surface.
- Do not touch semiconductor leads unless absolutely necessary.
- Store the semiconductors and electronic assemblies only in antistatic bags or boxes.
- Handle all PCB assemblies by their edges.
- Do not flex or twist a circuit board.

Protection from dust

WARNING EQUIPMENT DAMAGE AND ERRONEOUS READINGS. Module must be handled with care to prevent dust from entering the gas sampling system.

The gas sampling system must be protected from dust entering the tubes, valves and other components. In order to achieve this goal, the following measures must be taken:

- Always connect the D-fend Pro water trap to the module.
- Have a clean and dust-free working environment during all service procedures.
- Minimize the times with any open connections in the gas sampling system.
- Always close the open tube connections of the sampling system when not working on the module.

- Remove the protective caps on the gas pump only immediately before assembling it to the module.
- Take the CO_2-absorber out from the plastic bag only immediately before assembling it to the module.
- The clothing of the service person must be such that the dust risk has been taken into account.

Before disassembly

- Note the positions of any wires or cables. Mark them if necessary to ensure that they are re-assembled correctly.
- Save and set aside all hardware for reassembly.

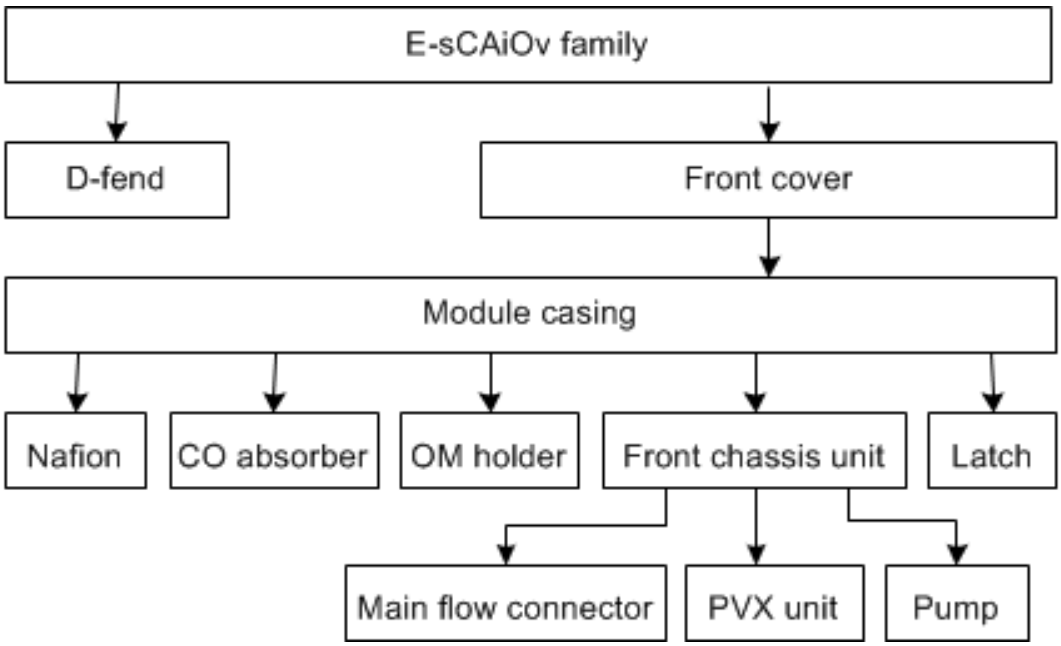
Required tools

- Flat blade screwdriver
- Torx screwdriver, T8
- Forceps
- Antistatic wristband

Disassembly procedures

For reference, see the exploded view in Service parts chapter.

Disassembly workflow



Detaching the front cover

1. Remove the D-fend Pro.
2. Detach the front cover of the module by releasing the snaps that hold the front cover to the front chassis unit by using a small flat blade screwdriver. There are 2 snaps on both sides of the module.

Detaching the module casing

1. Remove the two T8 screws mounting the D25 connector shield.

2. Detach the connector shield.
3. Remove the two T8 screws to detach the module casing.
4. Push the latch and pull the module casing.

When reassembling ensure that the module casing does not damage the conductive sealings on the front chassis unit.

Replacing planned maintenance parts

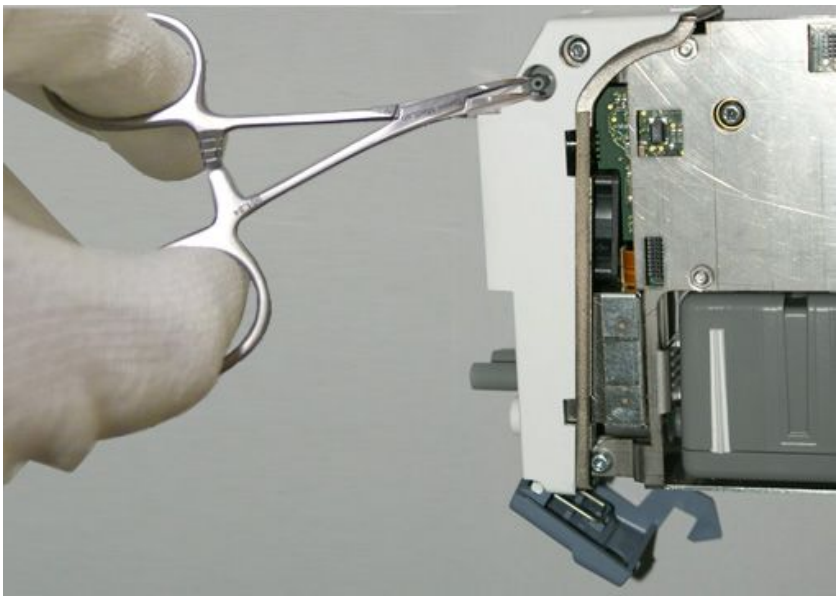
1. Carefully remove the main flow dehumidification tube and every 4th year the shorter zero line dehumidification tube.

NOTE: Remember the route of the tubes and reassemble correctly.

NOTE: Make sure that the dehumidification tubes are routed in such a way that they do not come near the fan, and there is no risk of the fan being obstructed by the tubes. An obstructed fan will result in degraded ventilation inside the module, and ***Service gas module*** message being displayed.

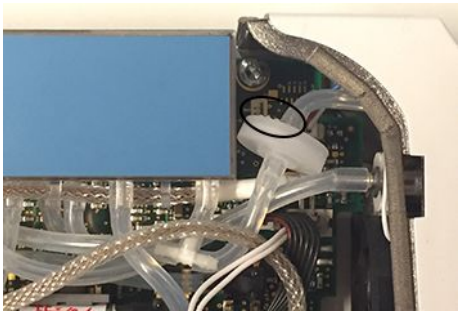
NOTE: The dehumidification tubes do not include the silicon fittings they are connected to. Use the original silicon fittings unless they are damaged or leaking.

2. Pull out the OM reference filter assembly with forceps.



3. Push the new filter assembly until it is on the same level with the front chassis.

4. Detach the OM reference disc filter from the tubes and replace it with a new one. When attaching the new filter note the correct filter position. Connect the side of the filter that is marked with the tree dots to the tube that is coming from the OM reference filter assembly.



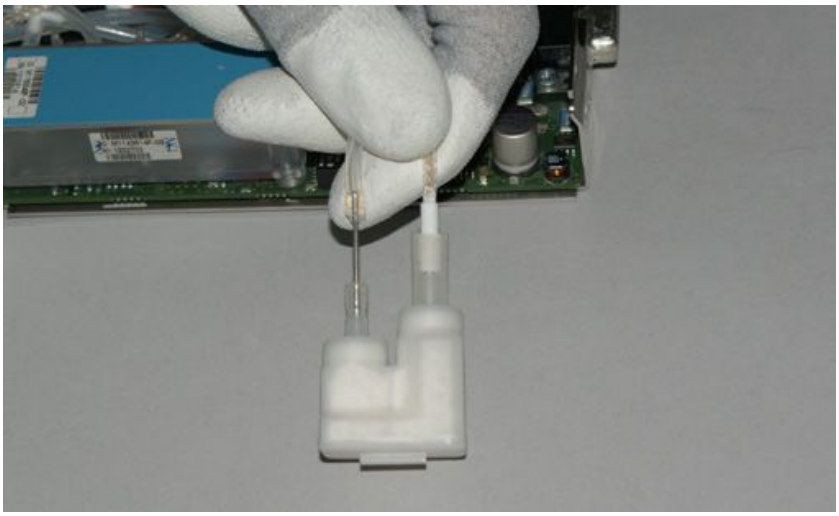
NOTE: If the module does not have a disc filter in the OM reference line, cut the tube between the OM reference gas filter assembly and the T-piece and place the disc filter as shown in the picture in step 1.

Replacing the CO_2 absorber

1. Lift the CO_2 absorber from the slot.

2. Detach the tubes from the absorber.

3. Connect the tubes to a new CO_2 absorber and place it to the slot.

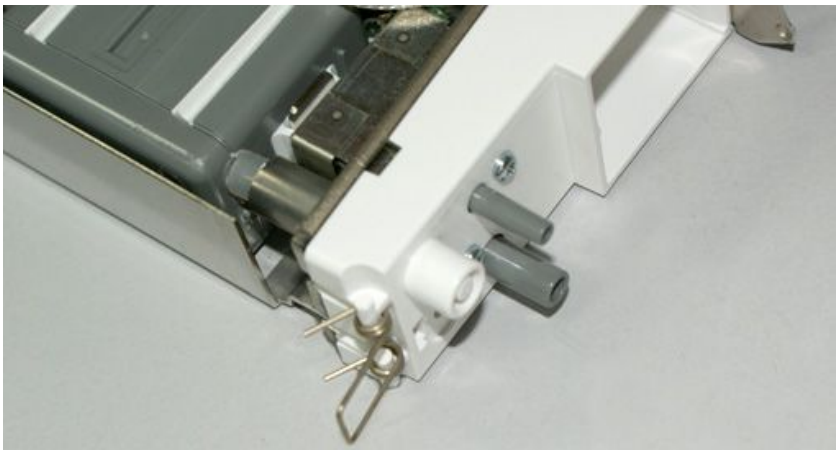


Detaching the latch

1. Pull the latch from the front chassis.

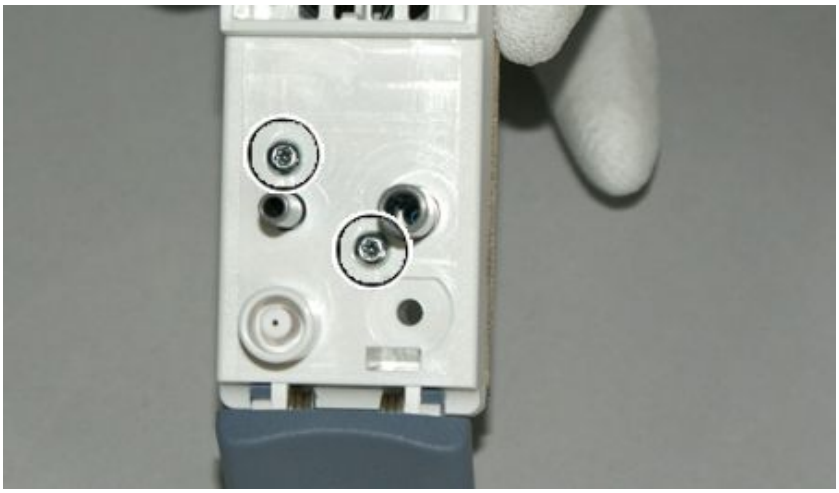
NOTE: Remember to detach the front cover first.

2. Remove the spring by squeezing it.

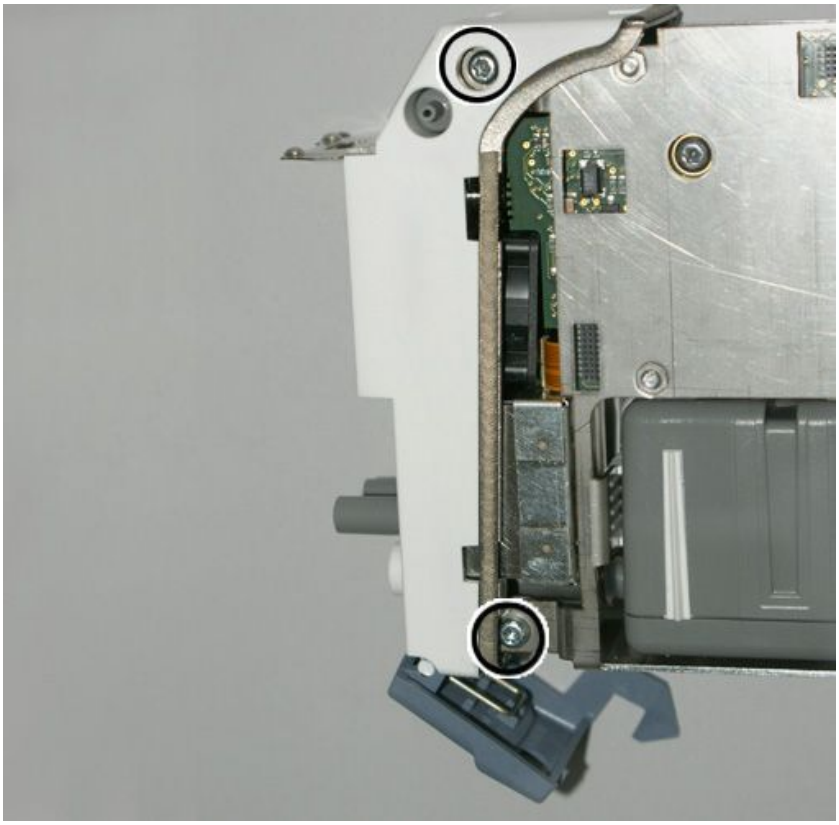


Detaching the front chassis unit

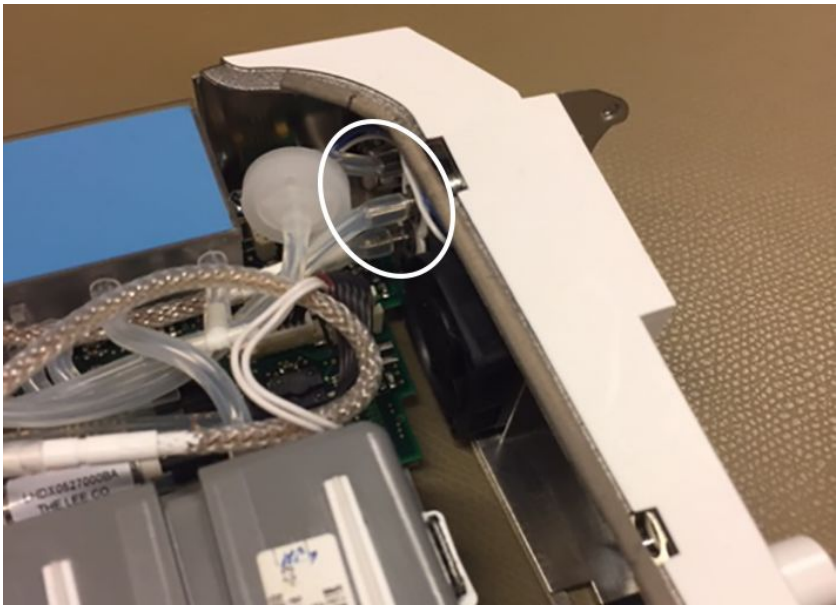
1. Remove the two T8 screws which fasten the PVX unit to the front chassis.



2. Remove the two screws (T8).

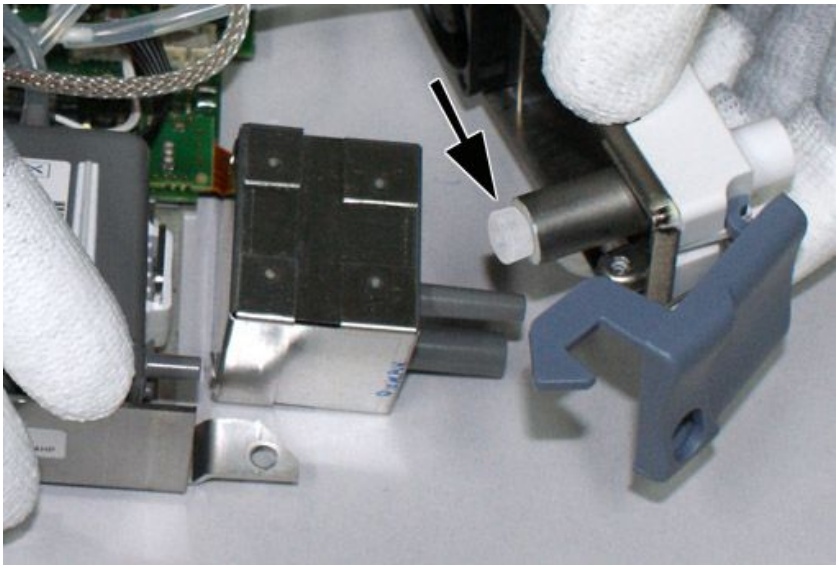


3. Carefully detach the three tubes.



4. Disconnect the fan and keypad cables.

5. Detach the front chassis unit.

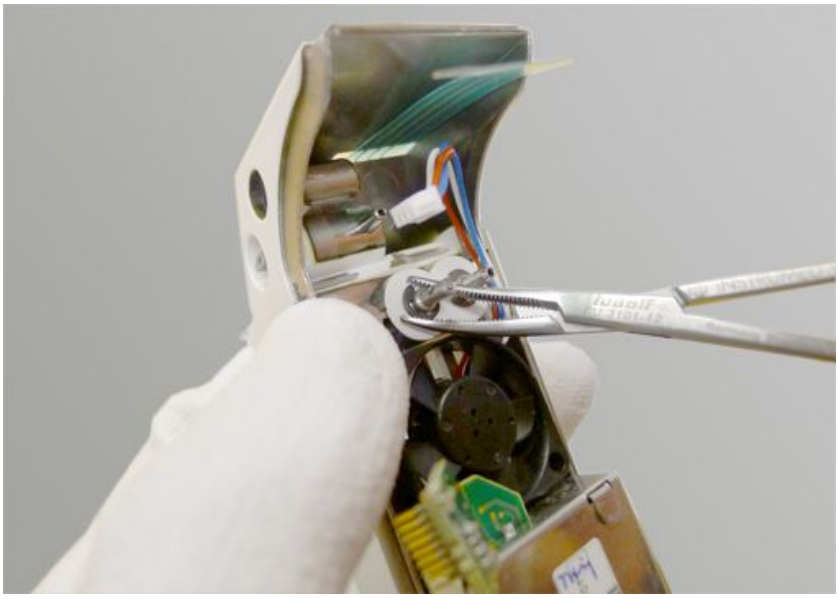


NOTE: When reassembling, insert the pump silicone tube in the front chassis connector.

Detaching the main flow connector

The original main flow connector is required to maintain proper gas flow restriction in the module. When the front chassis unit is replaced, move the original connector to the new unit.

1. Carefully detach the lock pin holding the main flow connector.



2. Carefully attach the main flow connector to the new front chassis unit.

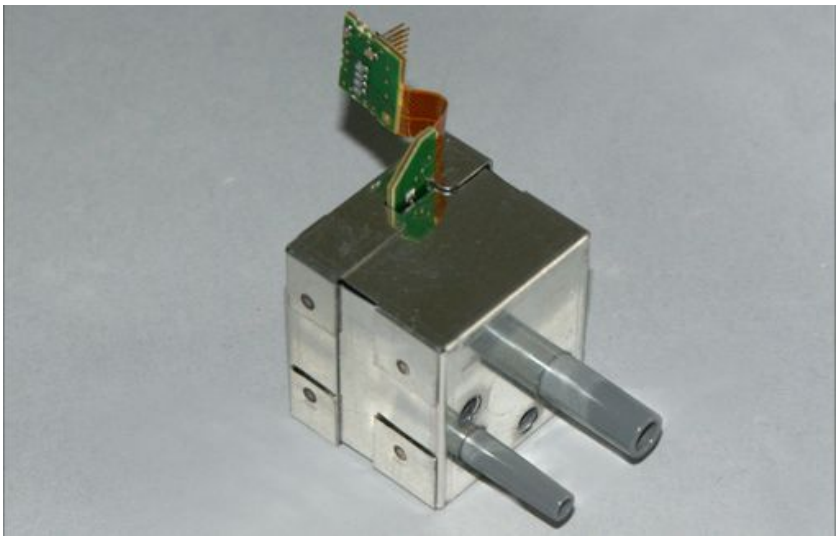
Detaching the PVX unit

The PVX unit is available as a FRU for E-sCAiOV and E-sCOV module models only.

WARNING ERRONEOUS READINGS. The PVX unit of E-sCAiOVX and E-sCOVX modules must not be replaced in the field. Attempting to do so may result in inaccurate gas exchange measurement.

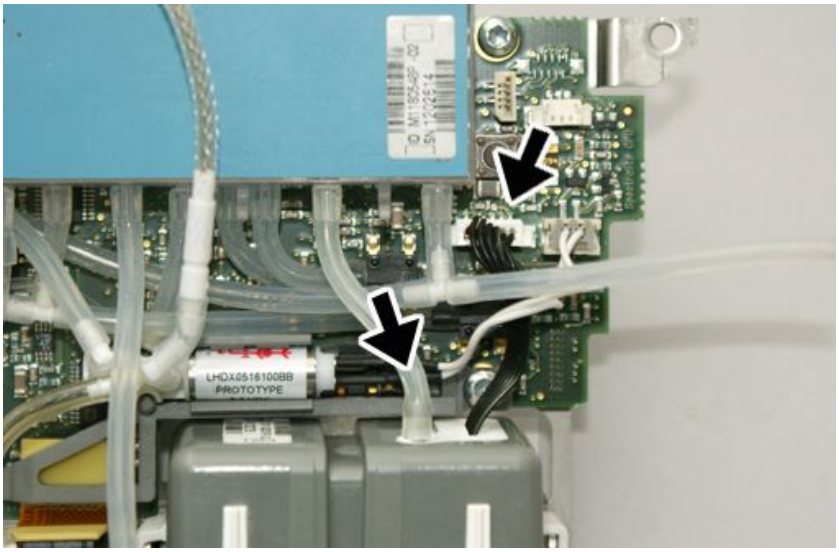
1. Carefully disconnect the PVX connector.

2. Detach the PVX unit.



Detaching the pump

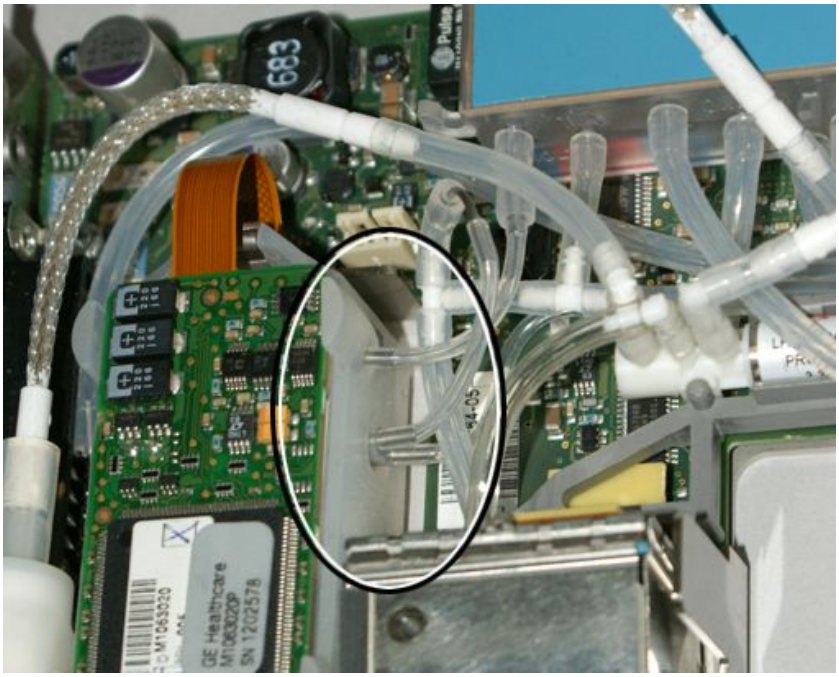
1. Carefully detach the tube from the pump.



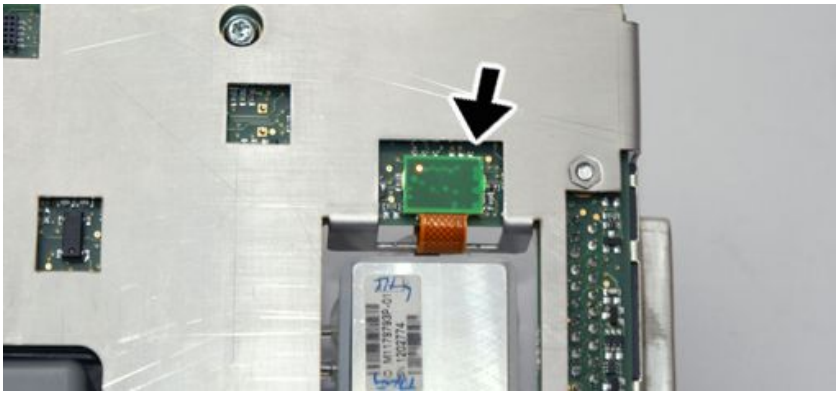
2. Disconnect the pump cable from the CPU board.
3. Lift the pump from the metal brackets.

Detaching the OM holder

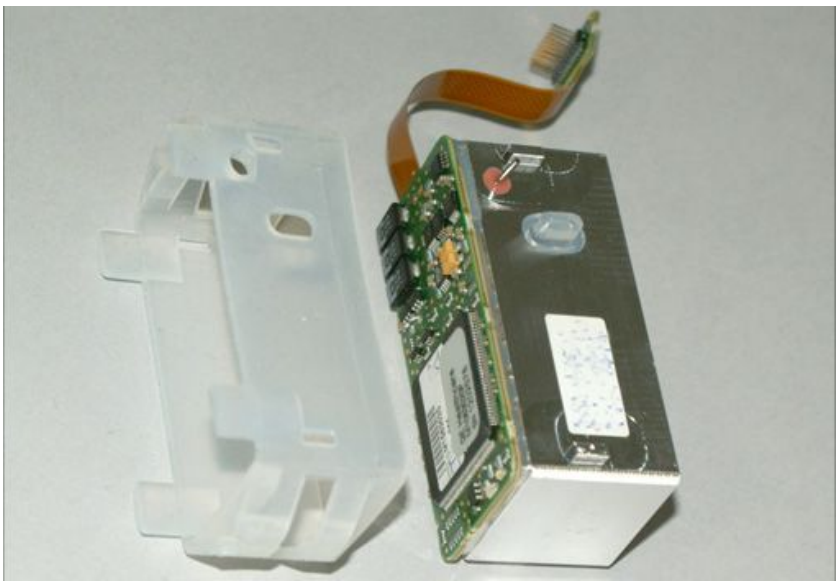
1. Carefully detach the three tubes from the OM unit.



2. Carefully disconnect the OM flex cable from the CPU board.



3. Carefully pass the flex cable through the metal frame.
4. Lift the OM unit with the holder from the metal brackets.
5. Detach the holder.



Reassembling the module

NOTE When reassembling the module, make sure that the dehumidification tubes are routed in such a way that they do not come near the fan and there is no risk of the fan being obstructed by the tubes. An obstructed fan will result in degraded ventilation inside the module, and a ***Service gas module*** message will be displayed.

1. Reassemble in reverse order. Make sure that:
   a. All screws are tightened properly.
   b. All cables are connected properly.
   c. Tubes are not pinched and there are no sharp ends on them.
   d. All tubes are connected properly.
   e. There are no loose objects inside the module.

7

Service parts

Ordering parts

To order parts, contact your local GE representative. Contact information is available at www.gehealthcare.com. Make sure you have all necessary information at hand.

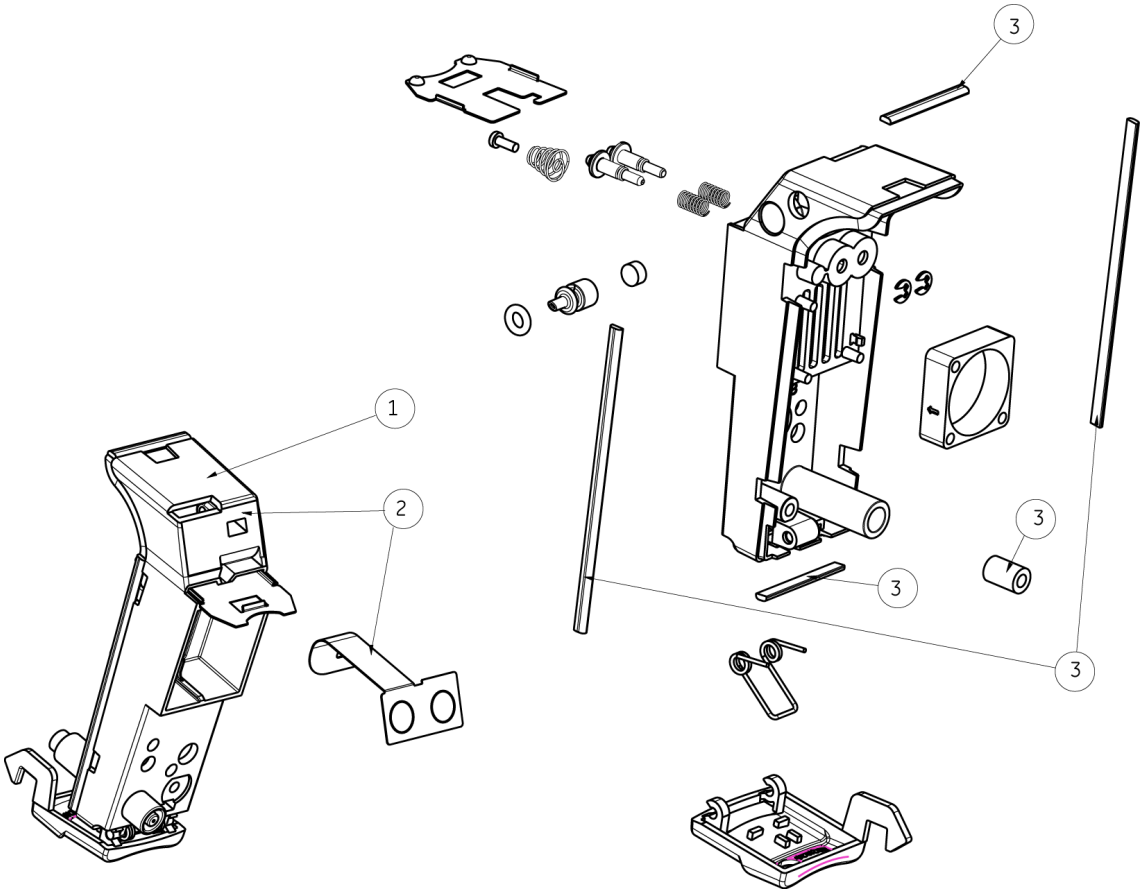
Planned maintenance kits

The required planned maintenance parts are included in PM kits.

Part number	Description
2093610-001	One year Planned Maintenance Kit for CARESCAPE Respiratory modules. The PM kit includes the required dehumidification tube, 230 mm (mainflow), the OM reference gas filter assembly with an O-ring, OM reference disc filter, and a PM sticker. NOTE: The one year PM kit does not include the CO_2 absorber and dehumidification tube, 85 mm (zero line).
2093594-001	Four year Planned Maintenance Kit for CARESCAPE Respiratory modules. NOTE: The four year PM kit contains all required PM parts.

Spare parts

Exploded view of Respiratory module chassis unit



Gas exhaust connectors

There are two types of connectors as indicated in the following figure:

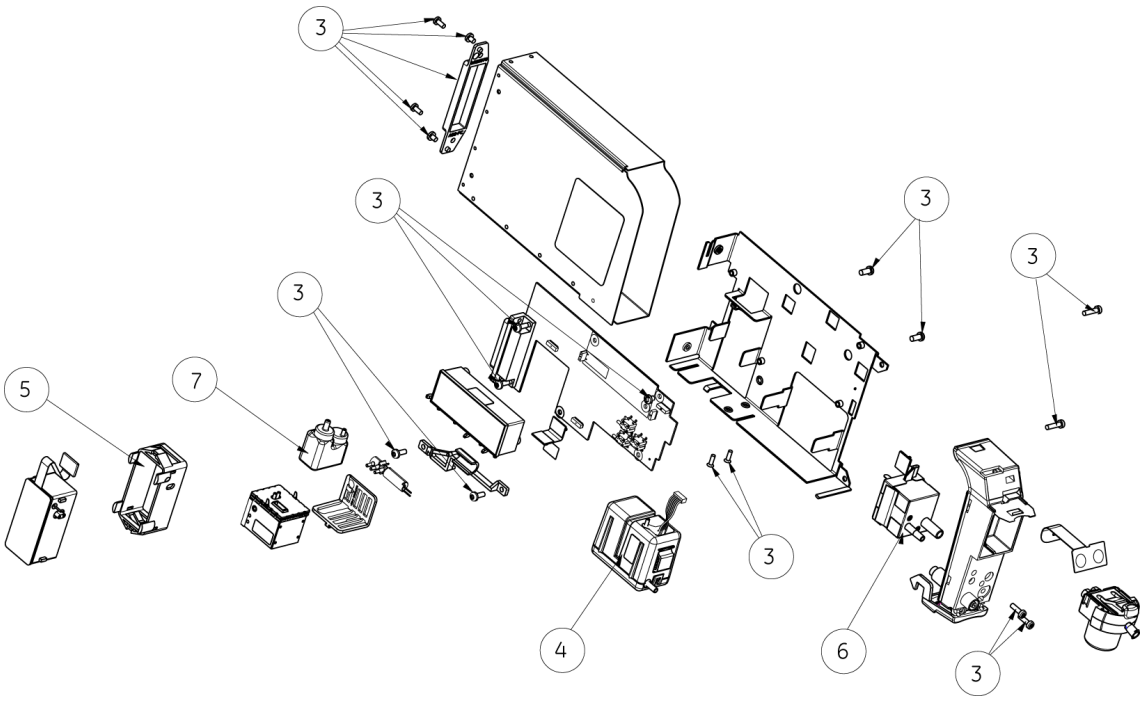
a. Luer exhaust connector

b. GE custom exhaust connector

List of FRUs for Respiratory module chassis unit

Item number	Part number	Description
1	M1206530	FRU, Front chassis unit, E-sCAiO, E-sCO • Front chassis assembly. NOTE: Use this FRU with the module with Luer gas exhaust connector (a).
1	5697235	FRU, Front chassis unit, E-sCAiO, E-sCO (SUA) • Front chassis assembly. NOTE: Use this FRU with the module with GE custom gas exhaust connector (b).
2	M1206529	FRU, Front chassis unit, E-sCAiOV, E-sCAiOVX, E-sCOV, E-sCOVX • Front chassis assembly, including membrane keyboard. NOTE: Use this FRU with the module with Luer gas exhaust connector (a).
2	5697236	FRU, Front chassis unit, E-sCAiOV, E-sCAiOVX, E-sCOV, E-sCOVX (SUA) • Front chassis assembly, including membrane keyboard. NOTE: Use this FRU with the modules with GE custom gas exhaust connector (b).
3	M1206533	FRU, HW kit • All mounting screws. • All conductive sealings. • Pump connector silicone tube. • D25 connector shield. • Latch. • Torsion spring.

Exploded view of Respiratory module



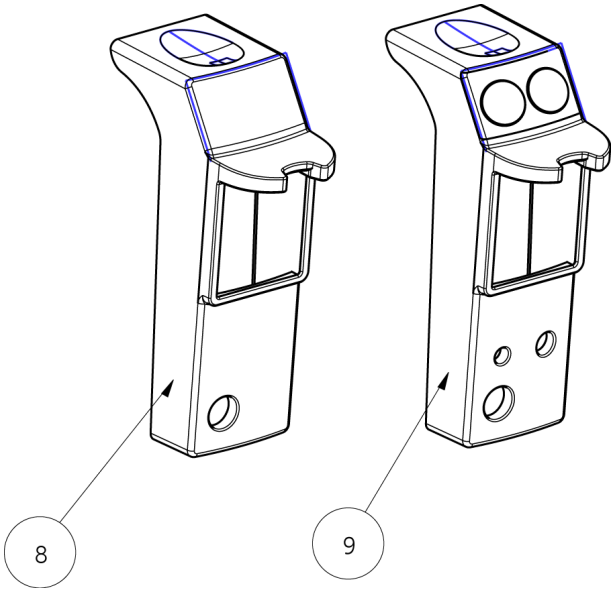
List of FRUs for Respiratory module

Item number	Part number	Description
3	M1206533	FRU, HW kit • All mounting screws. • All conductive sealings. • Pump connector silicone tube. • D25 connector shield. • Latch. • Torsion spring.
4	M1206290	FRU, pump unit
5	M1206531	FRU, OM holder
6	M1206528	FRU PVX unit[1], E-sCAiOV, E-sCOV
7	M1206555	CO2 absorber

WARNING ERRONEOUS READINGS. The PVX unit of E-sCAiOVX and E-sCOVX modules must not be replaced in the field. Attempting to do so may result in inaccurate gas exchange measurement.

1. The PX unit is available as a FRU for E-sCAiOV and E-sCOV module models only

List of FRUs for Respiratory module front covers



Item number	Part number	Description
8	M1206538	FRU, Front Cover, E-sCAiO
8	M1206539	FRU, Front Cover, E-sCO
9	2080272-001	FRU, Front Cover, EN, E-sCAiOVX
9	2080301-001	FRU, Front Cover, DA, E-sCAIOVX
9	2080302-001	FRU, Front Cover, DE, E-sCAIOVX
9	2080303-001	FRU, Front Cover, FI, E-sCAIOVX
9	2080304-001	FRU, Front Cover, FR, E-sCAIOVX
9	2080305-001	FRU, Front Cover, HU, E-sCAIOVX
9	2080307-001	FRU, Front Cover, IT, E-sCAIOVX
9	2080310-001	FRU, Front Cover, JA, E-sCAIOVX
9	2080313-001	FRU, Front Cover, NL, E-sCAIOVX
9	2080314-001	FRU, Front Cover, NO, E-sCAIOVX
9	2080316-001	FRU, Front Cover, PL, E-sCAIOVX
9	2080317-001	FRU, Front Cover, PT, E-sCAIOVX
9	2080318-001	FRU, Front Cover, RU, E-sCAIOVX
9	2080319-001	FRU, Front Cover, SV, E-sCAIOVX
9	2080320-001	FRU, Front Cover, ZH, E-sCAIOVX
9	2080322-001	FRU, Front Cover, CS, E-sCAIOVX
9	2080323-001	FRU, Front Cover, ES, E-sCAIOVX
9	M1207033	FRU, Front Cover, EN, E-sCAiOV
9	M1207034	FRU, Front Cover, CS, E-sCAiOV

Item number	Part number	Description
9	M1207035	FRU, Front Cover, DA, E-sCAiOV
9	M1207036	FRU, Front Cover, ES, E-sCAiOV
9	M1207037	FRU, Front Cover, FI, E-sCAiOV
9	M1207038	FRU, Front Cover, FR, E-sCAiOV
9	M1207039	FRU, Front Cover, HU, E-sCAiOV
9	M1207040	FRU, Front Cover, IT, E-sCAiOV
9	M1207041	FRU, Front Cover, JA, E-sCAiOV
9	M1207042	FRU, Front Cover, NL, E-sCAiOV
9	M1207043	FRU, Front Cover, NO, E-sCAiOV
9	M1207044	FRU, Front Cover, PL, E-sCAiOV
9	M1207045	FRU, Front Cover, PT, E-sCAiOV
9	M1207046	FRU, Front Cover, SV, E-sCAiOV
9	M1207047	FRU, Front Cover, DE, E-sCAiOV
9	M1213759	FRU, Front Cover, RU, E-sCAiOV
9	M1213760	FRU, Front Cover, ZH, E-sCAiOV
9	2080374-001	FRU, Front Cover, EN, E-sCOVX
9	2080378-001	FRU, Front Cover, DA, E-sCOVX
9	2080380-001	FRU, Front Cover, DE, E-sCOVX
9	2080381-001	FRU, Front Cover, FI, E-sCOVX
9	2080382-001	FRU, Front Cover, FR, E-sCOVX
9	2080383-001	FRU, Front Cover, HU, E-sCOVX
9	2080384-001	FRU, Front Cover, IT, E-sCOVX
9	2080385-001	FRU, Front Cover, JA, E-sCOVX
9	2080386-001	FRU, Front Cover, NL, E-sCOVX
9	2080387-001	FRU, Front Cover, NO, E-sCOVX
9	2080388-001	FRU, Front Cover, PL, E-sCOVX
9	2080389-001	FRU, Front Cover, PT, E-sCOVX
9	2080390-001	FRU, Front Cover, RU, E-sCOVX
9	2080391-001	FRU, Front Cover, SV, E-sCOVX
9	2080392-001	FRU, Front Cover, ZH, E-sCOVX
9	2080394-001	FRU, Front Cover, CS, E-sCOVX
9	2080396-001	FRU, Front Cover, ES, E-sCOVX
9	M1207048	FRU, Front Cover, EN, E-sCOV
9	M1207049	FRU, Front Cover, CS, E-sCOV
9	M1207051	FRU, Front Cover, DA, E-sCOV
9	M1207053	FRU, Front Cover, ES, E-sCOV

Item number	Part number	Description
9	M1207055	FRU, Front Cover, FI, E-sCOV
9	M1207057	FRU, Front Cover, FR, E-sCOV
9	M1207059	FRU, Front Cover, HU, E-sCOV
9	M1207062	FRU, Front Cover, IT, E-sCOV
9	M1207064	FRU, Front Cover, JA, E-sCOV
9	M1207067	FRU, Front Cover, NL, E-sCOV
9	M1207069	FRU, Front Cover, NO, E-sCOV
9	M1207071	FRU, Front Cover, PL, E-sCOV
9	M1207073	FRU, Front Cover, PT, E-sCOV
9	M1207075	FRU, Front Cover, SV, E-sCOV
9	M1207077	FRU, Front Cover, DE, E-sCOV
9	M1213757	FRU, Front Cover, RU, E-sCOV
9	M1213758	FRU, Front Cover, ZH, E-sCOV

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