3 Maintenance and checkout

To help ensure the equipment remains in proper operational and functional order, adhere to a good maintenance schedule.

Corrective maintenance

Service personnel shall perform the following checkout procedure after any corrective maintenance, before taking the module back into clinical use:

Performed service activity	Required checkout procedure	
	Visual inspections (section 3.2)	**Functional check (section 3.3)**
Any of the front panel stickers	All steps	Check “Module Keys” only
D-fend O-rings or Reference gas filter assembly	All steps	Check “Gas Sampling System Leak Test” and “Sample Flow Rate Check”
Fan filter	All steps	Check “Fan”"Fan Operation" only
Module case opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps

Planned maintenance

Service personnel shall perform the following checkout procedure completely every 12 months after installation:

1. 3.1. Replacement of planned maintenance parts
2. 3.2. Visual inspections
3. 3.3. Functional check

3.1 Replacement of planned maintenance parts

3.1.1 Required parts

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

Part number	Description	Pieces	Replacement interval
733382-HEL	Nafion Tube, 300 mm	1	Once a year
M1080137	Nafion tube, 130 mm	1	Once a year
886136-HEL	Occlusion filter for pneumatic unit	1	Once a year
M1028983	Reference gas filter assembly	1	Once a year
65340	O-ring for reference gas filter assembly	1	Once a year
M1130739	Ref gas sticker	1	Once a year

Part number	Description	Pieces	Replacement interval
65312-HEL	D-Fend O-ring	2	Once a year
M1028987	Fan filter	1	Once a year
895933	CO2 zero absorber	1	Once every 4 years

It is also recommended to replace the D-fend water trap, the gas sampling line and the spirometry tube as part of the planned maintenance procedure.

NOTE: See the supplemental information manual for compatible accessories.

3.1.2 Planned Maintenance Kits

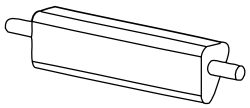
The required planned maintenance parts are included in a PM kit.

Part number	Description
8001760-HEL	Planned Maintenance Kit for Compact Airway modules. The PM kit includes the required Nafion tubes, the occlusion filter for the pneumatic unit, the reference gas filter assembly with an O-ring and a new sticker, the D-fend O-rings and the fan filter. NOTE: The PM kit does not include the CO2 zero absorber. Order it separately.

3.1.3 Replacement procedures

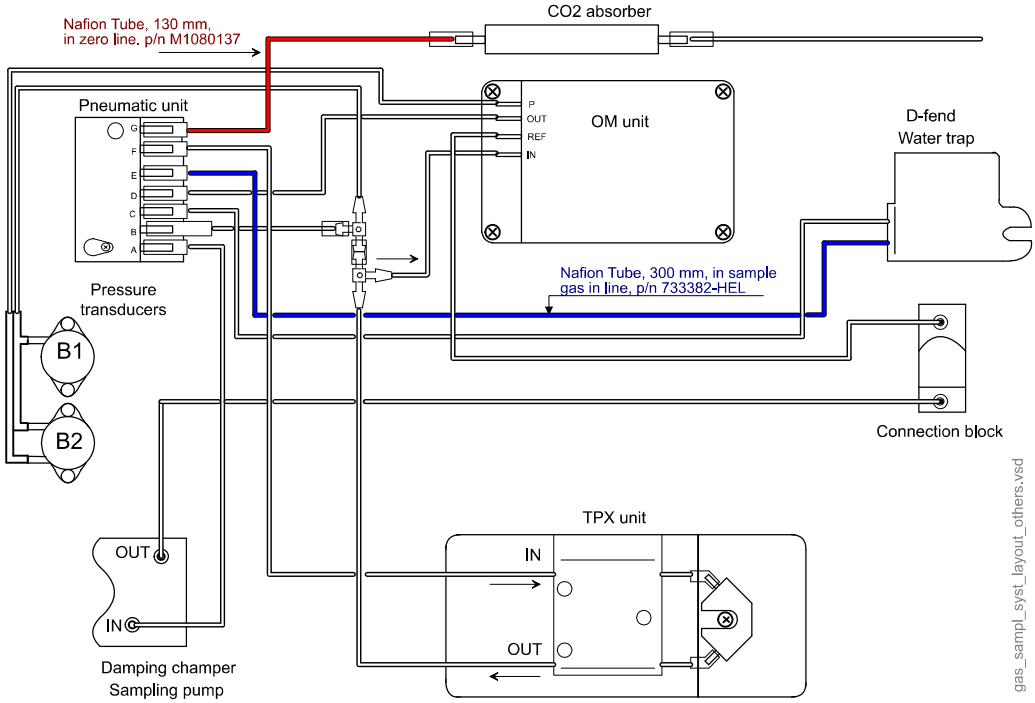
Replace the specified planned maintenance parts according to the following procedure. Refer to chapter 6. Disassembly and reassembly and chapter "7. Service parts" for additional information.

1. Replace the CO2 absorber every 4 years.



2. Replace the special tubes (Nafion) and check the condition of the internal tubing.
   - Replace the 130 mm Nafion tube in the zero line between the CO2 absorber and the pneumatic unit.
   - Replace the 300 mm Nafion tube in the sample gas line between the D-fend water trap and the pneumatic unit.

- 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 Healthcare for factory service.

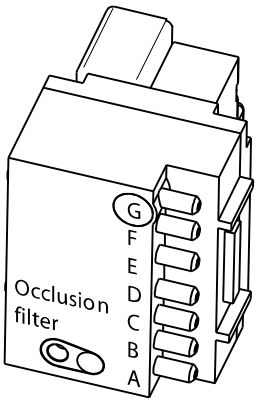


NOTE: The nafion tubes do not include the silicon fittings they connect to. Use the original silicon fittings unless they are not damaged or leaking.

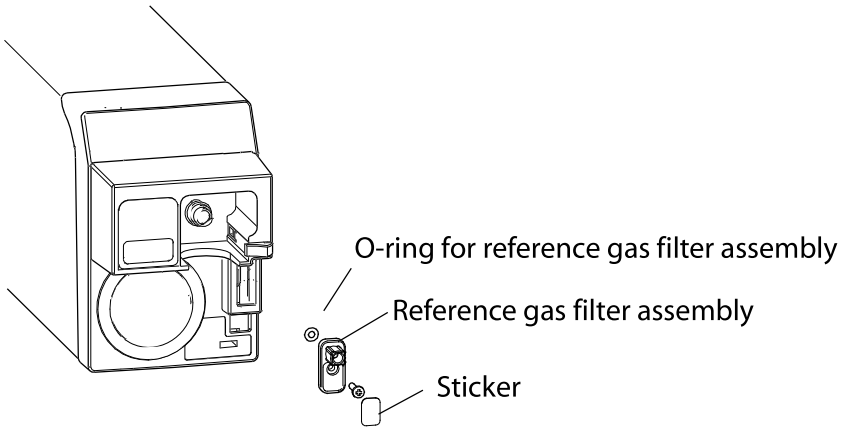
NOTE: Some older versions of Compact Airway modules were equipped with a longer 300 mm nafion tube in the zero line. You can replace it with the shorter 130 mm nafion tube.

3. Replace the occlusion filter in the pneumatic unit:
   a. Open the screw that holds the black filter cover to the pneumatic unit.
   b. Detach the filter cover e.g. using a small flat blade screwdriver.
   c. Detach the white occlusion filter e.g. by turning the module upside-down so that the filter drops.
   d. Attach a new occlusion filter to the pneumatic unit.

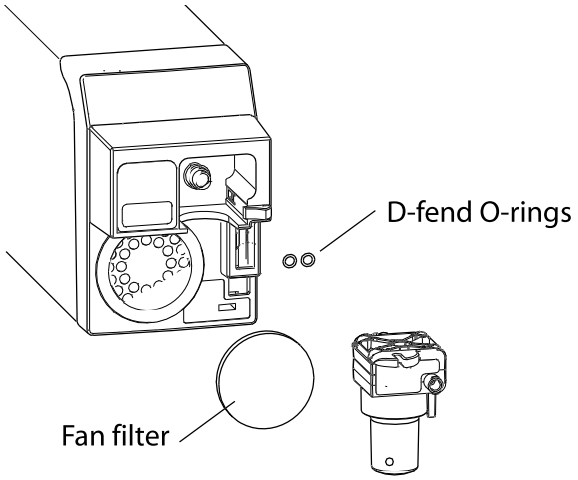
e. Attach the filter cover back and fasten the screw.



4. Replace the reference gas filter assembly:
   a. Detach the reference gas sticker.
   b. Open the screw that holds the reference gas filter assembly to the front cover. Pull out the reference gas filter assembly and discard it.
   c. Attach a new O-ring into the new reference gas filter assembly.
   d. Attach the new reference gas filter assembly with the O-ring to the front cover.
   e. Attach a new reference gas sticker to the reference gas filter assembly. Use the original labelling language. .



5. Replace the D-Fend O-rings:
   a. Detach the D-fend.
   b. Detach the old rubber O-rings that are around the metal D-fend connectors e.g. using a small flat blade screwdriver. Pay special attention not to scratch the metal D-fend connectors and thus causing leaking.
   c. Set the new rubber O-rings into place and attach a new D-fend.



6. Replace the fan filter in the front of the module.

3.2 Visual inspections

Detach the module from the module slot and check that:

- the front cover and the front panel sticker are intact
- all connectors are intact and are attached properly
- the D-fend latch is moving properly
- the module box and latch are intact
- the metal D-fend connectors and the D-fend O-rings are clean and intact
- the module and the applied parts are clean

The cleaning precautions, cleaning requirements, cleaning procedures, and recommended cleaning solutions for the monitor are described in the patient monitor's user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

3.3 Functional check

Turn the monitor on. Wait until the normal monitoring screen appears.

3.3.1 Test setup

Required tools

- A barometer
- A mass flowmeter for measuring air flow, minimum measurement range 100-300ml/min, accuracy 5% or better in the 100-300ml/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-CAiO, E-CAiOV, E-CAiOVX modules)
- P/N: 755581-HEL QUICK CAL calibration gas, CO2, O2, N2O, package of 4 cans (with E-CO, E-COV and E-COVX 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-CAiO, E-CAiOV, E-CAiOVX modules) US only
– P/N: 755587, Calibration Gas, CO2, O2, Balance, 4 cans/pkg (with E-CO, E-COV and E-COVX modules) US only
– D-Fend water trap
– 3 m / 10 ft anesthesia gas sampling line (with E-CO, E-COV, E-CAiO and E-CAiOV modules)
– 2 m / 7 ft anesthesia gas sampling line (with E-COVX and E-CAiOVX modules)
– Spirometry tube, 3 m/10 ft (with E-CO, E-COV, E-CAiO and E-CAiOV modules)
– Spirometry tube, 2 m/7 ft (with E-COVX and E-CAiOVX modules)
– Adult D-Lite sensor
– A pressure manometer with either an integrated or a separate pressure pump
– Tubing for spirometry leak tests

NOTE: See the supplemental information manual for compatible accessories.

Connections

- Disconnect the module from the monitor, if connected.

Monitor configuration

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 and Gas Exchange*** menu and configure:

   Scaling: Auto

   Sensor Type: Adult

   Show Volume: TV

3.3.2 Procedure

Mark each task as complete on the checkout form.

1. Gas Sampling System Leak Test

Check the gas sampling system for possible leakages.

a. Disconnect the module from the monitor.
b. Connect a new D-Fend water trap to the module.
c. Connect a new gas sampling line to the sampling line connector in the water trap.
d. Connect the other end of the gas sampling line to a pressure manometer and a pressure pump.
e. Block the "Ref Gas In" and "Sample Gas Out" connectors.
f. Pump 100 mmHg ± 20 mmHg pressure to the gas sampling system. Let the pressure stabilize for approximately 10 seconds.
g. Check that the pressure reading does not drop more than 4 mmHg during one minute.

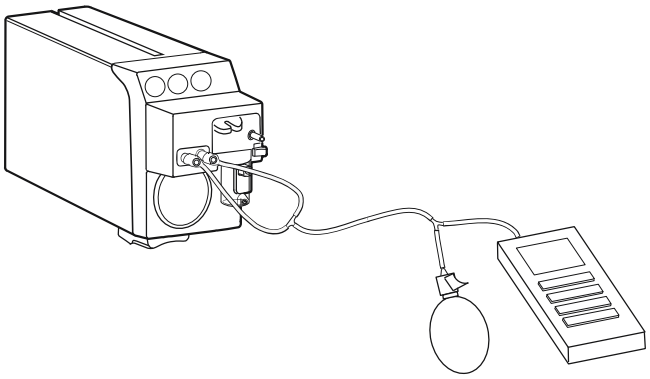
NOTE: The gas module shall be disconnected from the monitor during the leak test.

2. Spirometry System Leak Test

NOTE: Perform this test only for E-COV, E-COVX, E-CAiOV and E-CAiOVX modules.

Check the spirometry sampling system for possible leakages.

a. Ensure the module is disconnected from the monitor.
b. Connect a pressure manometer to the spirometry connectors.



c. Pump 50 mmHg ±10 mmHg (~68 cmH_2O) 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 3 mmHg during one minute.

NOTE: The gas module shall be disconnected 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.

3. Fan

a. Connect the module to the monitor.
b. Check that the gas module's fan is running.

4. Module Keys

NOTE: Perform this test only for E-COV, E-COVX, E-CAiOV and E-CAiOVX 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 to the screen.

5. Sample Flow Rate Check

Check the sample flow rate.

NOTE: Gas measurement is not available during the first 2 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.

a. Connect the gas sampling line (2 m / 7 ft with E-COVX and E-CAiOVX, 3 m / 10 ft with E-CO, E-COV, E-CAiO and E-CAiOV) 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 shall be within the specification limit 200 ± 20 ml/min.

NOTE: Readjustment is needed, if the measured value is not within the specification limit. Adjust the sample gas flow rate according to the instructions in section 4.1. Sample Flow Rate Adjustment.

6. Reference Gas Flow Rate Check

Check the flow rate in reference gas inlet:

a. Keep the gas sampling line connected 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 Oxygen reference gas inlet with a piece of tubing.
d. Check that the Reference Flow is within the following range:

31..45 ml/min with E-CO, E-COV, E-CAiO and E-CAiOV modules

27..40 ml/min with E-COVX and E-CAiOVX modules

7. Zero Valve Operation

Test the zero valve functionality:

a. Connect the gas regulator to the calibration gas container.
b. Connect the end of the gas sampling line to the regulator on the gas container. Leave the regulator overflow port open to room air.
c. Select **Monitor Setup > *Service Calibrations***.
d. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
e. Select ***Gases***.
f. Start feeding the specified calibration gas. Wait until the gas values shown in the gas calibration menu rise approximately to the level indicated in the labelling of the calibration gas container.

NOTE: The gas values in the Gas Calibrations menu is in percentages (%).

g. Open the zero valve to room air by selecting ***Zero valve Off*** (zero position).
h. Check that the CO2, N2O and anesthesia agent values drop back near 0% and the O2 reading near 21% (room air).
i. Stop feeding the calibration gas.
j. Turn the zero valve back to the normal measurement position by selecting ***Zero valve On*** (measurement position).

8. Gas Calibration

Perform gas calibration according to the instructions in section 4.2. Gas Calibration.

9. Agent Identification

NOTE: Perform this test only for E-CAiO, E-CAiOV and E-CAiOVX modules.

Check agent ID unreliability:

a. Feed the specified calibration gas for at least 30 seconds.
b. Check that the anesthesia agent is identified as Desflurane and the ***IDu*** value (=agent ID unreliability) shown in the ***Monitor Setup / Service calibrations / Gases*** menu 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.

- Check that the ambient pressure value shown in the Gas Calibrations menu does not differ more than ± 10 mmHg from the value shown by the barometer.

NOTE: The ambient pressure value in the Gas Calibrations menu is in mmHg.

11. Fall Time Measurement
    a. Select ***Start Fall Time Measurement***.
    b. Feed calibration gas until the message 'Feed gas' near the fall time values changes to 'Ready'.
    c. Check that the measured fall times are within the following ranges:
    CO2: < 400 ms
    O2: < 400 ms
    DEL: < 800 ms

If necessary, repeat the same procedure to get all the values on the screen.

12. Occlusion detection
    a. Block the tip of the sampling line by your finger.
    b. Check that a 'Sample line blocked' message appears to the parameter window within 30 seconds.

13. Air Leak detection
    a. Detach the D-fend water trap.
    b. Check that the message 'Check Water Trap' appears to 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 CO_2 waveform appears to the waveform field and the $EtCO_2$ and FiCO2 values are updated to the parameter window.

15. Apnea detection
    a. Stop breathing to the gas sampling line.
    b. Check that an 'Apnea' alarm appears to the message field within 30 seconds.

16. Flow waveform

NOTE: Perform this test only for E-COV, E-COVX, E-CAiOV and E-CAiOVX 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 goes downwards when you breathe in and upwards when you breathe out.

3.3.3 Test completion

- Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.
- Complete on the "Maintenance check form" on page 9-55.

4 Calibration and adjustments

4.1 Sample Flow Rate Adjustment

Sample flow rate shall be adjusted:

- if the sample flow rate check in section "3.3.2" failed.

4.1.1 Calibration setup

Required tools

– A mass flowmeter for measuring air flow, minimum measurement range 100-300ml/min, accuracy 5% or better in the 100-300ml/min range.
– 3 m / 10 ft anesthesia gas sampling line (with E-CO, E-COV, E-CAiO and E-CAiOV modules)
– 2 m / 7 ft anesthesia gas sampling line (with E-COVX and E-CAiOVX modules)

NOTE: See the supplemental information manual for compatible accessories.

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

NOTE: Refer to the flowmeter documentation for user instructions.

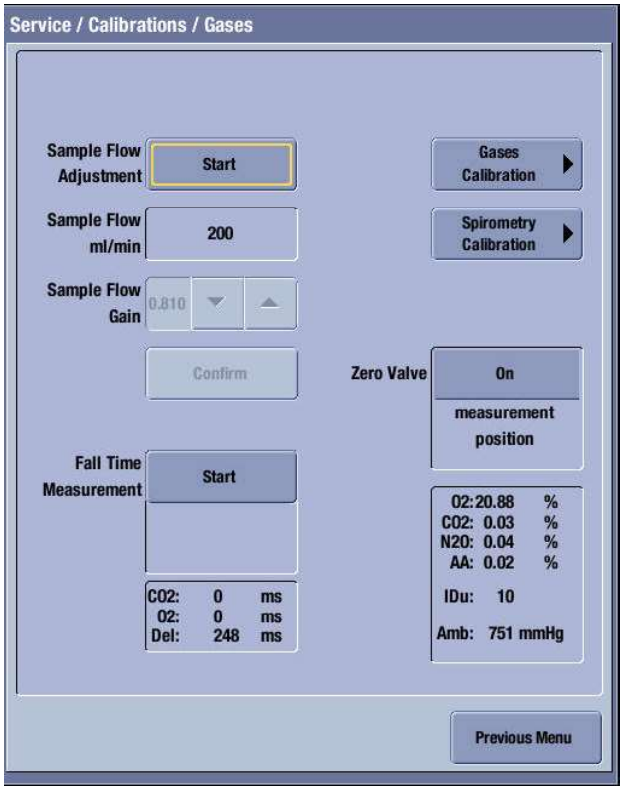
Connections

1. Ensure that the module is connected to the monitor.
2. Ensure that you have a new D-Fend 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.

4.1.2 Sample Flow Rate Adjustment

1. Select **Monitor Setup > *Service Calibrations***
2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Gases***
4. Select ***Start Sample Flow Adjustment***



5. Adjust the sample flow to the nominal value 200 ml/min by using the Sample Flow Gain up-down spinner controls:
   - To decrease the sample flow rate measured by the flow meter by approximately 7,5 ml / min, add gain value by 0.05.
   - To increase the sample flow rate measured by the flow meter by approximately 7,5 ml / min, lower the gain value by 0.05.
6. 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 200 ml/min and then check the actual measured flow rate from the flow meter.
7. Repeat steps 5 and 6 until the flow meter shows a 200 ± 20 ml /min flow rate.
8. Select ***Stop Sample Flow Adjustment*** 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 200 ml /min independent on the real flow rate.

4.2 Gas Calibration

Gas calibration shall be performed:

- each time planned maintenance is performed.
- each time corrective maintenance is performed.

NOTE: Gas calibration is a normal user action. Refer to the patient monitor's user's manual for the recommendation for gas calibration interval in clinical use.

4.2.1 Calibration setup

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-CAiO, E-CAiOV, E-CAiOVX modules)
- P/N: 755581-HEL QUICK CAL calibration gas, CO2, O2, N2O, package of 4 cans (with E-CO, E-COV and E-COVX 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-CAiO, E-CAiOV, E-CAiOVX modules) US only
- P/N: 755587, Calibration Gas, CO2, O2, Balance, 4 cans/pkg (with E-CO, E-COV and E-COVX modules) US only
- 3 m / 10 ft anesthesia gas sampling line (with E-CO, E-COV, E-CAiO and E-CAiOV modules)
- 2 m / 7 ft anesthesia gas sampling line (with E-COVX and E-CAiOVX modules)

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 labelling 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.

Connections

1. Ensure that the module is connected to the monitor.
2. Ensure that you have a new D-Fend 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.

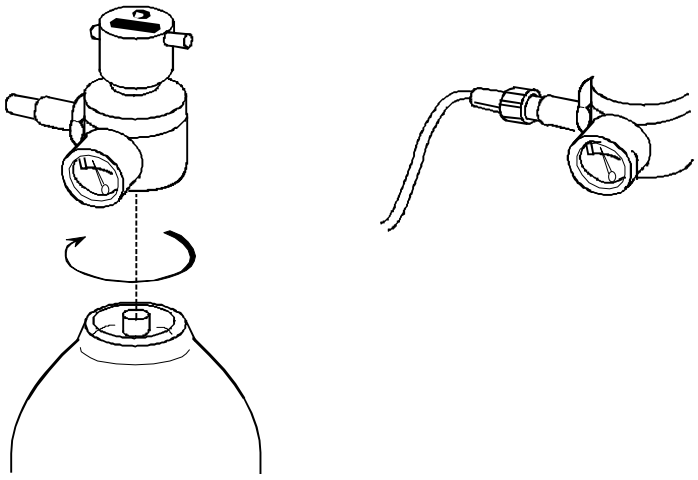


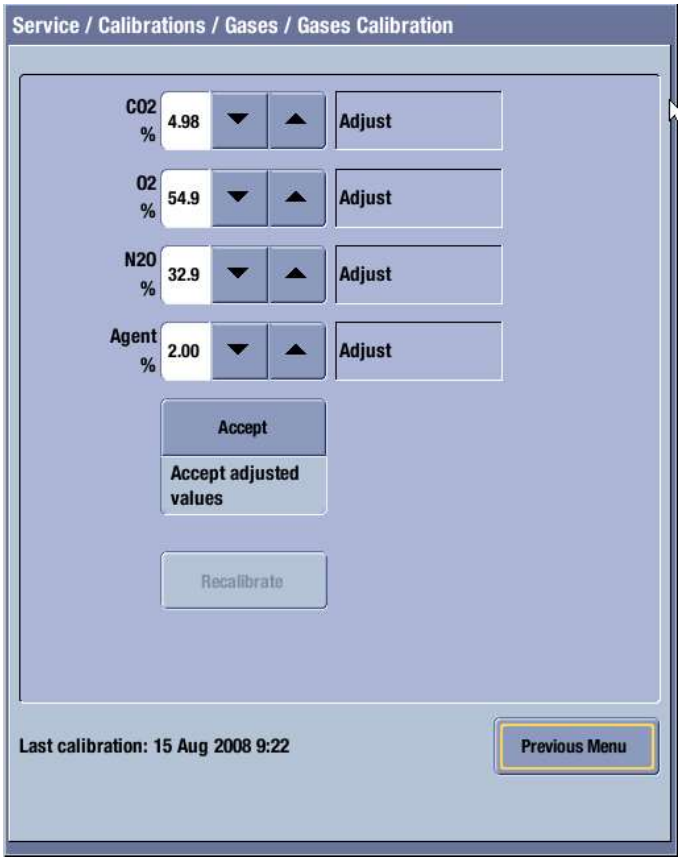
Figure 16 Connecting a gas regulator to the calibration gas container and connecting a sampling line to the gas regulator.

4.2.2 Procedure

1. Select ***Monitor Setup > Service Calibrations***
2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Gases***
4. Select ***Gases Calibration***

NOTE: Gas calibration is not available during the first 5 minutes after the module is connected. A message 'Gas calibration is not available during first 5 minutes' is shown in the lower left corner of the calibration menu. For maximum accuracy, let the monitor to warm up for 30 minutes before starting calibration.

NOTE: Gas calibration is not available during a 'Sample line blocked', 'Check Dfend' and 'Check sample gas out' alarm condition. A message 'Gas calibration is not available during gas sampling warning' is shown in the lower left corner of the calibration menu. Resolve the alarm condition before starting calibration.



5. The monitor will start automatic zeroing of the gas sensors. Wait until the message 'Zeroing' is replaced by a message 'Zero Ok' for all measured gases.
6. Open the regulator after a message 'Feed gas' is shown for all measured gases. The measured gas concentrations are shown in real-time in the gas calibration menu. Continue feeding the calibration gas until the measured gas concentrations are stabilized and a message 'Adjust' is shown for all measured gases. Close the regulator.
7. Use the up-down spinner controls in the calibration menu to adjust the gas readings shown in the calibration menu to match with the gas readings in the labelling of the

calibration gas container. Select Accept to accept the adjusted values when the gas readings match each other.

8. Wait until a message 'Ok' is shown for all measured gases.

NOTE: A message 'Zero Error' is shown in case the zeroing fails.

NOTE: A message 'Calibration Error' is shown, if you do not start feeding gas within 1 minute after the automatic zeroing is completed, or if the calibration fails due to too large gain adjustment.

NOTE: If zeroing or calibration failed, select the 'Recalibrate' button to restart the calibration procedure from the beginning.

4.3 Spirometry Calibration

Patient spirometry does not require regular service calibration during planned maintenance, or after the PVX unit has been replaced.

The PVX 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.

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

4.3.1 Calibration setup

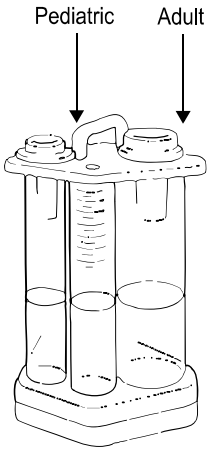
Required tools

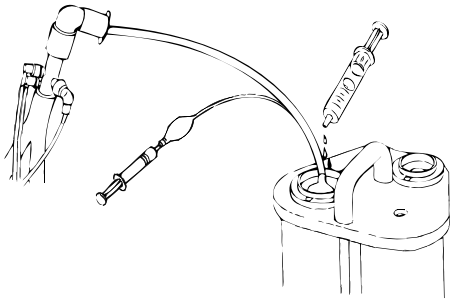
- P/N 884202-HEL Spirometry tester
- D-Lite and Pedi-lite sensors
- Spirometry tube
- Ventilator

NOTE: See the supplemental information manual for compatible accessories.

Connections

- Refer to the "Instructions for Use" -letter of the spirometry tester to see the setup.





Monitor configuration

- Configure the Flow waveform field to the monitor screen with adequate priority.
- Select the ***Setup*** tab in the ***Spirometry and Gas Exchange*** menu and configure:

  Scaling: Auto

  Sensor Type: Adult

  Show Volume: TV

Ventilator configuration

- Configure the ventilator to use air as fresh gas.
- 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.
- Set the RR =15, I/E =1/2 and PEEP 0cmH2O.

4.3.2 Calibration check

1. Perform the calibration check according to the steps 1 through 12a in the "Instructions for Use" -letter 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.

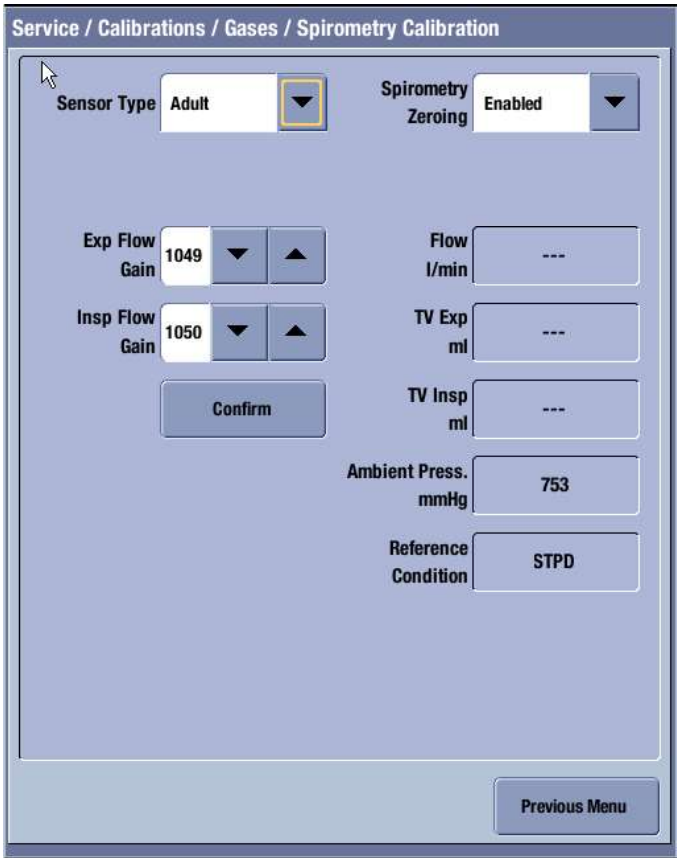
2. The measured flow values are shown in real-time in the ***TV Insp*** and ***TV Exp*** fields in the Flow parameter window. Compare these measured values to the TV value reading (highest water level) in the spirometry tester.

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 according to section 4.3.3 Flow calibration.

4.3.3 Flow calibration

1. Select ***Monitor Setup > Service Calibrations***
2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Gases***
4. Select ***Spirometry Calibration***
5. Ensure that the ***Sensor Type*** is correct and that ***Spirometry Zeroing*** is Enabled.
6. Wait until the PVX sensor performs an automatic zeroing. It will show a message "zeroing" in the Flow parameter window when zeroing takes place.
7. 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***.
8. Press ***Confirm*** to check the effect of the gain adjustment to the flow readings.
9. Repeat steps 6 and 7 until the flow values are within the specification.


Service / Calibrations / Gases / Spirometry Calibration
Sensor Type
Adult
Spirometry Zeroing
Enabled
Exp Flow Gain
1049
Insp Flow Gain
1050
Confirm
Flow l/min

TV Exp ml

TV Insp ml

Ambient Press. mmHg
753
Reference Condition
STPD
Previous Menu