





User's Instruction Manual

Rev. 1.0 – 07.2011

IMPORTANT

The information contained in this manual is subject to change without notice. The manufacturer reserves the right to make any changes to the characteristics or the design.

The use of this equipment on patients needs to be supervised by a specialized doctor.

Carefully read the instructions contained in this document before connecting the ventilator to a patient. The information included in this manual is aimed at describing the ventilator, what it can do and its possible settings, but it cannot, nor should not be considered as a substitute for the required judgment by competent professionals, who should decide and determine the mode of use for each patient in particular.



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Introduction

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- 1.1 Observed requirements and standards
- 1.2 Equipment overview
- 1.3 Intended use
- 1.4 Intended user
- 1.5 Intended use environment
- 1.6 Contraindications for use
- 1.7 User support
- 1.8 Symbols used
- 1.9 Abbreviations, acronyms and variable names

CHAPTER SUMMARY

This introductory chapter details the concepts defining *iTermIS ADV*. These definitions provide information about the equipment, and its appropriate use. The information included in this chapter is to be used as mandatory guidelines for the design and development of *iTermIS ADV*.

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1.1 | Observed Requirements and Standards

- **UNE-EN 794-1:1997+A1:2001+A2:2009.** Lung ventilators -- Part 1: Particular requirements for critical care ventilators.
- **IEC 60601-1:2005.** Medical electrical equipment -- Part 1: General requirements for basic safety and essential performance.
- **IEC 60601-1-2:2001+A1:2004.** Medical electrical equipment -- Part 1-2: General requirements for basic safety and essential performance - Collateral standard: Electromagnetic compatibility - Requirements and tests.
- **IEC 60601-1-4:1997+A1:2000.** Medical electrical equipment -- Part 1-4: General requirements for safety - Collateral standard: Programmable electrical medical systems.
- **UNE-EN 60601-1-8:2008.** Medical electrical equipment -- Part 1-8: General requirements for basic safety and essential performance - Collateral Standard: General requirements, tests and guidance for alarm systems in medical electrical equipment and medical electrical systems.
- **IEC 60601-2-12:2001.** Medical electrical equipment -- Part 2-12: Particular requirements for the safety of lung ventilators - Critical care ventilators.
- **UNE-EN 980:2008.** Graphical symbols for use in the labeling of medical devices.
- **ISO 13406-2 Class II.** Ergonomic requirements for work with visual displays based on flat panels -- Part 2: Ergonomic requirements for flat panel displays

1.2 | General Equipment Overview

iTermIS ADV is a microprocessor-controlled mechanical ventilator which incorporates the most advanced methods for ventilatory support. The electronic circuit operates two proportional valves which provide the gas flow necessary to satisfy the selected configuration.

1.3 | Intended Use

The *iTermIS ADV* ventilator was designed to be used with all types of patients: adult, pediatric, and neonatal infants requiring invasive and noninvasive ventilatory support, for a short or long period, allowing monitoring of the main ventilatory parameters. The equipment provides care for patients able or unable to make their own breathing efforts.

1.4 | Intended User

iTermIS ADV must be managed by or under the supervision of health professionals with the appropriate training in ventilatory therapies, and especially in the use of this ventilator.

1.5 | Intended Use Environment

The ventilator was designed to be used in hospitals and health care centers, specifically in intensive care wards, where the presence of competent professionals and of the required facilities ensure the proper use of the equipment

1.6 | Contraindications for Use

It is NOT possible to use a ventilator when any of the following events occurs:

- Starting and operating the ventilator in the absence of competent medical professionals supervising the procedure.

- If there is no alternative ventilation method and equipment that can be used as a backup.
- To drive an anesthesia machine. Never use it in the presence of flammable anesthetic gases.
- Connected the device to an inadequate electric mains power (e.g. without earth connection).
- The ventilator is located in the vicinity of magnetic resonance equipment or significant sources of electromagnetic radiation.
- With gas supply which do not meet medical grade specifications.
- During the inter hospital transfer of patients (mobilization outside the assigned institution).
- Failure to strictly comply with the instructions for use, user and intended use environment for this ventilator.

1.7 | User Support

If you need technical support, please send an email to service@heyermedical.de. Please be sure to include the name of the institution to which the equipment belongs, and the contact details where a response can be submitted.

1.8 | Symbols Used

	Keep upwards.
	Keep dry.
	Temperature limits.
	Fragile.
	Do not stack more than 5 boxes.
	Moisture limit.
	Manufacturer.
	Not reusable.
	Marking indicating compliance with the requirements of European Council Directive (93/42/EEC) on medical devices.

	Authorized representative in the European Community.
	Off (electric power).
	On (electric power).
	Warning
	Caution
	Note
	Type B applied part
IPN₁N₂	Degree of protection against ingress of particles (N1) and liquids (N2). IP Classification.
	Access to alarm limit configuration.
	Audio paused. Icon used to identify the control and the on-screen warning of the paused sound alarm signal.
	Alarm off. Icon indicating that an alarm has been deactivated.
	Alarm limits.
	Exhaled gas discharge port (from patient). Connection for the expiration set.
	Inhaled gas delivery port (to patient).
	Connection port for the nebulizer.
P1 P2	Connection ports for the distal pneumotachograph hoses.
Prox	Connection port for the proximal pneumotachograph.
O₂ %	Connection port for the O ₂ cell.

	Ventilator in Standby. There is no ventilation support in this state.
	Indicates patient-initiated breaths.
	States of charge of the internal battery.
	Rise Time. Control for the setting speed of the configured inspiratory pressure.
	On-screen display for enabled autoscale.
	On-screen display for screenshot in progress.
	On-screen display for nebulization on.
	On-screen display for [Ctrl] key pressed.
	On-screen display for passive humidifier selected.
	On-screen display for active humidifier selected.
	Screen lock.
	Proximal pneumotachograph activated.
	On-screen display for maintenance required.

1.9 | Abbreviations, Acronyms and Variable Names

%O₂	Concentration of O ₂
ADL	Adult
APRV	Airway pressure release ventilation
C_{di}	Dynamic compliance
C_{st}	Static compliance

Cmax	Maximum compliance
CPAP	Continuous positive airway pressure
Esc	Escape
Esp.	Expiration or expired
ETCO₂	Expiration-end CO ₂
f	Respiratory rate
F Espon	Spontaneous respiratory rate
F/VT	Respiratory rate:tidal volume ratio
FiO₂	Inspired oxygen fraction
f_{TOTAL}	Total respiratory rate
I:E	Inspiratory time:expiratory time ratio
Insp.	Inspiration or inspired
Lip	Upper inflection point
MMV	Mandatory minute ventilation
NEO-INF	Neonate-Infant
O₂ 100%	100% oxygenation
P/V flex	Inflection points
P0.1	Pressure during the first 100 ms
P1	Lower hose inlet of expiratory pneumotachograph
P2	Upper hose inlet of expiratory pneumotachograph
Paw	Airway pressure
PCV	Pressure controlled ventilation
PED	Pediatric
PEEP	Positive end expiratory pressure
Pimax	Maximum inspiratory pressure

Pmax	Maximum pressure
Pmin	Minimum pressure
PSV	Pressure support ventilation
Re	Expiratory resistance
Ri	Inspiratory resistance
SIMV	Synchronized intermittent mandatory ventilation
TCPL	Time-cycled, pressure-limited ventilation
Te	Expiratory time
Ti	Inspiratory time
Uip	Upper inflection point
$\dot{V}$	Flow
VCO₂	Eliminated CO ₂
VCV	Volume control ventilation
$\dot{V}E$	Expired minute volume
VE Espont	Spontaneous expiratory minute volume
VE Mandat	Mandatory expired minute volume
VM	Minute volume
Vmax	Maximum volume
NIV	Noninvasive ventilation
VT or V_T	Tidal volume
WOBi	Imposed work of breathing

Warnings - Precautions - Notes

CHAPTER CONTENTS

- 2.1 Definition of Terms
- 2.2 Warnings
- 2.3 Precautions
- 2.4 Notes

CHAPTER SUMMARY

Warnings, precautions and notes are used to highlight relevant information that the reader must know. This chapter defines the meaning of the terms warning, caution, and note in the context of this manual, and summarizes some of the most important definitions of each of them.

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2.1 | Definition of Terms



WARNING

- Means that it is possible to cause harm to oneself or to others.



PRECAUTION

- Means that it is possible to damage the equipment, or other equipment nearby.



NOTE

- Specifies the points of particular interest that must be taken into account for proper application.

2.2 | Warnings

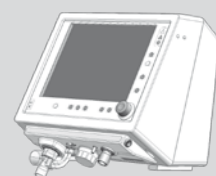


WARNING

- **Specialized personnel must keep a constant care when the ventilator is connected to a patient. Some situations require immediate corrective care. The alarm system itself is not meant to be a solution for an adverse condition, it is only intended to warn of its existence.**
- **The instructions concerning the implementation and regulations of the controls mentioned herein are to be used for guidance. Professionals in charge of operating this mechanical equipment must use their knowledge and judgment to adapt it to the needs of the patient.**
- **The iTernIS ADV ventilator is a life support device. It is mandatory to perform clinical surveillance on the patient, frequently and properly. It is also mandatory to be prepared to provide an alternative way of ventilation.**
- **iTernIS ADV is not intended to function as a support for anesthetic machines. The use of the ventilator in anesthesia administration procedures is not considered as an intended use indication.**
- **Do not use the ventilator in the presence of flammable anesthetic gases. This can cause an accident by explosion or fire.**
- **ALWAYS use a water filter for compressed air at the AIR inlet of the device. The use of this type of filters is necessary regardless of the type of compressed air source used.**
- **Antistatic and electrically conductive hoses shall not be used, neither in the ventilator pneumatic supply nor in the patient circuit.**
- **Operation with internal battery has a limited time. In the event of a dead battery, immediately replace the main power or switch to an alternative method of ventilation.**
- **To avoid risk of electric shock, this equipment must be connected to an earthed power source. Neither remove the third pin (earth) of the plug power cord, nor use a two-pin adapter.**



Keep a distance of NOT less than 3 meters (9.84 feet).



- **Observe separation distances it to other devices emitting high frequency (e.g., cell or wireless phones, defibrillators, electrocautery devices, etc.). Unwanted interference can be checked on the ventilator.**
- **Magnetic resonance equipment produces emissions that can damage the ventilator permanently.**
- **Do not remove the back panel under any circumstances. Otherwise it will be sufficient cause to void the warranty included in this manual. If you remove the back panel, HEYER Medical AG. shall not responsible for the consequences that this may cause on the equipment or to people. There may be a risk of electrocution if it is removed while the device is in operation.**
- **Use only gases (air and O₂) that meet medical grade requirements of applicable rules.**
- **Do not connect any accessory other than those specified as part of the system.**
- **Do not use any device that may restrict the flow or pressure between the output supply and the supply hoses that feed the ventilator. Therefore, DO NOT USE pressure regulators with shutoff valves, or flow meters.**
- **In the event of a significant leak, check the patient circuit to detect the section with the leak. Replace or repair the segment to prevent any inadequate change in ventilation.**
- **The expiratory flow sensor (pneumotachograph) contains in the inner middle a membrane whose integrity is essential for the proper reading of the expired volume. When cleaning this part, you must be careful not to damage the membrane.**
- **While the ventilator is ventilating a patient, do not establish any connection between it and a data network, or to any external equipment that does not meet electrical safety requirements necessary to be considered as an electromedical system or equipment.**
- **Only HEYER Medical AG. or personnel authorized by the company may replace or modify the ventilator or its parts.**

2.3 | Precautions



PRECAUTION

- **Do not use solvents, acetone, chloroform or strong acidic substances or chlorinated solvents to clean plastic parts or hoses in the patient circuit.**
- **DO NOT USE sodium hypochlorite solutions (bleach) to clean the "Hytrel" patient circuit hoses.**
- **DO NOT USE pure alcohol anywhere, or cleaning solutions containing alcohol, or cleaners containing conditioners.**
- **The ventilator cabinet must not be subjected to sterilization with ethylene oxide gas. This can cause irreparable damage to its components.**
- **Ethylene oxide can cause alterations in the surface of plastics and accelerate the aging of rubber components.**
- **If when switching on the equipment, after an extended time of disuse, the system displays low battery power warnings, the ventilator must be connected to a network of adequate power for a period of 8 (eight) hours. If these signals persist, they may indicate the need for a battery replacement. In this case, contact the authorized service.**

- *When replacing the battery, the discarded unit must be processed following the instructions of the institutional authority. The discarded battery must not be thrown into the fire. That would pose a danger of explosion.*

2.4 | Notes



NOTE

- To discard all equipment or obsolete parts or elements provided by other companies, follow the requirements of the institutional authority.
- Each programmed operative mode maintains its own values and is stored in temporary memory while the computer stays on.
- It is not possible to start the calibration of the ventilator using only compressed AIR.
- While a ventilator parameter value is being changed and is still not accepted, the previous value remains active. Similarly, if the change is not accepted within a maximum time of 15 seconds, the previous value is not modified.



MAINTENANCE NOTICE

When the first 5000 hours of operation are completed, and thereafter, every 5000 hours, a tool icon appears at the *Icons and messages bar*. The presence of the icon is deleted by the authorized service after the maintenance protocol is performed.

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Assembly and Installation

CHAPTER CONTENTS

- 3.1 Set of Items for Complete Assembly
- 3.2 Assembly of the Pedestal
- 3.3 Attachment of Ventilator to the Pedestal
- 3.4 Connection to the Gas Source
- 3.5 Connection to the Power Source
- 3.6 Patient Circuit
- 3.7 O₂ Sensor

CHAPTER SUMMARY

This chapter contains the information needed to assemble the ventilator, mount it on the pedestal, connect it to power sources, and prepare it to be put into use.

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3.1 | Set of Items for Complete Assembly

The complete set, including accessories, comprises the following items:

Table 3-1 Contents of the Complete Ventilator Assembly

Qty	Description	Standard Accessory	Optional Accessory
1	<i>iTernIS</i> ADV ventilator.		
1	Pedestal base with four wheels.	•	
1	Vertical pedestal column with locking screws	•	
1	Pedestal support plate with locking screws and hex key.	•	
1	Articulated extension arm with support for patient circuit.	•	
1	Compressed oxygen supply hose with connection ends.	•	
1	Compressed air supply hose with connection ends.	•	
1	O ₂ supply hose for intra-hospital transfer (from 2 O ₂ tubes).	•	
1	Compressed air filter.	•	
2	Expiratory sets (expiratory valve + expiratory pneumatograph and connecting hoses).	•	
1	Reusable patient circuit for ADL, PED, or NEO-INF class, with connectors.	•	
1	O ₂ Sensor.	•	
1	Test lung.	•	
1	Nebulizer with connectors.	•	
1	Power cord for 110-220 V.	•	
1	Heater/Humidifier with connecting elements.		•
1	Capnograph.		•
1	Proximal pneumotachograph (for NEO-INF)		•

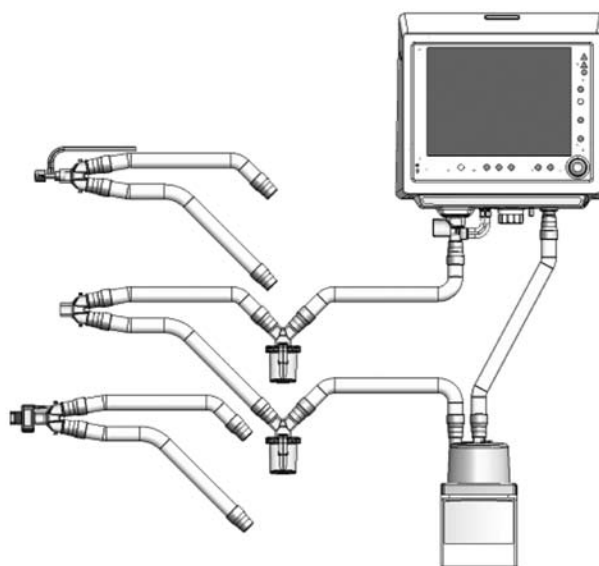


Fig. 3-1 Diagram of the ventilator assembly with patient circuit. The Y-shaped part has been redrawn to show the optional capnograph connection. The proximal pneumotachograph may be placed in the same position.



WARNING

• Do not use parts or accessories which have not been described as ventilator parts or are not provided or recommended by HEYER. Otherwise, the performance of the ventilator may differ from that stated in this manual.



NOTE

• The following accessories are not manufactured by HEYER:

- Reusable or disposable patient circuit.
- Heater/humidifier (optional).
- Capnograph (optional).
- Proximal pneumotachograph (optional).
- Nebulizer.
- Test lung.
- Water traps.

3.2 | Assembly of the Pedestal

- Attach the vertical column to the rolling base with Allen screws, adjusting it with the 6 mm hex key. Check that the support for the heater/humidifier on the vertical column and the wheels with brakes on the base are facing to the same side (front of the pedestal).

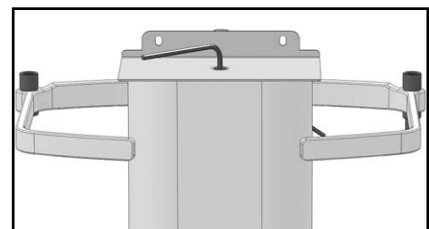
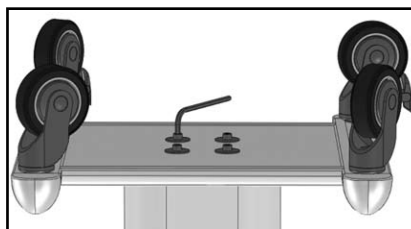


Fig. 3-2 Pedestal Assembly Images. Left, vertical column mounting on the base. Right, plate locking screw tightening.

- Place the plate on top of the vertical column, aligning the plate bolt with the opening in the column. Insert and tighten the locking screw with the 5 mm hex key.
- Attach the lateral bars to the rear of the vertical column. Use the appropriate screws and the 4 mm hex key. Using the two central screws, also attach the J-shaped cross section provided in the set (Fig. 3-3).
- Attach the articulated extension arm with hose support, twisting it onto one of the ends of the lateral bars.

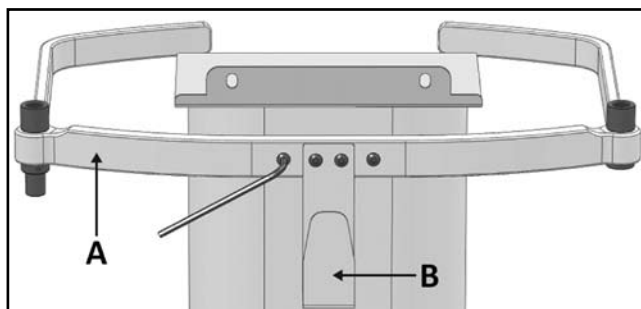


Fig. 3-3 Rear view of the vertical column while attaching the lateral bars (A). The J-shaped cross section (B) is placed over the lateral bars.

3.3 | Attachment of the Ventilator to the Pedestal

Place the ventilator over the pedestal so that the grooves coincide with the upper plate. Slide the ventilator over these guides to the edge of the back angle of the plate. Attach the ventilator to the plate with the two locking screws, as shown in Fig. 3-4.

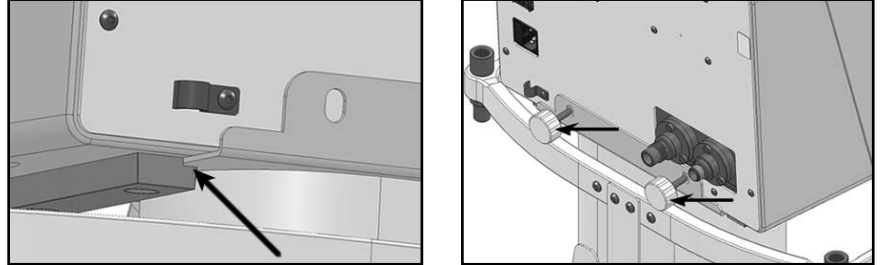


Fig. 3-4 Illustrations showing how to attach the ventilator to the pedestal. The left image shows the ventilator groove, and the right image shows the locking screws.

3.4 | Connection to the Gas Source

- Connect the compressed air filter to the ventilator AIR inlet, as shown in Fig. 3-5. Tighten it firmly by hand.
- Tighten the female connector for the compressed air pressure tube to the free end of the compressed air filter. Tighten it by hand. Place the free end of the pressure tube into the compressed air source outlet (central air source or compressor).
- Tighten by hand the female connector of the oxygen pressure tube to the ventilator OXYGEN inlet. Place the free end of the oxygen pressure tube into the compressed oxygen source intake.

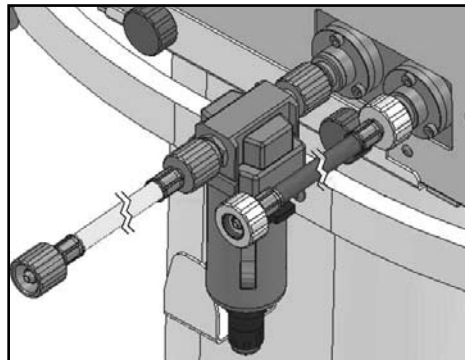


Fig. 3-5 Connection of gases from the source. A compressed air filter inserted at the AIR inlet is shown.



WARNING

- **ALWAYS** use a water filter for compressed air at the equipment AIR intake. The use of this type of filters is necessary regardless of the type of compressed air source used.
- Do not use any device that restricts flow or pressure between the source outlet and the supply hoses that feed the ventilator. Therefore, **DO NOT USE** pressure regulators with shutoff valves or flow meters.
- Only use gases (air and O₂) that comply with the medical grade requirements of the applicable standards.



PRECAUTION

- The supply pressure for both gases should be in the range of 3.5 to 7.0 bar (approximately 50-100 psi).



NOTE

- It is possible to calibrate and initiate ventilation when there is not enough pressure at the AIR inlet (3.5 – 7.0 bar), but there is enough pressure at the OXYGEN inlet. This action should be considered exceptional and in extreme necessity. If there is insufficient supply pressure at the OXYGEN inlet, calibration cannot be done and ventilation cannot be initiated.
- The responsibility for correctly supplying air and oxygen rests solely with the user, not HEYER
- The gas supply source should be capable of providing peak flows of up to 180 L/min and never less than 120 L/min for compressors.
- Within the allowed supply pressure limits, it is NOT necessary for gases to have equal pressures. The ventilator pneumatic system makes the necessary adjustments for proper functioning.

3.5 | Connection to the Power Source

The intake for the power source connection is on the back panel of the equipment.

- Connect the provided power cable to the equipment 110 - 220 V power intake socket (switching from one voltage to another is automatic). Attach the safety clasp to the cord to avoid accidental disconnections. Use a 2.5 mm hex key to do this (Fig. 3-6).
- Plug the other end of the power cord into an appropriate three-pin power intake. Do not remove the third pin of the power cord plug. The removal of the earth contact may cause dangerous consequences for the user, the patient, and the equipment.

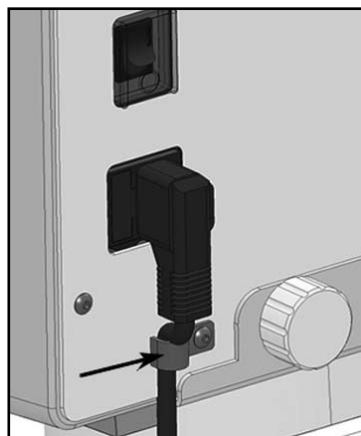


Fig. 3-6 Connected power cord, secured by a mechanical safety clasp (indicated with the arrow) to avoid accidental disconnections.



WARNING

- **To avoid risk of electric shock, this equipment must be connected to an earthed power source. Neither remove the third pin (earth) of the plug power cord, nor use a two-pin adapter.**
- **Place the ventilator in a position that allows free access to the main power connection and power distribution network. To electrically isolate the ventilator from the main source, the power cable must be unplugged.**

3.5.1 | Main electrical power failure

Main electrical power failure may be due to the following circumstances:

- No power in the electrical power network.
- Disconnected power cable.
- Burned-out inlet fuse.

If any of these circumstances occurs while the equipment is in the active process of ventilation, the power source automatically changes over to the internal battery. This event is signaled by medium priority alarm signals (see *Alarms* chapter).

If main power failure occurs before initial calibration, ventilation cannot be started. The Power Loss alarm signals are activated and calibration cannot be performed until main power supply is restored.



WARNING

- ***External electrical power failure is an emergency. If the situation is prolonged, the use of an alternate ventilation system should be considered.***



PRECAUTION

- *Before operating the ventilator for the first time, the battery must be fully charged. To do this, connect the ventilator to an appropriate electrical power source for eight (8) hours.*
- *If after a prolonged time in disuse, the Low Battery charge alarm signals appear when the equipment is turned on, the ventilator should be connected for at least eight (8) hours. If these signals persist, it may be an indication that the battery needs replacing. In this case, consult with an authorized service provider.*



NOTE

- When the ventilator is powered by the internal battery, it has the same operational capacities as when plugged into the power network using the main power cord, with the exception that the Capnography is disabled.

3.6 | Patient Circuit

The patient circuit is understood as the system of hoses that transport gas between the ventilator and the patient. This definition includes all accessories attached to the hoses (humidifier, water traps, nebulizers, valves, connectors, etc.).



WARNING

- ***Antistatic and electrically conductive hoses shall not be used, neither in the ventilator pneumatic supply nor in the patient circuit.***
- ***Adequate inspiratory and expiratory resistance of the respiratory system should be verified when accessories or sub-assemblies not listed in this manual are added to the patient circuit.***

Each category of patient uses a different sized patient circuit. The tube diameters are: 22 mm for ADL, 15 mm for PED, and 10 mm for NEO-INF. Consequently, the

connectors and accessories should be of those same measurements.

3.6.1 | Inspiratory Segment

Fig. 3-1 shows a diagram with the patient circuit connected to the ventilator with the included optional accessories. The patient circuit assembly is divided into the inspiratory segment, the expiratory segment, the Y piece which connects both segments, the expiratory set, and the proximal pneumotachograph.

The inspiratory segment includes the elements of the patient circuit between the outlet opening to the patient and the Y-connection piece. The elements of this segment, from the ventilator to the patient, are:

- Short segment of hose, if the active humidifier is used. Otherwise, a segment of hose up to the water trap.
- Active Heater/Humidifier (optional).
- Segment of hose up to the water trap (if the active humidifier is used).
- Water trap.
- Segment of hose up to the nebulizer (if it has this option).
- Nebulizer.

3.6.2 | Expiratory Segment

The expiratory segment connects the Y-piece to the expiratory set. The elements of this segment, from the Y-piece to the ventilator, are:

- Segment of hose up to the water trap.
- Water trap.
- Section of hose up to the expiratory set.
- Expiratory Set.

3.6.3 | Y-piece - Connection to the Patient

The Y-piece is a single unit that links the inspiratory and expiratory segments of the patient circuit and provides the connection to the patient. The tracheal tube intermediary is connected to the 15 mm female opening of the piece. A capnograph or a proximal pneumotachograph can optionally be placed at the end to the patient.

3.6.4 | Assembly of the Circuit

To assemble the patient circuit, just follow the order of the elements described above, or use the diagram in Fig. 3-1 as a reference.

Take into account size compatibility for hoses, connectors and accessories. Maintaining airtightness is important at every point in the circuit. Otherwise, losses with undesired consequences at a functional level may occur. The connection of the expiratory set is explained below.



PRECAUTION

- *The patient circuit may have water traps in the middle portion of the inspiratory and/or expiratory segments. Ensure the airtightness of these devices. Any leak may cause a loss of volume in the circuit.*

3.6.5 | Expiratory Set

The expiratory set integrates into its body the distal expiratory pneumotachograph (flow sensor) and the expiratory valve. The pneumotachograph is a delicate element that must be handled with care.

The expiratory set houses a diaphragm that is essential for the proper functioning of the valve. It is very important to correctly position the diaphragm to ensure proper functioning. The diaphragm may be replaced, which requires disassembly of the set.

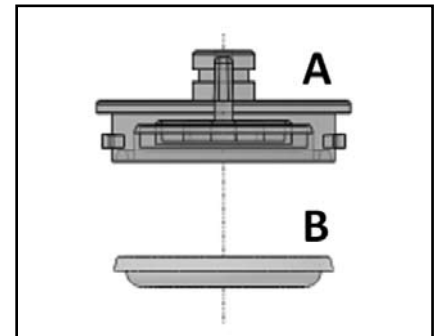
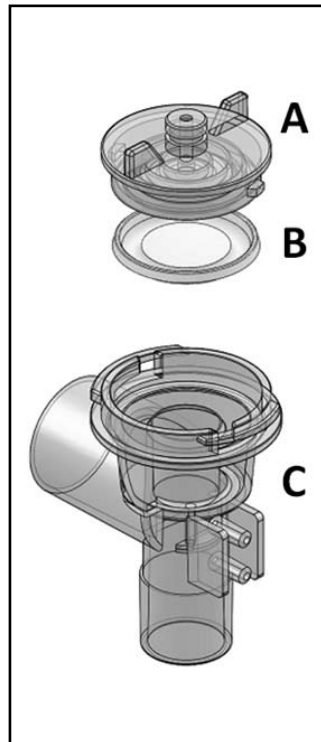


Fig. 3-7 Left, the cap (A), the diaphragm (B), and the body of the set (C) are shown. Right, the expiratory set cap. This occupies the upper part of the set and provides a closure over the ventilator gas outlet opening. The cap is shown in a face-down vertical position, as placed on the body of the set, with the diaphragm in the correct position.

To disassemble the set:

- Grasp the cap and turn counterclockwise until it can be removed. Once the cap is removed, the diaphragm is freed.

To assemble the set:

- Place the diaphragm in the expiratory set cap, as shown in Fig. 3-7. It can also be done on the upper part of the set body, carefully keeping the ring-shaped piece pointing downward when the set is vertical (Fig. 3-7 or Fig. 3-8).
- Place the cap on the set body. To do this, place the cap such that the perimeter flanges line up with the notches on the top side of the set body.
- Gently turn the cap clockwise until the flanges reach the edge of the body lateral slots.

To place the set into the ventilator:

- Face the ventilator.
- Introduce the set into the corresponding connection opening at the lower block of connections, such that the connectors for the hoses that run toward P1 and P2 face to the front.

- Once the set has been introduced, make a quarter turn in the counterclockwise direction. The set should be in the position shown in Fig. 3-8, that is, with the exhaled gases outlet facing towards the left (horizontal outlet).
- Place the silicon hoses into the cylindrical connectors in the pneumotachograph (in Fig. 3-8 they are identified as 'To P1' and 'To P2'). The free ends of the hoses should be connected to P1 and P2 at the base of the ventilator, such that the upper connector links to P2 and the lower connector to P1.
- Once placed, the lower end of the set (22 mm male connector) can receive the free end of the last segment of the expiratory segment.



WARNING

• ***The pneumotachograph incorporated into the expiratory set has a delicate transparent membrane inside it. This must not be damaged in order for the expiratory flow and volume measurements to be correct.***

• ***When replacing, always use original diaphragms. Similar non-original diaphragms may cause malfunctioning of the valve with blockage of the expiratory airway.***



PRECAUTION

• ***Incorrect connection of the silicon hoses to P1 and P2 produce incorrect flow and volume readings. It is important to correctly connect the pneumotachograph hoses.***

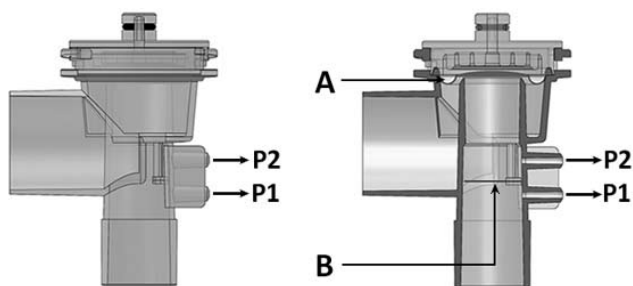


Fig. 3-8 Drawings of the expiratory set Left, front view of the set. Right, same view, but of a cross-section of the front of the set. (A) position of the diaphragm, and (B) position of the internal membrane.

3.6.6 | Proximal Pneumotachograph

The proximal pneumotachograph is a disposable (non-reusable) accessory used to measure flow at a point close to the connection to the patient, for NEO-INF category. It is a differential pressure sensor with a fixed opening that does not require calibration.

The proximal pneumotachograph is placed over the Y-piece, in the same direction as the flow passing through it. There is a mark on the sensor body that indicates the correct position. See Fig. 3-9.

The ventilator uses the distal pneumotachograph on the expiratory set in a predetermined manner. To activate the proximal pneumotachograph, consult the *Menu* chapter.

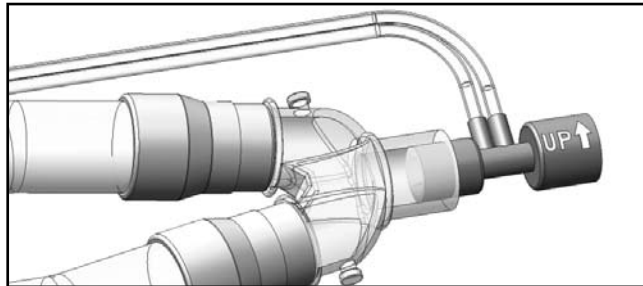


Fig. 3-9 Proximal pneumotachograph connected to the Y-piece.



WARNING

- **The proximal pneumotachograph and its hoses should always be free of fluids or other particles. Periodically verify that there is no condensed water or other substance inside the sensor body or hoses. Do not use the sensor during nebulization.**
- **Place the pneumotachograph on the Y-piece so that the hoses stay upward (as the mark on the pneumotachograph body indicates). This is useful to avoid that condensed water penetrates into the hoses and obstructs the airway.**
- **The sensor hoses should not be obstructed. Periodically verify that the hoses are not kinked or caught.**
- **Do not use force on the sensor hoses. Do not pull them to disconnect the sensor.**



PRECAUTION

- **The proximal pneumotachograph may only be used to ventilate with peak flows of not more than 20 L/min. Do not exceed this limit, otherwise the flow and volume readings may be seriously affected.**
- **The position of the pneumotachograph when connecting it to the Y-piece is very important. The device can only be connected on the Y-piece in one way (because of the connectors size). An improperly placed pneumotachograph prevents the ventilator from reading the expiratory flow values.**
- **When a proximal pneumotachograph is used, verify its connections before ventilating the patient. If any of the hoses is incorrectly connected, serious leakage of respiratory gases may result.**

3.7 | O₂ Sensor

The O₂ sensor is found in the ventilator lower block of connections (Fig. 3-10). It is in a position that allows the sensing of gas mixtures before reaching the outlet opening to the patient. This allows the monitoring of oxygen concentration in the gases flowing to the patient at the point where they leave the ventilator.

It is protected by a cylindrical cap. The cap may be removed to reveal the sensor by turning the cap counterclockwise.

The plastic body of the sensor or O₂ cell has a threaded segment in its upper part that keeps it in a fixed position. To remove the sensor, the connector (Jack plug) must first be removed, and then the body of the sensor turned until it is freed.

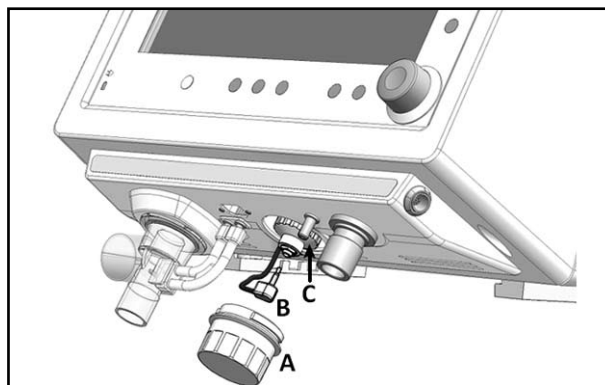


Fig. 3-10 Picture of the lower block of connections showing the oxygen sensor. (A) sensor cap, (B) sensor connector, and (C) the sensor itself.



NOTE

- When the O₂ sensor is used for the first time, it should be exposed to ambient air for at least 20 minutes before being connected to the ventilator.

Description - Sections of the ventilator

CHAPTER CONTENTS

- 4.1 Overview
- 4.2 Front Panel
- 4.3 Lower block of connections
- 4.4 Rear Panel
- 4.5 Upper Panel

CHAPTER SUMMARY

This is a descriptive chapter which individualizes the ventilator parts and highlights, in detail, each of their functions. The equipment is divided into three sections, grouping the descriptions of related attributes.

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4.1 | Overview

The *iTernIS ADV* ventilator integrates user interface, connections to the patient circuit, and connections to power sources (electric and pneumatic) into its cabinet.

The user interface has a touch screen, fixed keys and a rotary knob which allows for the management of all functions.

All connection points of the ventilator, whether they are electric or pneumatic, respect the relevant standards.

For the purpose of its description, the ventilator is divided into four sections:

- Front panel.
- Lower block of connections.
- Rear panel.
- Upper panel.

4.2 | Front Panel

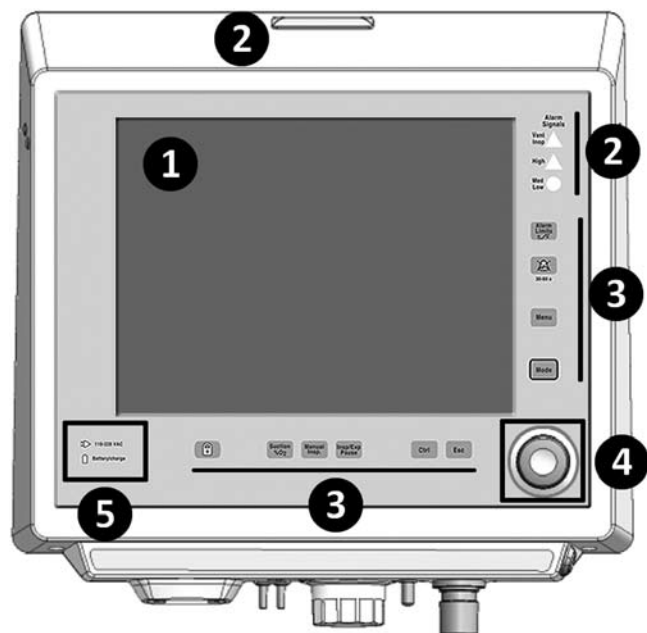


Fig. 4-1 Picture of *iTernIS ADV* front panel.

References of the Fig. 4-1

- 1 Screen.
- 2 Alarm Signals - Light Indications of the alarm system.
- 3 Fixed keys.
- 4 Rotary knob.
- 5 Electric power source indicators.

4.2.1 | Screen

The ventilator features a 12" touch screen which continuously displays the monitoring of the ventilator parameters, and various curves which can be selected according to user preference. The description of the on-screen graphics attributes handling is presented in chapter *Graphics handling*.

The screen is sectioned to facilitate the interpretation of the information presented. The characteristics of these fields are as follows.

4.2.1.1 | Control adjustments.

The lower area of the screen displays the ventilator parameters involved in the operative mode (Fig. 4-2). These values can be adjusted by the user. As one or other operative mode is selected, the amount and nature of these parameters may vary.

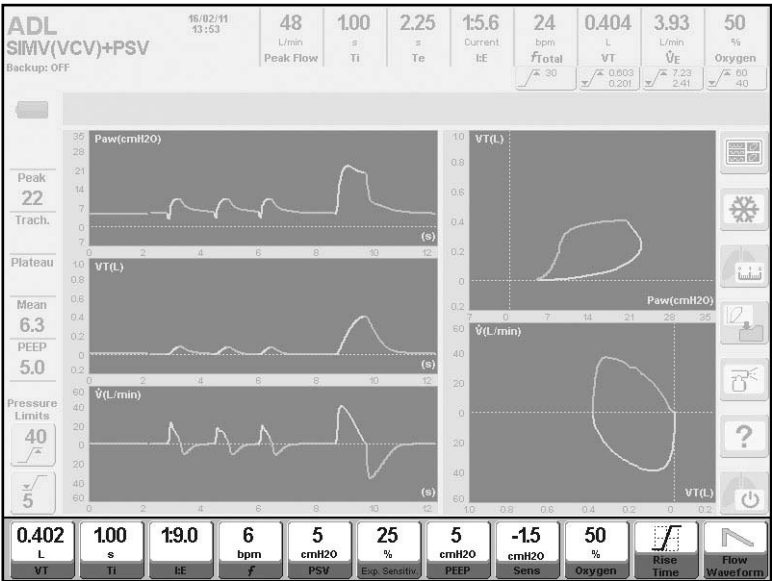


Fig. 4-2 Picture of a screenshot in which the field reserved for the controller settings is highlighted (operative mode screen: SIMV (VCV) + PSV).

4.2.1.2 | Monitored data.

The upper area of the screen houses the parameter values monitored by the ventilator. On the left of this area, a label indicates the patient category, the operative mode and, if possible to program backup ventilation, the operative mode configured as a backup. This area also includes the date and current time.

Below some of the monitored parameters lie touch buttons. These buttons allow for direct access to the configuration of the corresponding alarm. These buttons display the limit value of such alarms at all times (see chapter *Alarms*.)

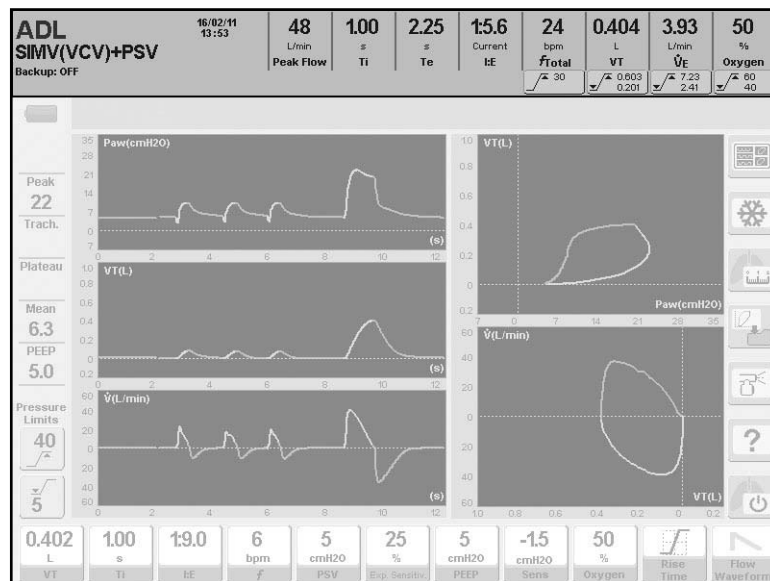


Fig. 4-3 Picture on a screen where the high portion has been highlighted, dedicated to indicate the monitored parameters. On the left of this area, the general data of ventilation are shown, such as the category of patient, the operative mode, and the configured mode set up as backup ventilation.

The monitored parameters are:

- **Peak flow - Inspiratory Peak flow (L/min)**
Peak flow in liters per minute. In all modes the maximum flow of gas, sent by the ventilator with each breath, is indicated.
- **T_I - Inspiratory time (s)**
It is indicated for each breath in all modes. The pause time is added when programmed or when run manually.
- **T_E - Expiratory time (s)**
Resulting expiratory time upgraded with each new breath.
- **Current I:E - I:E**
It indicates the inspiration/expiration resulting ratio.
- **f_{TOTAL} - Total rate (rpm)**
Total rate (spontaneous and mandatory breaths) expressed in breaths per minute.
- **V_T - Expired tidal volume (L for ADL/PED and mL for NEO-INF)**
Tidal volume breath by breath.
- **$\dot{V}_E$ - Expired minute volume (L/min)**
Value of the expiratory volume from the patient. This is a parameter that is monitored in all operative modes. Updating this value is done on a continuous basis.
- **Oxygen - Oxygen Monitor (%)**
It indicates the percentage of oxygen in the gas sent to the patient.

4.2.1.3 | Touch screen buttons.

On the right-hand area of the screen, a series of touch buttons, associated with the following features, appear (more on chapters *Basic Operations and Menu*):



Graphics (Displays screen graphics options).



Freeze (Freezes on-screen graphics).



Respiratory mechanics.



Save loop.



Nebulizer.



Help (help on the meaning of touch and fixed keys).



Stand by.

On the left-hand area of the screen, there are two touch buttons for rapid access to modifying the limits of inspiratory pressure alarms.



Maximum inspiratory pressure.



Minimum inspiratory pressure.

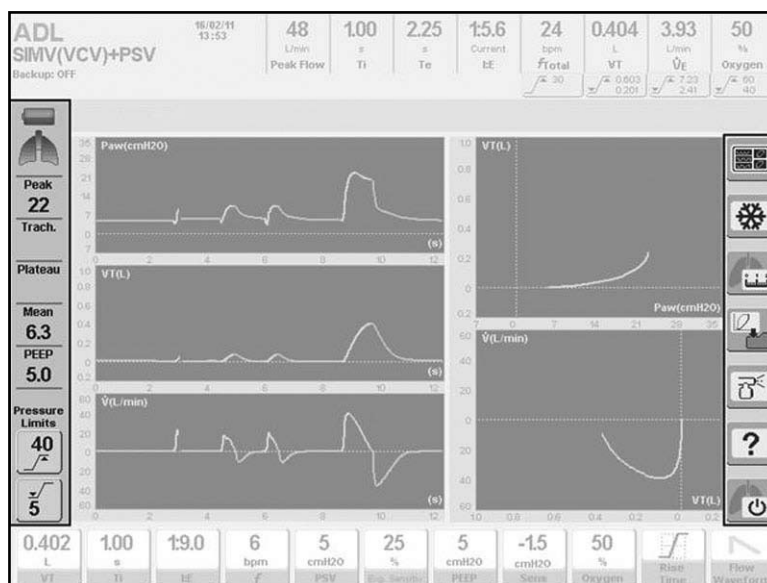


Fig. 4-4 The right-hand toolbar, which identifies touch commands for certain functions, and the left-hand toolbar which, among other things, indicates the numeric monitoring of pressure, are highlighted.

4.2.1.4 | Left-hand toolbar

On the left-hand area (see Fig.4-4) the following information is found:

- **Battery status**

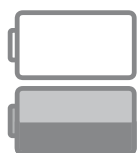
Indicator of the battery charge status. The declared autonomy for the internal battery in the chapter *Technical Specifications* covers the status of full battery and low battery.



Full battery (green icon).



Low battery (yellow icon).



Inoperative battery. Very low battery (red icon flashes).



WARNING

• *When the icon for inoperative battery appears, the remaining charging time is unpredictable, and main power source should be restored or replaced with an alternative ventilation system.*

- **“Lung” icon**

It is activated with every breath triggered by the patient.

- **Peak pressure (Peak)**

It indicates the peak pressure (maximum) achieved in each breath.

- **Tracheal pressure (Trach)**

It indicates the estimated tracheal pressure when the function Tube Compensation is activated.

- **Plateau pressure (Plateau)**

It indicates the pressure maintained during inspiration when inspiratory pause has been scheduled or when pressing **[Insp/Exp Pause]**.

- **Mean pressure (Mean)**

It indicates the mean pressure of each breath.

- **PEEP**

It indicates the pressure of the end of the expiratory phase.

- **Alarm limits of the inspiratory pressure**

Corresponds to the alarm limit levels of the set maximum and minimum pressure (chapter *Alarms* explains how to change these limits).

4.2.1.5 | Icons and messages bar and Onscreen alarm notices.

Between the *Monitored data* and the graphics area there is a space dedicated to Icons and messages and Onscreen notices of the alarm system.

The toolbar that shows icons and messages reporting a particular state of the ventilator, or feature thereof, is located on the left-hand area of the screen. The meanings of the icons are found in chapter *Introduction*.

If the number of the active messages displayed on this toolbar are superior to the space reserved for them, a rotating sample function is automatically activated. To indicate the presence of messages not being shown at that time, an arrow icon will appear in the upper right-hand corner of the toolbar. Every 5 s the messages rotate in a way that all active messages are displayed. In Fig. 4-5 a sequence of three statuses of the Toolbar icons and messages have been copied when there are 4 active messages.

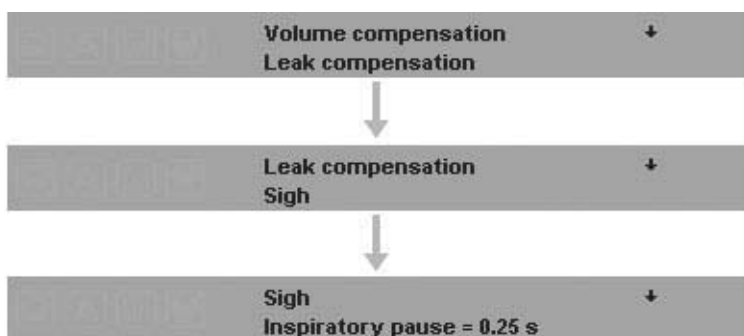


Fig. 4-5 The three toolbars indicate the sequence of messages, when functions are found to be active Volume compensation, Leakage compensation, Sigh, and Inspiratory pause.

The right-hand area is dedicated to a space for the emergence of On-screen notices of the alarm system. Whenever an alarm is triggered, the ventilator displays the name of that alarm in this area. The name appears on a red or yellow background which indicates the priority of that alarm (see Chapter *Alarms*).



Fig. 4-6 Picture in which the space reserved for the emergence of On-screen notices of alarms is highlighted. In this case the alarm of Maximum inspiratory pressure is found to be active.

4.2.2 | Alarm signals

It corresponds to the visual light signals forming part of the alarm system.

4.2.2.1 | Frontal panel

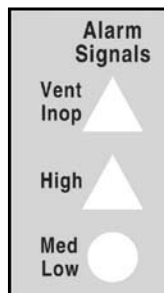


Fig. 4-7 Appearance of the Alarm Signals area where alarm light indicators are found.

- **Inop. Vent.**

It turns itself red if the ventilator goes into technical failure and remains inoperative. At start-up, this indicator lights up momentarily during the initial automatic tests, without signifying a technical failure. Alarm condition of maximum priority.

- **High**

Reserved for high priority alarms. It lights up red.

- **Med - Low**

Light signal accompanying alarms of medium to low priority. It lights up yellow.

4.2.2.2 | Upper panel

On the top of the upper panel there is the upper light indicator, which is part of the alarm system. Its behavior is described in *Alarms* chapter.

4.2.3 | Fixed keys



Alarm limits setting

Alarms have preset values, but can be reprogrammed. By pressing the key a menu appears with the alarms modifiable by the user.



Paused audio

Pressing the key once will pause the alarm beep during 30 s; pressing the key twice will result in a pause of 60 s.



Selection of operative modes

Pressing this key leads to the menu *OPERATIVE MODES*, from which you can select one of the enabled operative modes for the current patient status. Consult the *Basic Operations* chapter.



Menu

This key allows for access to the main menu of the ventilator. Given the importance of these key functions, a chapter is especially dedicated to its description. See chapter *Menu*.



Screen Lock – Touch screen lock

Fixed key used to block the functions of the touch screen as well as the fixed keys of the right-hand area of the front panel. More information on using this key can be found in chapter *Basic Operations*.



%O₂ suction

Allows for ventilation with a concentration of O₂ configurable for suction maneuvers. The time destined to suction can also be configured (see chapter *Menu*).



Manual Inspiration

While the ventilator is operating, pressing this key initiates a manual inspiration, with the values of the selected mode. By pressing **[Ctrl] + [Manual Insp.]** a sigh will be initiated, if they are programmed.



Manual Inspiratory/Expiratory Pause

It suspends ventilation and maintains the inspiratory or expiratory phase while the key is held down for a maximum of 7 s for inspiration and 20 s for expiration. This command works in VCV, PCV, and PRVC modes.



Ctrl

This key is always used in combination with another. Some examples of these functions are:

- **[Ctrl] + [Alarm Limits]** = 1) Alarms test. 2) Help message when an alarm is activated.
- **[Oxygen] + [Ctrl]** = Change of the value in steps of ten units.
- **[Ctrl] + [Ctrl]** = Reset all sensors to zero.
- **[Ctrl] + [Manual Insp.]** = Sigh (if programmed).
- **[Ctrl] + [Graphic]** = 1) Refreshes screen. 2) Deletes the reference loop on the screen but remains in memory.



Esc

It is a key with multiple, primary functions or in combination with other keys. This key, among other functions, allows for:

- Restoring the light signal of any activated alarm.
- Cancelling or aborting of the current ongoing operation, returning to the previous function.
- Closing an open menu while returning to the graphics display.
- Cancelling the current screen and returning to the main screen (FIVE CURVES).
- Cancelling a maneuver in progress.

4.2.4 | Rotary Knob

The rotary knob is located on the lower right-hand corner of the front panel. This knob rests on a luminous ring which lights up each time it is enabled for use. This is the device which permits the modifying of the ventilator configuration, and with which it is also possible to navigate through the enabled menus.

Some specific tasks can also be carried out by using the knob. For example, changes in scale, or the scrolling of the cursor over the graphics.

By pressing the knob, the executed modification is assimilated, or the submenu on which it is positioned will be selected. The use of this device is very intuitive. When it is necessary to use it will be described throughout this instruction manual.

4.2.5 | Electric power source indicators

This sector links two light indicators which inform on the status of the electric power supply of the ventilator. Refer to Table 4-1.

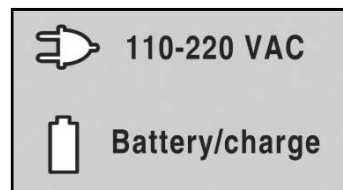


Fig. 4-8 Light indicators reporting the status of the electric power supply.

Table 4-1 Electric power source light indicators

Indicator	On/Off (Color)	Status
110-220 VAC	On (green).	Ventilator powered by 110-220 VAC mains.
Battery/Charge	Off.	
110-220 VAC	Off.	Ventilator powered by its internal battery.
Battery/Charge	On (Blue).	
110-220 VAC	On (green).	Ventilator powered by 110-220 VAC mains. Battery charging time.
Battery/Charge	On (green).	

4.3 | Lower Block of Connections

In the chapter *Assembly and Installation*, the types of connections are described. This section only lists the items which form part of the block.

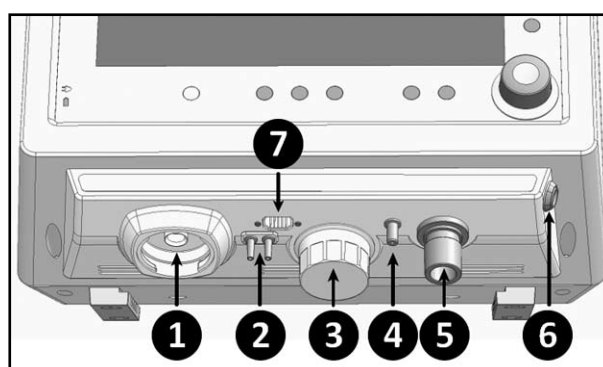


Fig. 4-9 Picture of the lower area of the ventilator.

References of the Fig. 4-9

- 1 Connection for the expiratory set.
- 2 Connections for pneumotachograph hoses of the expiratory valve.
- 3 O₂ cell.

- 4 Connection for the nebulization hose.
- 5 Connection Towards Patient of the patient circuit.
- 6 Inlet for the capnograph connector.
- 7 Connection for proximal pneumotachograph.

4.4 | Rear Panel

The inlet openings for the gas connection, the electric power source input, and the ventilator on/off switch are found on the rear panel. In the chapter *Assembly and Installation*, there is a description on how to execute the connections.

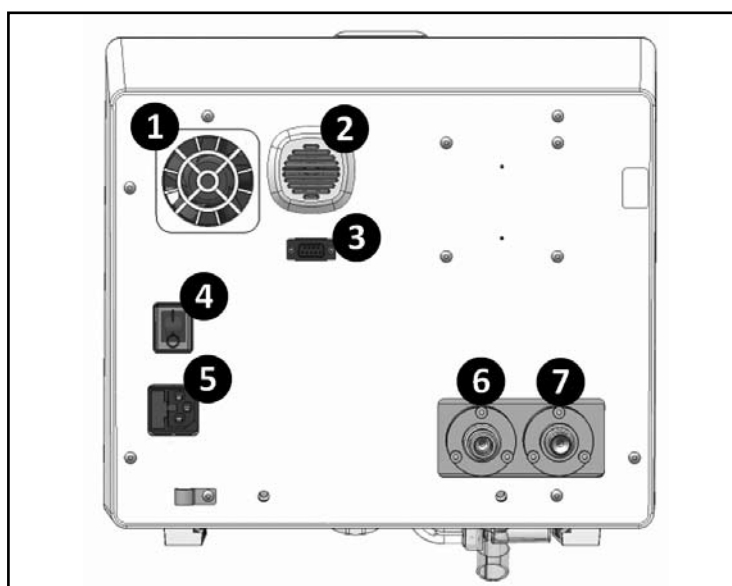


Fig. 4-10 Picture of the rear panel of the ventilator.

References of the Fig. 4-10

- 1 Blower air outlet.
- 2 Audio output for the alarm audio.
- 3 RS-232 port.
- 4 Electric switch.
- 5 Input (AC filter) for the electric power source with fuse box.
- 6 Air inlet.
- 7 Oxygen inlet.

4.5 | Upper Panel

On the upper part of the ventilator cabinet, there is the upper light indicator which functions as a visual alarm signal, see Fig. 4-1. A detailed description of this indicator can be found in the chapter *Alarms*.

Start-up and initial calibration

CHAPTER CONTENTS

- 5.1 Start-up
- 5.2 STAGE 1 - Initial Automatic Control
- 5.3 STAGE 2 - Patient category selection
- 5.4 STAGE 3 - Tidal Volume (VT) based on the Ideal Body Weight (IBW)
- 5.5 STAGE 4 - Selection of humidification system
- 5.6 STAGE 5 - Start patient circuit calibration
- 5.7 STAGE 6 – Calibration in process

CHAPTER SUMMARY

The ventilator can be used right after it has been properly assembled and installed in the place of intended use. This chapter describes the initial procedure, from start-up, up to the time of configuration of the operative mode that the ventilator will use to operate. This document contains the information needed for the configuration and initial calibration that must be carried out each time the ventilator is turned on.

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5.1 | Start-Up

To turn on the equipment, access the rear panel and trigger the power switch so that it is set to ON. This is the same switch used to turn OFF the ventilator. To do this trigger the power switch to the OFF position.

Every time the ventilator is turned on, it is necessary to perform an initial calibration before being able to ventilate a patient. The initial calibration process involves a series of functional verification processes of critical components, and calibration of measurement devices. Some of these processes are automatic, while others require user assistance.

5.2 | STAGE 1 Initial Automatic Control

This step requires no user intervention and starts immediately after start-up.

- Verification of the integrity of the RAM and EPROM memories of the electronic circuit and the alarm Inop. Vent.
- Operational test of the proportional valves.

5.3 | STAGE 2 Patient Category Selection

Stage 2 and Stage 3 are performed simultaneously. The screen displays a menu with the options for patient category and the corresponding window for *IBW-based VT* (Fig. 5-1). When choosing a category, the ventilator selects the operative modes and the appropriate predetermined values.

Use touch-screen buttons to select the chosen category.



NOTE

- Changing category of the patient is performed only at this stage. To change the category of patient while operating the equipment, first be sure to turn off the ventilator and complete again the stages outlined in this chapter.

5.4 | STAGE 3 Tidal Volume (VT) Based on the Ideal Body Weight (IBW)

By choosing a patient category, the menu is displayed on the screen *IBW-BASED VT*, where you can set two variables. With these data the ventilator determines a predetermined tidal volume value for the modes with volume control or target, based on patient characteristics. Press the buttons on the touch screen for each variable to change it using the rotary knob.

The first line of the menu allows changing the IBW value (see Fig. 5-1). The increases depend on the current value of this variable as shown in Table 5-1:

Table 5-1 Change increases according to the current IBW value

IBW values range [kg]	Magnitude of the Increase [kg]
0 to 3	0,1
3 to 10	0,5
10 to 150	1

On the second line of the menu, it is possible to set a constant stated in mL/kg. This constant determines the magnitude of the volume (mL) to be delivered for each kg of set IBW. In the same window it is possible to view the VT resulting from the

combination of IBW and mL/kg with which the ventilator will initiate the modes with volume control or target. Tables 5-2 and 5-3 show Ideal Body Weight values for women and men, and the resulting tidal volumes as mL/kg used to ventilate them.

The predetermined mL/kg value is 6 mL/kg for all categories. The mL/kg constant is a value that is stored in the system memory, and is not deleted when it is turned off. Therefore, by turning on the ventilator, the last value set by the user will be shown.

NOTE

- The IBW and mL/kg configuration only affects the determination of the initial VT. The rest of the ventilatory parameters keep the preset values.

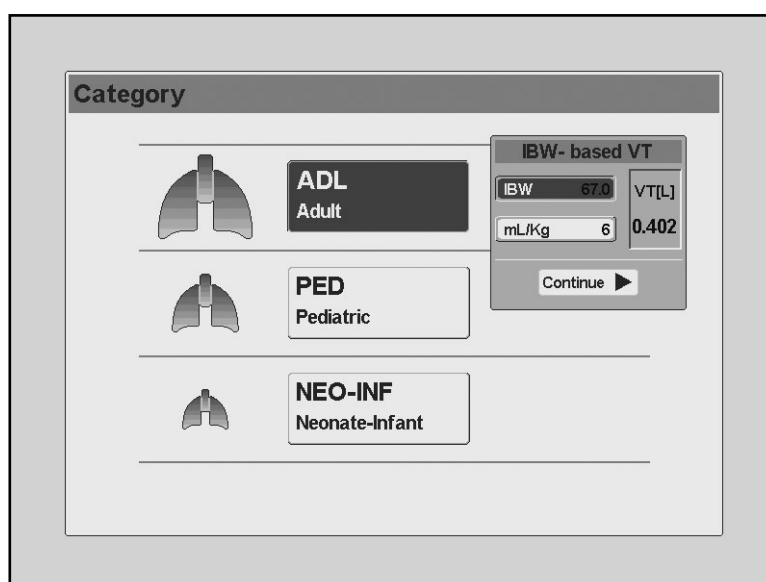


Fig. 5-1 Menu display IBW-BASED VT.

Table 5-2 Ideal Body Weight - Women

IBW (kg) = 45.5 + (0.91 x (height en cm – 152.4)) ¹					
Height		IBW (kg)	4-6 mL/kg VT Range	6-8 mL/kg VT Range	8-10 mL/kg VT Range
In	Cm				
54	137.2	31.6	127-190	190-253	253-316
55	139.7	33.9	136-204	204-272	272-339
56	142.2	36.3	145-218	218-290	290-363
57	144.8	38.6	154-231	231-309	309-386
58	147.3	40.9	164-245	245-327	327-409
59	149.9	43.2	173-259	259-346	346-432
60	152.4	45.5	182-273	273-364	364-455
61	154.9	47.8	191-287	287-382	382-478
62	157.5	50.1	200-301	301-401	401-501
63	160	52.4	210-315	315-419	419-524

64	162.6	54.7	219-328	328-438	438-547
65	165.1	57.1	228-342	342-456	456-571
66	167.6	59.4	237-356	356-475	475-594
67	170.2	61.7	247-370	370-493	493-617
68	172.7	64.0	256-384	384-512	512-640
69	175.3	66.3	265-398	398-530	530-663
70	177.8	68.6	274-412	412-549	549-686
71	180.3	70.9	284-426	426-567	567-709
72	182.9	73.2	293-439	439-586	586-732

¹ Formula for IBW calculation from: ARDS Network. NEJM. May 2000, 342 (18): 1301-08.

Table 5-3 Ideal Body Weight - Men

IBW (kg) = 50 + (0.91 x (height en cm – 152.4)) ¹					
Height		IBW (kg)	4-6 mL/kg VT Range	6-8 mL/kg VT Range	8-10 mL/kg VT Range
In	Cm				
60	152.4	50	200-300	300-400	400-500
61	154.9	52.3	209-314	314-418	418-523
62	157.5	54.6	218-328	328-437	437-546
63	160	56.9	228-342	342-455	455-569
64	162.6	59.2	237-355	355-474	474-592
65	165.1	61.6	246-369	369-492	492-616
66	167.6	63.9	255-383	383-511	511-639
67	170.2	66.2	265-397	397-529	529-662
68	172.7	68.5	274-411	411-548	548-685
69	175.3	70.8	283-425	425-566	566-708
70	177.8	73.1	292-439	439-585	585-731
71	180.3	75.4	302-453	453-603	603-754
72	182.9	77.7	311-466	466-622	622-777
73	185.4	80.0	320-480	480-640	640-800
74	188	82.4	329-494	494-659	659-824
75	190.5	84.7	339-508	508-677	677-847
76	193	87.0	348-522	522-696	696-870
77	195.6	89.3	357-536	536-714	714-893
78	198.1	91.6	366-550	550-733	733-916

¹ Formula for IBW calculation from: ARDS Network. NEJM. May 2000, 342 (18): 1301-08.

5.5 | STAGE 4 Selection of Humidification System

After accepting the *IBW-BASED VT* menu, the screen displays the option to configure the type of humidifier to be used. Press the corresponding button on screen to select the humidification system, and then press the rotary knob to accept.

The choice of one or other humidification method, affects the volume compensation that the ventilator performs to adjust the readings of its sensors to the temperature and humidity of the gases flowing through the patient circuit (BTPS). The *Menu* chapter contains a description of the characteristics of the volume correction according to the selected type of humidifier.

It is also possible to change the type of humidifier once the ventilator has started operating, (**[Menu]>>Ventilatory adjuncts>>Humidifier**).

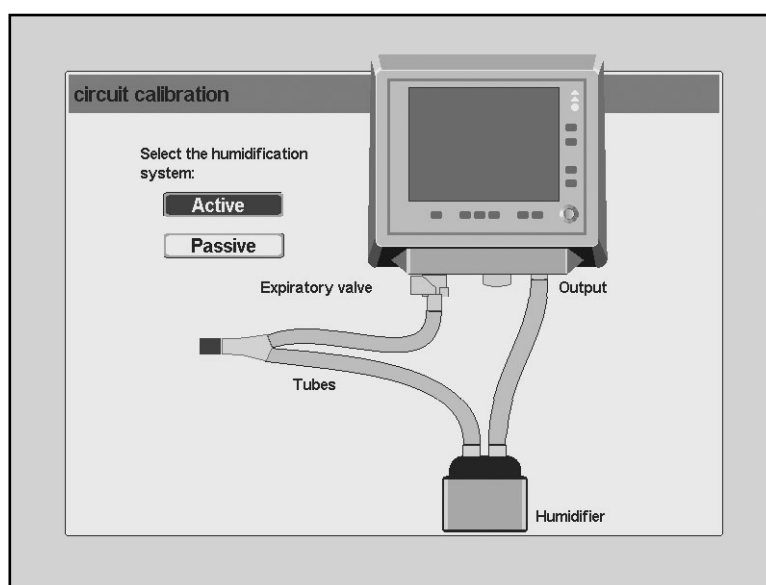


Fig. 5-2 Initial calibration state where it is possible to select the humidification system.

5.6 | STAGE 5 Start Patient Circuit Calibration

After accepting the type of humidifier, the screen will display the instructions to start the patient circuit calibration.

For calibration, use the assembled and connected patient circuit, as shown in the image of Fig 5-3. It is necessary to occlude the free opening of the Y-shaped connector. A plug may be used to cover it as recommended on the screen, or the connector may be placed on the metal conic part which is at one end of the side arms of the pedestal (Fig. 5-4).

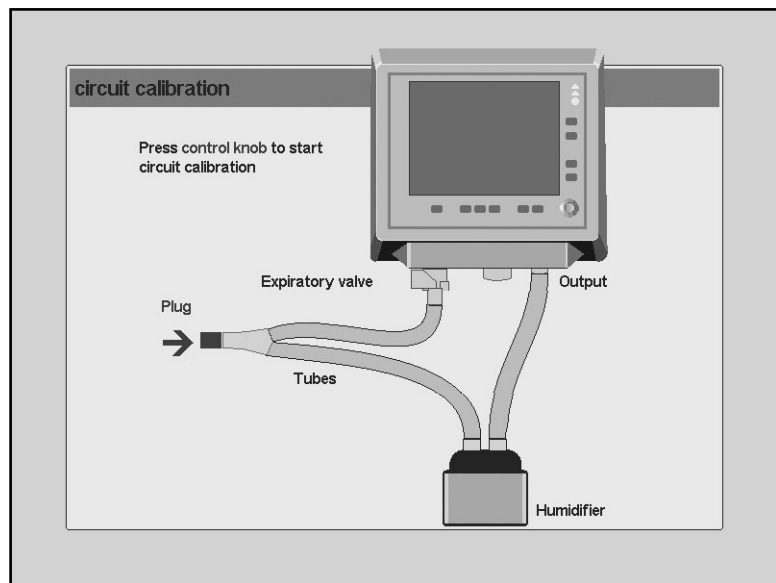


Fig. 5-3 Screen image prior to the calibration of the patient circuit.

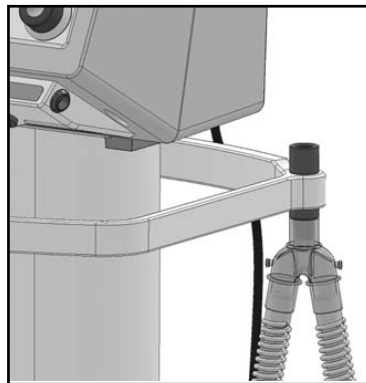


Fig. 5-4 Y-shaped connector placed in the metal conic part located at one end of the side arms of the pedestal.



NOTE

- If the oxygen supply does not provide enough pressure, the ventilator will not accept the initial calibration (the calibration is not feasible using only air).
- Calibration of the patient circuit depends on the ambient pressure. From **[Menu]>>Tools>>Settings>>Mean ambient pressure**, it is possible to enter manually the value of the mean ambient pressure where the ventilator is installed. Ensure that this value is suitable for the calibrations to be carried out correctly, and for the volume and flow readings to be correct.

5.7 | STAGE 6

Calibration in Process

By accepting the previous display, the patient circuit automatic calibration will start. There is a bar indicating the progress of the calibration, and below it, the name of the task being executed is shown. These tasks are:

- Check for leaks in the circuit.
- PEEP valve calibration.
- Expiratory pneumotachograph calibration.
- O₂ sensor calibration.
- Circuit compliance calculation.



NOTE

- The calibration of the patient circuit must be implemented without the nebulizer connected.
- After the first calibration of a new ventilator (or when it is moved to a new city) the Mean ambient pressure value must be configured. With this value, the equipment carries out volume compensations that are essential for the effective functioning of the ventilator. See Menu chapter to learn the procedure.

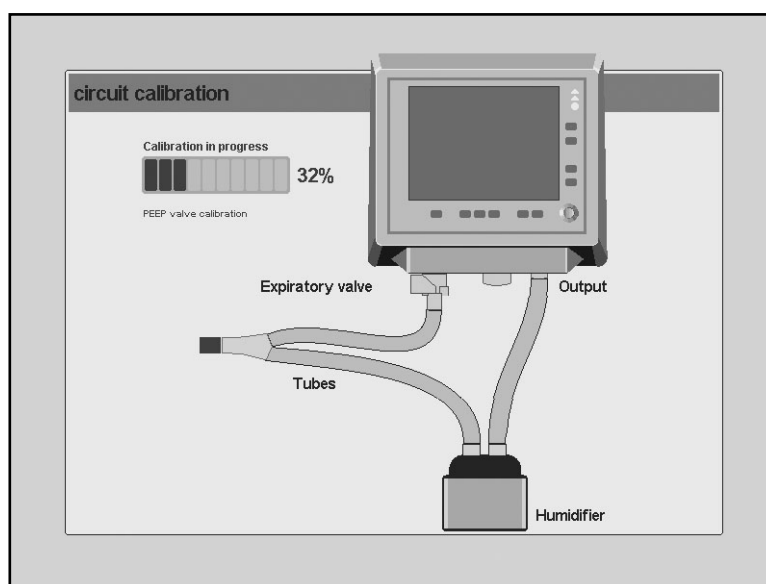


Fig. 5-5 Calibration of the patient circuit in progress.

5.7.1 | Leaks through the circuit during calibration

The patient circuit integrity is checked at the beginning of the calibration. When a continuous leak occurs from any part of the circuit, and is less than 10 L/min, the message appearing in Fig. 5-6 is shown, which indicates the magnitude of the leak. According to the leak warning, you can continue with the calibration by pressing the rotary knob, or recalibrate the circuit pressing **[Esc]**.

If a leak less than 10 L/min is accepted, an on-screen message is displayed permanently showing the magnitude of the recorded leak. The message is placed in the Icons and messages Bar.

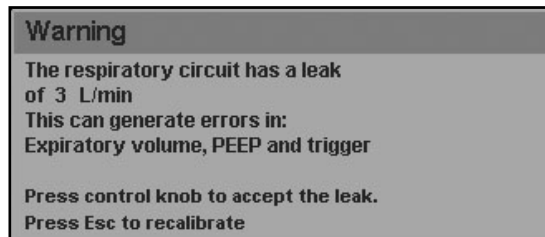


Fig. 5-6 On-screen message warning of a leak less than 10 L/min during calibration.

NOTE

- While it is possible to start to ventilation with a leak detected during the calibration, less than 10 L/min, it is recommended not to ventilate a patient when leak is detected by the circuit.

If the leak detected is greater than 10 L/min, the circuit calibration is aborted. Until the leak is repaired, the equipment will fail the calibration stage, and will not start operating (Fig. 5-7).

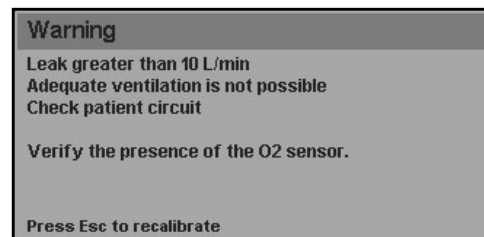


Fig. 5-7 On-screen message showing a leak greater than 10 L/min during calibration.

WARNING

- ***In the event of a significant leak, check the patient circuit to detect the section with the leak. Replace or repair the segment to prevent any improper change in ventilation.***

If while performing the calibration circuit, the airtightness of the patient circuit is lost, or the valve is defective, the calibration shall not be completed, and the screen will display the message in Fig. 5-8.

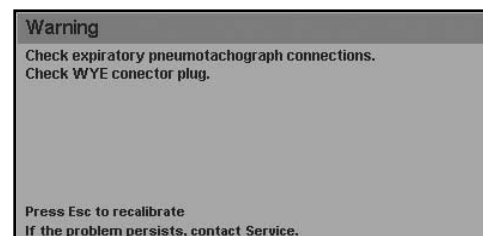


Fig. 5-8 On-screen message showing that the patient circuit has lost its airtightness.

5.7.2 | PEEP valve calibration

PEEP is produced from an air flow generated by a proportional valve. The calibration of this valve is the first calibration carried out during this procedure.

5.7.3 | Calibration of expiratory pneumotachograph

In each initial calibration, the expiratory flow measurement element is calibrated. The known flows are sent through the expiratory pneumotachograph, and the response of the related differential pressure transducers is monitored to characterize their response and to develop an accurate calibration table.

5.7.4 | Calibration of the O₂ cell

During the final stage of the calibration process, a calibration of the O₂ cell shall be performed.

5.7.4.1 | Oxygen sensor failed calibration

The oxygen sensor calibration may fail in the following cases:

- The gas entering the OXYGEN inlet is not oxygen, or its concentration is not adequate.
- The sensor is exhausted.

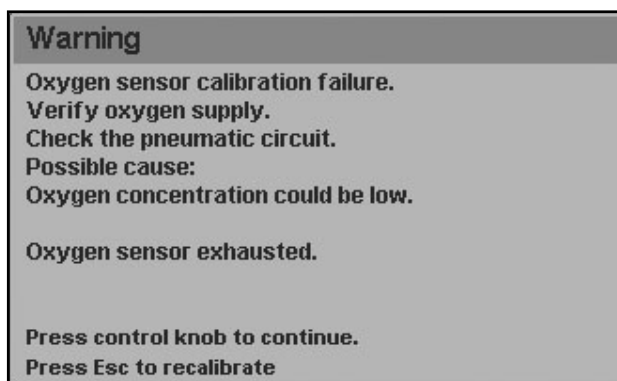


Fig. 5-9 On-screen message showing an O₂ sensor calibration failure.



NOTE

- Recalibration of the patient circuit during operation of the ventilator must be carried out by disconnecting the patient circuit and occluding the opening of the Y-shaped connector. Take precautions to provide an alternative ventilation method during recalibration, if this were necessary.



WARNING

- *It is possible to recalibrate the patient circuit, and the O₂ cell at any time during operation of the ventilator. Accessing from [Menu] >> Tools >> Calibrations both calibrations can be run individually (see Menu chapter).*

5.7.4.2 | Undetected oxygen sensor

If an electrical connection between the sensor and the microprocessor cannot be established, the screen will display the message shown on Fig. 5-10.

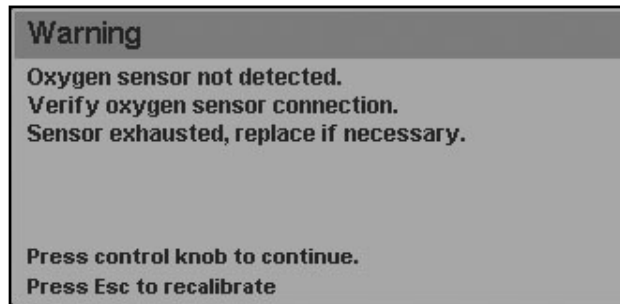


Fig. 5-10 Undetected oxygen sensor message.



NOTE

- The oxygen sensor is a consumable that has a lifespan which heavily depends on the amount of oxygen that it has been exposed to. The equipment works correctly with an exhausted oxygen sensor, but in this case is not possible to monitor the O₂ concentration.

5.7.5 | Circuit compliance calculation

The ventilator injects known volumes in the tight circuit and records the pressure levels generated by these volumes. In this way, the circuit calculates the patient circuit compliance for the different values of the existing volume.

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Basic Operations

CHAPTER CONTENTS

- 6.1 Overall User Interface Management
- 6.2 Selecting the Operative Mode
- 6.3 Configuring the Operative Mode
- 6.4 Standby
- 6.5 Additional Functions
- 6.6 Ventilation Parameters

CHAPTER SUMMARY

Upon completing the initial calibration process, *iTermIS ADV* allows the configuration of an interesting variety of ventilation functions. This chapter describes how to configure and program the equipment main functions, such as: selecting an operative mode, its configuration, entering and exiting the Standby mode, and programming additional functions for ventilation in specific modes. The functions accessed from the **[Menu]** key are described in another chapter.

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6.1 | Overall User Interface Management

The *iTermIS ADV* user interface combines a 12" touch screen and a series of fixed keys on the front panel of the ventilator. This same front panel has a rotary knob that completes the list of control commands.

The user interface has been designed to avoid accidental changes in the ventilation parameters. The touch screen does not allow modifications unless a minimum sequence of actions is performed, or unless it is used in conjunction with the rotary knob.

The screen menu can be navigated by either pressing the buttons on the touch screen or using the knob. The operating instructions in this manual are for using the touch screen, but the user may use the knob to move through the menus and accept the options displayed.

For ease of use, the touch areas of the screen have been designed to be shown as buttons or easily identifiable areas. The touch screen can be used to perform:

- Initial calibration.
- Modification of ventilation parameters (the selection of each parameter can only be done using the touch screen. The modification is done with the knob).
- Menu navigation. Menus can be scanned with a single touch on the option desired. A function cannot be enabled or disabled using the one-touch mode.
- Activation of additional functions. The screen has a series of buttons that function as direct access to different ventilation functions.
- Graphics scaling. The scale of the graphics can be changed by pressing one of the axes of the graphics shown on the screen. See the *Graphics Management* chapter.



WARNING

- ***Do not use sharp objects like pens or scissors on the touch screen or the fixed keys. Only fingertips should be used to press on the screen. Do not use fingernails, since the keys and the screen may become damaged.***
- ***Do not clean the screen with abrasive chemical solutions or acid or alkaline substances. Use a soft cloth moistened with a neutral cleaning solution and water. An 80% isopropyl alcohol solution may also be used.***

6.2 | Selecting the Operative Mode

Once the initial calibration of the equipment has been carried out, the *iTermIS ADV* screen will display the *OPERATIVE MODES* menu, as seen in the left image in Fig. 6-1. The *OTHER OPERATIVE MODES* window is accessed from the line labeled as such on the previous menu.

Once the operative mode has been selected, this menu changes to a window showing the name of the operative mode selected and waits for acceptance to initiate ventilation (Fig. 6-2). The ventilation parameter values can be changed before starting ventilation (see 6.3 Configuring the Operative Mode), or ventilation may be initiated with the preset values by pushing the knob when the window in Fig. 6-2 appears.

The operative mode may be changed while the ventilator is working. When the **[Mode]** key is pressed, the *OPERATIVE MODES* menu will appear, and from there, follow the steps described in the previous paragraph.

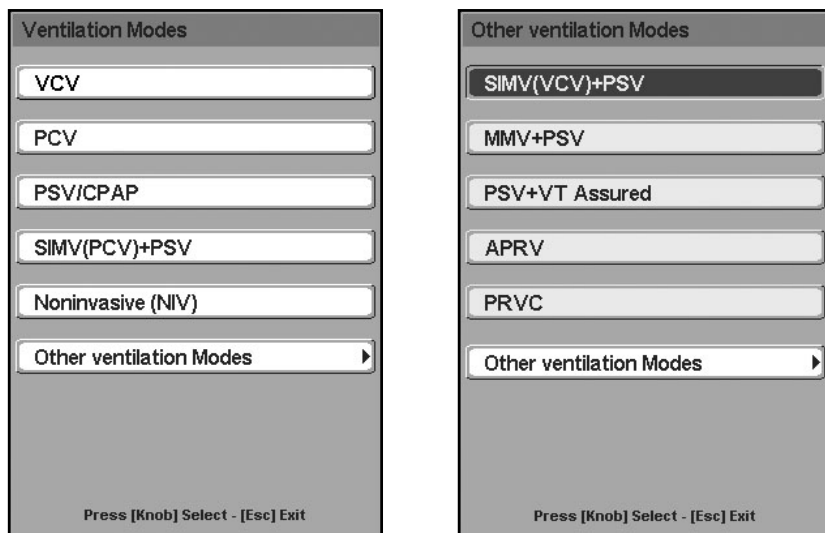


Fig. 6-1 Left: *OPERATIVE MODES* menu for the ADL category. Right: *OTHER OPERATIVE MODES* sub-menu.

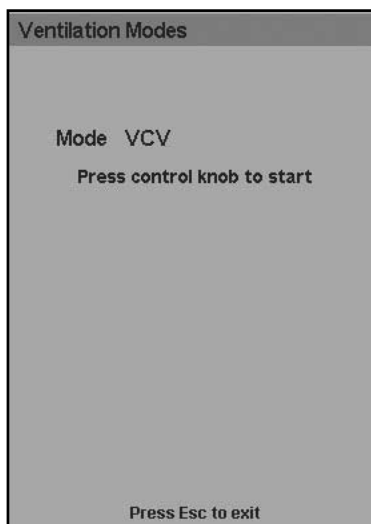


Fig. 6-2 Acceptance window for the selected mode, in this case, VCV.



NOTE

- If this is the first time the ventilator is used (or if it was transferred to a new city), the Mean Ambient Pressure value must be set. The equipment uses this value to carry out important volume compensations that are essential for the efficient functioning of the ventilator. See the Menu chapter to learn about the procedure.

6.3 | Configuring the Operative Mode

Each operative mode has a characteristic group of ventilatory parameters (see the *Operative Modes for ADL/PED* and *Operative Modes for NEO-INF* chapters). The parameters that can be configured appear on the lower area of the screen. Section 6.6 Ventilation Parameters describes the ventilation parameters.

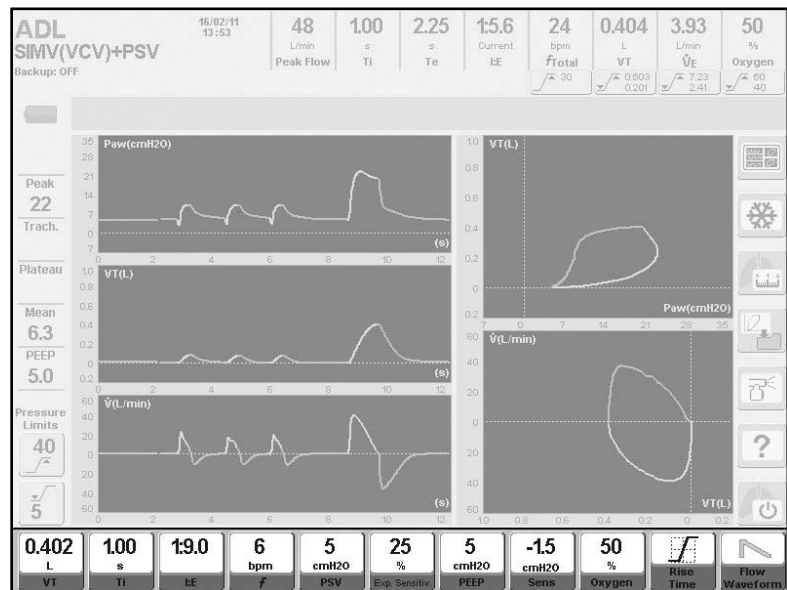


Fig. 6-3 Image with ventilation parameters highlighted, in the SIMV(VCV)+PSV mode.

To change the value of a parameter, follow these steps:

- Press the button on the touch screen for the parameter to be modified. The field for that parameter changes color, indicating that it can be modified.
- Turn the knob until you reach the desired value.
- Press the knob to accept.



NOTE

- If the touch screen button is pressed and after 15 seconds nothing changes, the parameter is no longer modifiable. In the same way, if the parameter value has been changed but not accepted, after 15 seconds, the parameter is no longer modifiable, and the previous value is shown.

6.3.2 | Backup Ventilation

For spontaneous modes with no programmed mandatory respiratory rate, the characteristics for a *Backup Ventilation* must be configured (to ensure that the ventilator continues ventilating the patient in case his/her respiratory efforts cease). In other operative modes, it is an optional configuration. If a mode requiring *Backup Ventilation* is selected for the first time after the ventilator is turned on, the following steps must be followed to be able to start ventilation (see the sequence of images in Fig. 6-4):

- Press the **[Menu]** key. This takes you directly to the main menu at the *Backup Ventilation* line.
- Push the knob to enter the *BACKUP VENTILATION* menu.
- Configuring *Backup Ventilation* (see the *Menu* chapter, which describes this configuration).
- Press the Accept button. The window for the selected operative mode is shown below, but with the message that *Backup Ventilation* has been correctly configured.

After the *BACKUP VENTILATION* window is modified or accepted for the first time, the *Backup Ventilation* does not need to be reset when entering an operative mode that uses it. The configuration can always be modified, but it is no longer required to start ventilation in that mode. Instead, the *OPERATIVE MODE* window will display a message indicating that the *Backup Ventilation* has already been configured (as shown in the fourth image in Fig. 6-4).

To access the *BACKUP VENTILATION* menu at any time and modify the configuration, carry out the following sequence: **[Menu] >> Backup Ventilation**. A window appears on the screen, similar to the one shown in the third image of Fig. 6-4, where the *Backup Ventilation* characteristics can be modified. Later on, the *Menu* chapter describes this modality in greater detail.



Fig. 6-4 Navigating menus for configuring Backup Ventilation for the first time after the unit is turned on. In this case, it has been configured for the PSV/CPAP mode with Backup Ventilation using VCV.

6.3.3 | Configuring Alarm Limits

Alarm limits can be modified at any time from the **[Alarm Limits]** fixed key. When this button is pushed, the *ALARM SETTINGS* menu is displayed (see Fig. 6-5).

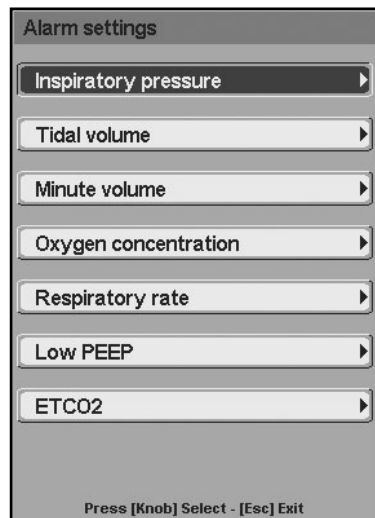


Fig. 6-5 ALARM SETTINGS menu.

Some alarms are not enabled for certain operative modes. These alarms are shown in a clear font, indicating that their limits cannot be modified. If a button for an enabled alarm is pushed, a window is accessed where changes can be made to the values of the corresponding limits. When the modification has been accepted, it is possible to return to the main menu by pressing the **[Esc]** key.



NOTE

- If the user does not modify the alarm limits values, the ventilator will function with the preset limits that are in the system default configuration.

For more information, see the *Alarms* chapter. The complete alarm system is described there, along with the specifications for each alarm.

6.3.4 | Other Functions

The addition or programming of other functions that modify the final configuration of an operative mode are described in the section below 6.5 Additional Functions. Some examples of these functions are: nebulization, sighs, inspiratory pause, volume compensation, etc.

6.4 | Standby

To put the ventilator on **STANDBY**, press the **[Standby]** button on the right side of the screen and accept using the knob. This status leaves the ventilator charged, but not ventilating. Upon resuming ventilation after a **STANDBY** period, the values for the ventilation parameters remain unchanged.

To exit the **STANDBY** mode and restart ventilation, push the **[Esc]** key.



NOTE

- Pressing the **[Standby]** touch screen button will have no effect if a window is open on the screen. The main screen must be accessed to be able to enter Standby.

6.5 | Additional Functions

There are two types of additional functions. Direct-access functions (using a touch-screen button or fixed key on the panel) and functions that are part of the equipment main Menu.

6.5.1 | Direct Access

6.5.1.1 | Nebulizer

By pressing the corresponding touch-screen button, the ventilator starts delivering a flow of O₂ at 8 L/min through the Nebulizer exit, during the inspiratory phase. This flow should be channeled through the patient circuit. Use the accessories included in the nebulizer kit for this. The nebulizer kit is placed between the final inspiratory segment of the patient circuit and the Y-shaped connection.

The flow provided by the Nebulizer is considered by the equipment to be an inspiratory flow and is added to the flow coming from the patient outlet opening to complete the programmed volumes (in VCV).



WARNING

• *If the Nebulizer function is activated and the flow provided by the Nebulizer outlet is NOT directed to the patient circuit, volumes that are lower than the adjusted values will be delivered in VCV breaths.*

Nebulization can be interrupted in three different ways:

- By time. 30 minutes after the function is activated.
- Voluntarily. By pressing the **[Nebulizer]** key.
- Automatically by the ventilator. If, during nebulization, the peak flow does not reach an adequate value to be compatible with nebulization, the nebulization is interrupted. This event is accompanied by low priority alarms (Interrupted Nebulization alarm).

Nebulization is enabled for all operative modes in ADL and PED patient categories. For NEO-INF patients, only the TCPL and SIMV (TCPL) + PSV modes have an option for nebulization with a continuous flow of 8 L/min.

6.5.1.2 | Respiratory Mechanics

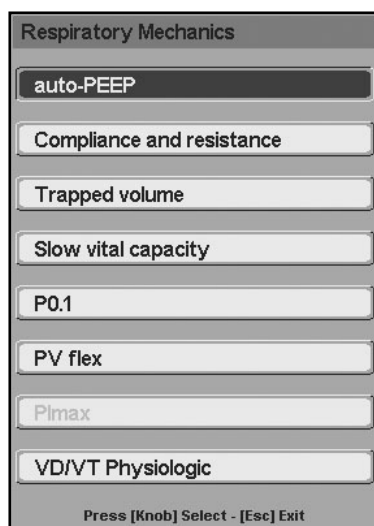


Fig. 6-6 RESPIRATORY MECHANICS Menu.

iTermIS ADV offers the possibility of performing different tests to categorize the respiratory mechanics of the patient being ventilated. For further information, consult the *Respiratory Mechanics* chapter, which describes all the tests in detail.



NOTE

• Keep in mind that some respiratory mechanics tests may only be performed in certain operative modes and under certain conditions (see the *Respiratory Mechanics* chapter).

6.5.1.3 | Suction %O₂

This function allows breaths to be delivered with a variable O₂ concentration, before and after a tracheal suction maneuver.

To activate the suction sequence, just press the **[Suction %O₂]** key and accept using the knob.

The sequence consists of three periods:

- An initial period of 60 seconds during which breaths are delivered with an O₂ concentration that can be configured by the user.
- A second period with a variable duration (that may be configured by the user), during which aspiration is performed.
- A third period of 60 seconds during which breaths are delivered with the same characteristics as those during the initial period.

The suction time and O₂ configuration from breaths before and after suction may be configured. The sequence for accessing this configuration is: **[Menu]>> Tools>> Suction Configuration** (the values for each variable are found in the *Menu* chapter).

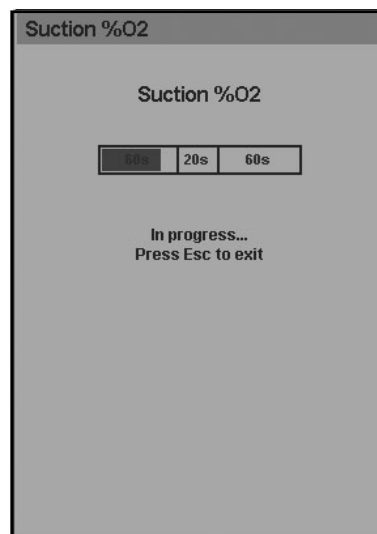


Fig. 6-7 Window showing the Suction %O₂ in progress.

6.5.1.4 | Freeze

This function freezes the screen, immobilizing the status of the current graphics. It is activated by pressing the **[Freeze]** button on the ventilator screen. To unfreeze the screen, press the **[Esc]** key. This function is enabled in all modes and for the three patient categories.

The frozen screen is saved in memory until the next capture and can be saved as an image file in the computer connected through the ventilator RS232C serial port. The *Capture iTermIS*® software, developed by HEYER, is used for this; this is a freeware program that may be requested at no cost.

6.5.1.5 | Manual Inspiration (user-initiated inspiration)

A manual inspiration can be generated by pressing the **[Manual Insp.]** fixed key. The inspiration generated is of the same type as those programmed for the current operative mode.

6.5.1.6 | Inspiratory/Expiratory Pause

It is possible to generate a pause at the end of the inspiratory period by pressing

the **[Insp/Exp Pause]** key. To do this, the button should be pressed just before the end of the period in which the pause is desired. There is no cycling during the pause, and this period is extended for as long as the button is pressed. Consult the maximum times for each pause in Table 17-7, in the *Technical Specifications* chapter.

6.5.1.7 | Help

The **[Help]** button is used to learn about the touch-screen buttons and the fixed keys. To obtain help, press the **[Help]** button and then the key or button you wish to learn about. A window will then be displayed on the screen, describing the key or button in question.

6.5.1.8 | Save loop

This button allows saving the loops obtained from any breath. These loops can be shown statically on the screen to compare current loops with saved ones.

For further information about this function, see the *Graphics Management* chapter.

6.5.1.9 | Graphics

This button allows changing the screen view that the ventilator shows. See the *Graphics Management* chapter.

6.5.1.10 | Screen Lock

By holding the **[Screen Lock]** key for 2 seconds the touch screen is locked, preventing to make changes through this means during the ongoing ventilation. The fixed keys on the right side of the front panel are also locked. However, the keys on the bottom row and the knob stay active while the screen is locked.

The **[Screen Lock]** key is illuminated when it is pressed (for 2 seconds), indicating that the lock is active. If the touch screen or one of the locked keys is touched while locked, the **[Screen Lock]** key emits a small burst of blinking lights and displays a message on the screen indicating that the screen is locked.

To unlock the screen, press the **[Screen Lock]** key. It will no longer be illuminated, indicating that the screen and the corresponding fixed keys are again active.



NOTE

- If the screen is locked when an alarm is triggered, it is automatically unlocked. To re-lock, press the **[Screen Lock]** button again.

6.5.4 | Menu

A description of the functions that are accessible from the **[Menu]** key is found in the *Menu* chapter.

6.6 | Ventilation Parameters

Section 6.3.1 Modifying ventilation parameter describes the mechanism for modifying the ventilation parameters that will be described in this section. The adjustment values for these parameters can be found in Table 17-7.

For a better understanding of the parameters that *iTemIS ADV* manages, they are divided into four groups:

- **SHARED:** these are parameters shared by the majority of the operative modes.
- **VOLUME CONTROL OR OBJECTIVE:** this is a series of parameters used exclusively for configuring breaths with tidal volume control or objective.

- **CONTROL OR SUPPORT PRESSURE:** the parameters in this group characterize breaths controlled by pressure or those which are delivered with support pressure.
- **SPECIAL:** there are some modes that present special parameters that are only used for configuring that mode.

6.6.1 | Shared

- **RESPIRATORY RATE (f):** this parameter is present in those controlled or intermittent modes where the frequency of required breaths per minute that the ventilator should deliver needs to be established.
- **INSPIRATORY TIME (Ti):** the configuration of this parameter determines the duration of the inspiratory phase of the required respiration that the ventilator delivers in controlled or intermittent modes.
- **I:E RELATIONSHIP (I:E):** this parameter shows the relationship between inspiratory and expiratory times. The I:E value appears in some operative modes, but it may only be modified in the PCV and VNI mode for the ADL and PED categories, and in the PCV and TCPL modes for the NEO-INF category. In these modes, when the I:E relationship is modified, the inspiratory time automatically adjusts to adapt the new values regarding the set respiratory rate.
- **PEEP:** the regulation of this parameter modifies the positive end expiratory pressure.
- **OXYGEN CONCENTRATION:** this parameter is found in all operative modes and represents the fraction of oxygen contained in the gas mix that the ventilator sends to the patient.
- **INSPIRATORY SENSITIVITY (Sens):** this is a parameter that characterizes the least or greatest effort that the patient should make in order to initiate a spontaneous or assisted breath. The configuration of an inspiratory sensitivity value determines the magnitude of the demand that the patient must make to initiate inspiration. The inspiratory will of the patient can be detected using two methods in *iTermIS ADV*, either by reducing the pressure in the patient circuit or by a certain flow demand.



NOTE

- Inspiratory sensitivity is configured for spontaneous breaths, both for assisted breaths in controlled modes and VCV or PCV. In this case, the detection operates in the same way as in the spontaneous modes.

Flow sensitivity

Flow sensitivity allows the patient to initiate an inspiration once a flow demand greater than or equal to the selected one has been detected. To do this, the ventilator injects a known constant flow through the patient's opening and measures it in the expiratory valve. When the difference between the sent flow and the flow received by the expiratory valve is greater than or equal to the set one, the ventilator allows inspiration to be initiated. The value of the constant flow that circulates through the circuit is slightly higher than the flow configured as sensitivity.

Sensitivity by pressure

In sensitivity by pressure, the inspiratory trigger is produced when a decline in pressure greater than what is selected for sensitivity is detected in the respiratory circuit during the expiratory phase.



NOTE

- The default inspiratory sensitivity for all modes is by flow. The values depend on the category of patient being ventilated. If a nebulization maneuver is enabled, the detection automatically changes to sensitivity by pressure.

6.6.2 | Control or Support Pressure

- **TIDAL VOLUME (VT):** also known as current volume, it represents the volume delivered by the ventilator in each breath. Among the monitored parameters there is one with the same name that represents the volume exhaled by the patient in each breath.
- **FLOW WAVEFORM:** this parameter determines the shape of the flow wave with which the ventilator delivers the set volume. There are two possibilities for configuring this parameter:

Descending ramp flow waveform

The descending ramp flow wave begins at the calculated peak flow value and makes a linear decline to zero. In response to this decelerated flow, the pressure and volume curves are similar to those in the pressure controlled mode (PCV). However, in modes controlled by volume; the flow descent is calculated and respected regardless of the mechanics of the patient's respiratory system. In PCV, the flow descent is the result of respiratory impedance through which the flows travel. In VCV, the preset flow wave is a descending ramp.

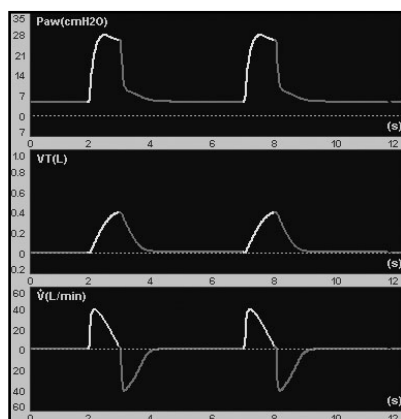


Fig. 6-8 Image of the pressure, volume and flow curves generated when using the descending ramp flow waveform.

Constant Flow Wave

A constant flow produces a rectangular wave. The flow quickly reaches its maximum value and keeps it until the delivery of the selected volume is completed. During the inspiratory phase, the pressure developed in the airway shows two segments. The first has an initial quick rise due to the abrupt pressurization of the tubes by the continuous flow and is considered to be a reflection of the system resistive properties (resistance x flow). The second segment has a less pronounced but progressive rise and depends on the flow derived from the inspiratory time and the regulated volume, representing the system elastic properties. The pressure continues to rise until the end of the breath, which coincides with the cessation of the flow.

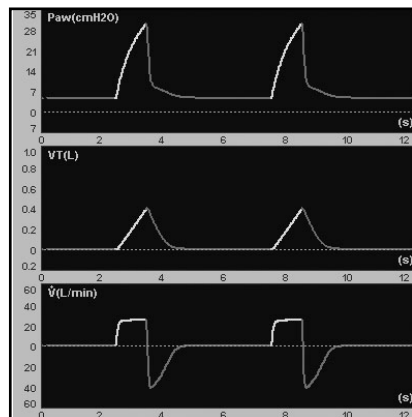


Fig. 6-9 Image of the waveforms when a constant flow is configured. The pressure presents a form that obeys to the characteristics of compliance and resistance of the respiratory system and patient circuit.

6.6.3 | Control or Support Pressure

- **CONTROL PRESSURE (PCV):** the configuration of this parameter regulates the level of positive pressure over the PEEP value for breaths controlled by pressure.
- **SUPPORT PRESSURE (PSV):** this parameter represents the level of pressure with which spontaneous breaths are delivered (in completely spontaneous or synchronized intermittent modes). The value of the support pressure is established over the PEEP level.
- **RISE TIME:** this control allows the speed at which regulated pressure control is reached to be modified. Modifications to rise times can be seen graphically as a rise or decline in the tracing of the initial segment of the inspiratory pressure curve.



NOTE

- In modes where support pressure (PSV) and controlled pressure (PCV) are combined, the regulation of rise time affects both types of breaths.

- **EXPIRATORY SENSITIVITY (Exp. Sensitiv.):** this parameter allows adjusting the criterion for the inspiratory period end according to the magnitude of the current flow. Expiratory sensitivity is programmed as a percentage of the peak flow. Therefore, the end of inspiration is produced when the instantaneous flow has reached a level equal to the percentage of the set peak flow. The expiratory phase starts at that moment.

6.6.4 | Special

- **MINUTE VOLUME (VE):** this is the parameter enabled only in the MMV + PSV mode for ADL and PED categories. The configuration of this parameter permits automatic follow-up and control of the minute volume exhaled by the patient.
- **HIGH AND LOW PEEP:** these are the two parameters that are enabled only for the APRV mode. They regulate the two values of continuous positive pressure for the upper and lower inspiratory times, respectively.
- **HIGH AND LOW INSPIRATORY TIME:** These two parameters allow adjusting the HIGH and LOW PEEP times, respectively, in the APRV mode.

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Menu

CHAPTER CONTENTS

- 7.1 General information
- 7.2 Patient's data
- 7.3 Backup ventilation
- 7.4 Ventilatory adjuncts
- 7.5 Records
- 7.6 Tools
- 7.7 Intra hospital transport

CHAPTER SUMMARY

This chapter describes the ventilator main menu functions (**[Menu]** key). The description includes a functional explanation, and the use and configuration instructions for each of them.

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7.1 | General Information

All ventilator functions that do not have direct access by means of a fixed key or touch screen button are in a main menu. This menu is accessed with the fixed key **[Menu]** (Fig. 7-1). This menu is managed in the same way as the rest of the ventilator windows, using the touch screen, the knob, and the **[Esc]** key.

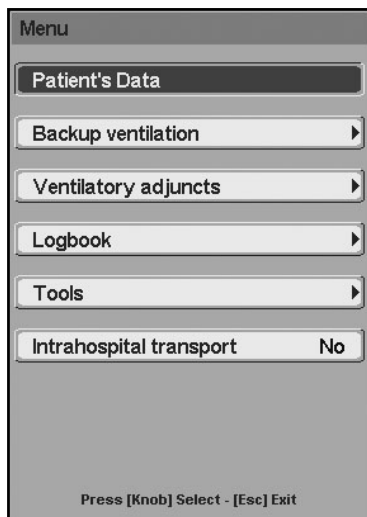


Fig. 7-1 Main MENU window.

7.2 | Patient's Data

PATIENT'S DATA is a window with two pages that shows a series of complementary monitored parameters (Fig. 7-2). Window pages are identified with a number 1 or a number 2 on the right upper corner of the same window. To show the hidden page, turn the knob as long as no other functions are open.

The respiratory mechanics data shown in the lower corner of number 1 window only display information if the corresponding test has been performed before.

When a parameter has three hyphens instead of a number, it means that the information is not available or the current operative mode does not allow monitoring of that parameter.

Patient's Data		1
VE Mandat	---	L/min
VE Spont	4.31	L/min
F Spont	21	bpm
TCexp	0.29	s
F/VT	98	bpm / L
Cdyn	17	mL/cmH ₂ O
WOBi	22	mJ/min
ETCO ₂	---	mmHg
VCO ₂ (STPD)	---	mL/min
Cst	28	mL/cmH ₂ O
Ri	16/02/11 15:42	7 cmH ₂ O/L/s
Re		14 cmH ₂ O/L/s
auto-PEEP	16/02/11 15:42	1.0 cmH ₂ O

Patient's Data		2
VE Mandat	---	L/min
VE Spont	4.37	L/min
F Spont	22	bpm
TCexp	0.28	s
F/VT	115	bpm / L
Cdyn	15	mL/cmH ₂ O
WOBi	22	mJ/min
ETCO ₂	---	mmHg
VCO ₂ (STPD)	---	mL/min
Leak	0.3	L/min
% de fuga	9	%
Ti/Ttot	0.21	
Ptracheal	15	cmH ₂ O

Fig. 7-2 **PATIENT'S DATA** windows (the two pages are shown). The image for this window was captured during ventilation with a test lung in PSV mode. ETCO₂ and VCO₂ show no values because no capnograph was being used at the time of the capture.

7.2.1 | Definition of the shown parameters

Table 7-1 Detail of parameters in Patient's Data

Parameter	Description
Mandatory minute volume (VE Mandat)	It is the minute volume calculated only from mandatory breaths. That is, those triggered by the ventilator or by the patient as long as they are not PSV or CPAP. A VCV or PCV breath triggered by the patient or by the ventilator is considered a mandatory breath. In NIV, mandatory breaths are triggered by the ventilator based on the programmed respiratory rate. In APRV, the only breaths computed as mandatory are those that are due to pressurization from a low PEEP level to a high PEEP level.
Spontaneous minute volume (VE spont)	It is the minute volume calculated from spontaneous breaths generated from PSV or CPAP.
Spontaneous respiratory rate (Fspont)	It is the respiratory rate caused by the breaths triggered by the patient.
Expiratory time constant (TCexp)	Calculated from the slope of the exhalation phase of the volume flow curve taken from the 30%-70% segment of the expiration.
F/VT Index (F/VT)	Also called Yang and Tobin index. It gives information about the fast and superficial breathing pattern that patients usually assume when they are disconnected from the ventilator. It is used as a success indicator to discontinue mechanical ventilation. Values higher than 105 are associated with a lower probability of success after discontinuing. It is enabled in the PSV/CPAP mode. In the other modes, this parameter has three hyphens (---) to indicate that it is disabled.
Dynamic compliance (Cdyn)	It shows the dynamic compliance calculation performed breath to breath. The <i>Respiratory Mechanics</i> chapter describes how this parameter is calculated.
Imposed Work Of Breathing (WOBi)	It indicates the work performed by the patient to trigger spontaneous inhalations. It is expressed in mJ/min. The measurements are updated every minute. To obtain the first reading, a minute of spontaneous breaths must have elapsed (during that time, hyphens will appear instead of numerical data). It is enabled for the PSV/CPAP operative mode.
End of expiration CO₂ (ETCO₂)	This line indicates the value of the partial CO ₂ pressure at the end of the expiration. This monitoring is only activated if the capnograph is connected.
Eliminación de CO₂ (VCO₂)	It indicates the rate of elimination of CO ₂ in mL/min.
Static compliance (Cest) Inspiratory resistance (Ri) Expiratory resistance (Re)	It indicates the last measurement of these parameters in Respiratory Mechanics. The results are reported with the date and time the last test was conducted.
auto-PEEP	Like the rest of the Respiratory Mechanics parameters, it shows the last measurement, with the date and time the test was conducted.
Leak	It indicates the magnitude of the flows that leak through the patient circuit in L/min.
Leak %	It indicates the VT percentage driven by the ventilator that leaks through the patient circuit.
Ti/Ttot	Ratio between the inspiration time and the time needed for a full breath (inspiration + expiration).
Tracheal pressure	It indicates the pressure on the distal end of the endotracheal or tracheostomy tube. This reading is shown if the Tube compensation has been activated.

7.3 | Backup Ventilation

This line of the main menu gives access to the *BACKUP VENTILATION* window. It is defined as a tool used to ensure ventilation for patients who, being in a spontaneous operative mode, do not generate enough demand to trigger breaths (decreased respiratory effort or apnea episodes).

There are operative modes that do not require setting *Backup Ventilation*, others for which it is optional, and, lastly, there is a group of operative modes that need a *Backup Ventilation* to be configured (see Table 7-2).

Table 7-2 Requirement of *Backup Ventilation* setting according to the operative mode

Mandatory setting	Optional setting
ADL/PED	
PSV/CPAP	SIMV (VCV) + PSV
MMV + PSV	SIMV (PCV) + PSV
PSV + Assured VT	APRV
NEO-INF	
PSV/CPAP	SIMV (VCV) + PSV
CPAP Continuous flow	SIMV (PCV) + PSV
	SIMV (TCPL) + PSV
	APRV

7.3.1 | Backup Ventilation Configuration

To access the *Backup Ventilation* configuration menu, execute the following sequence: **[Menu]>>Backup Ventilation**. The displayed window changes three parameters:

- **OPERATIVE MODE:** the breaths provided in Backup Ventilation may belong to different operative modes. For ADL/PED patients, the options are VCV and PCV. The possibility of TCPL is added in NEO-INF as a backup.
- **APNEA TIME:** defined as the time elapsed from the last breath triggered by the patient until the ventilator determines that there is an apnea episode. It is the time the ventilator waits after the last valid spontaneous breath to start the *Backup Ventilation*. It is a time that can be programmed between 5 and 60 s, at 5 s intervals.
- **SIMV/APRV or CPAP BACKUP:** in SIMV and APRV modes or in CPAP Continuous Flow (in NEO-INF), enabling the *Backup Ventilation* is optional. It is disabled (NO option) by default for SIMV/APRV and enabled (YES option) for CPAP Continuous flow in NEO-INF. But by accessing to this line on the menu, it is possible to enable/disable the backup for these modes.

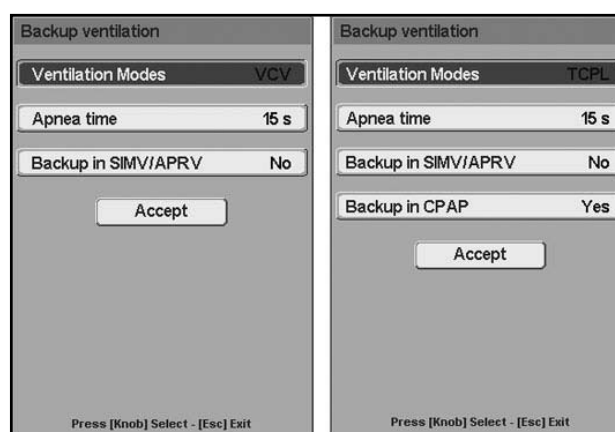


Fig. 7-3
BACKUP VENTILATION
menu window.
Left for ADL/PED category and right for NEO-INF.

Finally, to save changes, the Accept button must be pressed. Otherwise, if the **[Esc]** key is pressed, the last configuration is discarded.

7.3.2 | Apnea Alarm

The apnea episodes that result in the activation of the *Backup Ventilation* are signaled with medium priority alarm signals under the name of Apnea condition.

As long as the Apnea condition remains, the system will keep the appropriate alarm signals, visual and auditory, activated. If the patient recovers the inspiratory effort while the *Backup Ventilation* is in operation, ventilation continues with the originally programmed mode and the audible alarm signal is cancelled, while the lit alarm indicator (yellow LED) changes to continuously lit without flashing (steady signal) until the **[Esc]** key is pressed.

7.4 | Ventilatory Adjuncts

The *VENTILATORY ADJUNCTS* window includes a series of functions whose configuration can change the ventilation pattern that has been delivered. Depending on the operative mode being used, these functions will be enabled or disabled. In the latter case, the appropriate line on the *VENTILATORY ADJUNCTS* menu is displayed in a lighter color than the lines that represent the enabled functions.

There is a rapid access to access this window. Pressing the **[Menu]** key twice in a row brings the window shown in Fig. 7-4 to the screen. 7-4. This window shows different options based on the type of patient category.

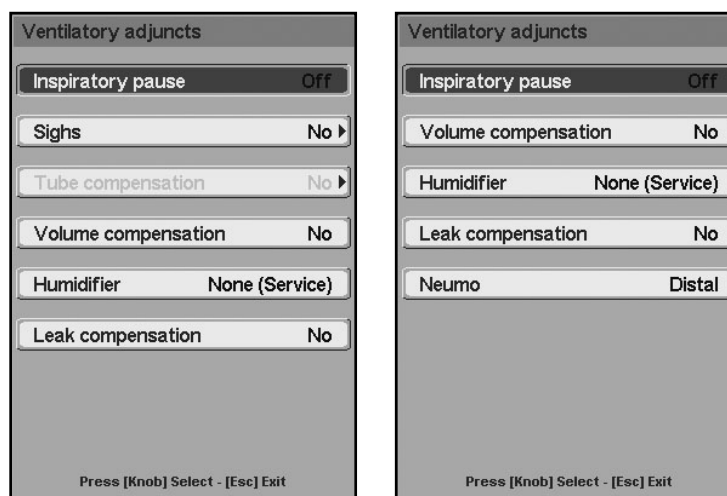


Fig. 7-4 *VENTILATORY ADJUNCTS* window. Left, window for the ADL/PED patient category. Right, window for the NEO-INF patient category.

7.4.1 | Inspiratory pause

With the VCV breaths, it is possible to configure a pause that is activated at the end of the inspiratory phase. A constant pressure level is maintained during the pause. This pressure value is monitored and displayed in the Plateau pressure field.

The length of the pause can be configured in the range of 0.25 to 2.00 s, at 0.25 s intervals. If the NO option is selected (default condition) for the Inspiratory pause line, the pause is disabled. If an inspiratory pause is set, it will be executed for all of the inspirations.

7.4.2 | Sighs

A sigh is defined as the additional volume that the ventilator possibly delivers during volume controlled ventilation (VCV). Sighs are not enabled for the NEO-INF patient category.

Sigh configuration includes the following parameters (Fig. 7-5):

- **NUMBER:** it indicates the number of consecutive breaths with sighs executed for each event. It is possible to configure from 1 to 3.
- **EVENTS PER HOUR:** frequency with which breaths with sighs are repeated for each hour of ventilation. Each event includes a number of sighs equal to the number set in Number. 5, 10, 15, or 20 events can be set per hour.
- **SIGHT VT:** it is the volume of the sigh that is added to the regulated volume. It indicates the VT percentage added to the current one, and it can be regulated between 10% and 100% at 10% intervals.
- **MAXIMUM PRESSURE:** it is a maximum inspiratory pressure limit that has an effect only in breaths with sighs. In this way, the maximum pressure alarm and the maximum pressure limit take the new value configured here only for breaths with sighs. The maximum pressure can be configured from 10 cmH₂O to 120 cmH₂O, at 5 cmH₂O intervals.
- **ACTIVATED:** this line activates (YES option) the sighs with the configured values, or it disables them (NO option).

The screenshot shows a window titled "Sighs" with the following parameters and values:

Parameter	Value
Number	1
Events per hour	5
Sigh VT	30 %
High pressure	40 cmH ₂ O
Activated	No

At the bottom of the window is an "Accept" button and a footer instruction: "Press [Knob] Select - [Esc] Exit".

Fig. 7-5 SIGHs window.

When the sigh configuration is completed, the Accept button must be pressed to confirm the values that have been selected. Otherwise, the configuration is not saved.

7.4.3 | Tube compensation

The Tube Compensation function has been designed to compensate for the resistance imposed by the endotracheal or tracheostomy tube. This function is not available for NEO-INF category patients.

Inspiration is controlled according to the estimated intratracheal pressure. This pressure is estimated based on the configuration entered into the TUBE COMPENSATION window. The following parameters are configured in this window:

- **TUBE:** Endotracheal or Tracheostomy.

- DIAMETER: 4 – 12 mm (depending on the type of patient).
- COMPENSATE: compensation percentage, adjustable between 10% and 100% with 50% as default value.
- ACTIVATED: YES or NO. It enables the compensations. If the NO option is selected and it is later accepted, the configuration of the previous parameters is saved in the memory.

Lastly, the cursor must be placed on the Accept button and the dial must be pressed to confirm the changes.

Fig. 7-6 TUBE COMPENSATION window.

The purpose of the *Tube compensation* is to get the tracheal pressure to stay equal to the pressure configured by the operator (PCV or PSV). To that effect, the ventilator adjusts the pressure in the patient circuit to compensate for the drop in pressure throughout the tube. To achieve this, it is necessary to generate a pressure in the patient circuit higher than the configured one, whose magnitude is calculated according to the following equations:

$$P_{tracheal} \cong \text{Configured pressure (PCV o PSV)} \rightarrow P_{aw} > P_{tracheal}$$

$$P_{aw} = P_{tracheal} + P_{comp} \rightarrow P_{tracheal} = P_{aw} - P_{comp}$$

$$P_{comp} = K \cdot \text{Flow}^2 \cdot (\text{compensation \%})$$

Where:

- P_{comp} is the pressure level added to the pressure in the circuit (P_{aw}) to compensate for the resistance of the tube.
- K is a coefficient derived from the resistive characteristics of the tube. This coefficient depends on the diameter and the characteristics of the tube used.
- The Flow in the equation is the flow of gases that the ventilator drives to generate the configured pressure.

When the *Tube compensation* is activated, it will be possible to observe a superimposed white curve on the pressure/time graph (and on the pressure/volume loop) that corresponds to the calculated tracheal pressure. Depending on the flow provided or required and the compensation percentage, it will be possible to see that the airway

pressure line (green) has a higher peak than the tracheal pressure that corresponds to the level needed to compensate for the resistance of the tracheal tube.

The peak value of the tracheal pressure is displayed on the left of the screen (under the peak pressure) and on the *PATIENT'S DATA* window.

The maximum inspiratory pressure alarm behaves in a particular way when the Tube compensations enabled. The alarm system always monitors the pressure of the airway (green curve), and this system does not use an estimated tracheal pressure. If the pressure of the airway must exceed the alarm limit to achieve *Tube compensation*, it is limited so that it NEVER exceeds the alarm limit due to the compensation, and the alarm signals do not go off. If, during *Tube compensation* breaths, an event causes the airway pressure to rise above the configured limit, then the alarm system fires off the appropriate signals and depressurizes the circuit down to the configured PEEP level.



WARNING

• **Because this modality works as an amplified pressure control system, it is very important to perform an appropriate adjustment of the compensation percentage, Rise Time and tube diameter in order to avoid excessive compensation that may result in exceeding airway pressure.**

Tube compensation is used for ADL and PED category patients in pressure controlled modes, i.e. PCV, PSV, APRV, PRVC, MMV + PSV, and their combinations. In SIMV (VCV) + PSV, the volume controlled mandatory breaths only show the superimposed tracheal pressure line without compensation. *Tube compensation* is not enabled in PSV + Assured VT.



Fig. 7-7 Screen captured during PCV mode ventilation. The image shows the $P_{tracheal}$ and P_{aw} graphs. $P_{tracheal}$ monitoring is under the Peak pressure value.

7.4.3 | Volume compensation

When this option is enabled (YES option), the ventilator compensates for the tidal volume according to the patient circuit compressible volume. In this way, the driven and the monitored tidal volumes reflect a value that represents the value received and exhaled by the patient, respectively.

During the initial calibration (see the *Start-up and initial calibration* chapter) the ventilator calculates the compliance of the patient circuit and uses that information to determine tidal volume compensation. Based on this determination, the ventilator estimates the volume to be added (volume modes) or subtracted (pressure modes).

The Volume *Compensation* option is active by default (YES option). In this case, a message appears in the Icosn and messages bar, warning that the compensation is active. To deactivate the volume compensation, select the NO option on the appropriate *VENTILATORY ADJUNCTS* line.



WARNING

• *If the patient circuit configuration is changed (hoses, humidifier, etc. being changed or added) the volume compensation prior to the change will no longer be valid. The circuit will have to be calibrated again to re-calculate the new compensation value. Otherwise, the patient may receive and exhale a volume that will not be reflected in the values displayed on the screen.*

7.4.5 | Humidifier

This is an option used if the kind of humidification used during ventilation is changed.

When the humidification system is changed, the temperature and humidity condition of the gases are changed. Because of this, the volumes delivered and monitored at BTPS condition must be corrected (body temperature, steam-saturated ambient pressure).

The humidification system options are:

- **ACTIVE:** this is the option that must be configured when an active humidifier/heater is used. In this case, flow and volume readings are corrected to take into account the humidity and temperature generated by this kind of humidifier.
- **PASSIVE:** this is the option that must be configured if a passive humidifier is used (heat and moisture exchanger - HME).
- **NONE (TECHNICAL):** this is an option used by technical services. It is intended to be selected when no humidification is used and, therefore, no volume reading corrections are done. It must not be used while a patient is being provided ventilation.



WARNING

• *Selecting the NONE (TECHNICAL) option implies disabling the BTPS correction. Therefore, it should never be used while a patient is being provided ventilation.*

7.4.6 | Leak compensation

Auto-triggering may occur when there is a leak in the circuit because the leak could be interpreted as flow that has been diverted by patient requirements. Similarly, the ventilator may consider the depressurization generated by the loss of gases a result of the patient's inspiratory effort if it is working with sensitivity by pressure.

The purpose of leak compensation is to stabilize triggering sensitivity to avoid auto-triggering occurrences. If there is a leak, it is measured by the ventilator and used as a point of reference to establish triggering criteria (inspiratory sensitivity).

The compensation operates up to certain leak levels (see Table 7-3).

Table 7-3 Leak Compensation (in L/min)

Mode	Category		
	ADL	PED	NEO-INF
NIV	50	30	10 ⁽¹⁾
Remaining modes	15	15	10

⁽¹⁾For NEO-INF this value applies to Continuous Flow CPAP, where, as occurs with NIV, leak compensation is automatically activated and cannot be disabled.

If the leak is greater than those indicated on Table 7-3, the excess is not compensated. In NIV and Continuous Flow CPAP, the leaks are compensated by default, and the compensation cannot be disabled.

7.4.7 | Pneumo

This option, available only for NEO-INF patients, is used to enable one of the two pneumotachograph accepted by the ventilator.

The expiratory set includes the distal pneumotachograph. The distal pneumotachograph is a different device, located above the Y connector and able to provide small flow (or volume) readings with greater precision.

The distal pneumotachograph is enabled by default. To enable the proximal pneumotachograph, execute the following string **[Menu]>>Pneumo>>Proximal**. Always make sure that it is correctly connected before enabling it.

For each pneumotachograph change, the ventilator automatically runs a zeroing procedure on its flow sensors.



PRECAUTION

- *The proximal pneumotachograph must be connected before being enabled. Otherwise, the ventilator will not receive information about exhalation flow. This will result in the ventilator not operating appropriately.*
- *The position of the pneumotachograph when connecting it to the Y-piece is very important. The device can only be connected on the Y-piece in one way (because of the connectors size). An improperly placed pneumotachograph prevents the ventilator from reading the expiratory flow values.*
- *The proximal pneumotachograph must be used to ventilate with peak flows under or at 20 L/min only. Do not exceed that limit. Otherwise, flow and volume readings can be seriously affected.*

7.5 | Records

The **RECORDS** menu includes three functions that constantly store information on the progress of the current ventilation and past events. They are:

- **TRENDS**: for further details, see the *TRENDS* chapter.
- **SAVED LOOPS**: for further details, see the *Graphics management* chapter.
- **ACTIVATED ALARMS**: for further details, see the *Alarms* chapter.

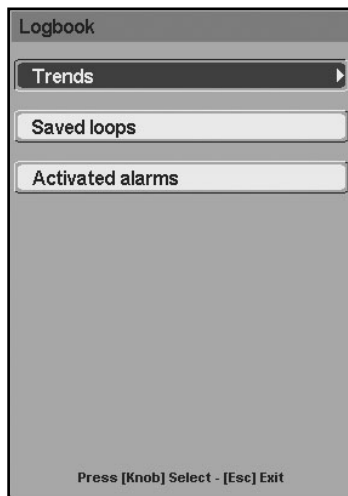


Fig. 7-8 RECORDS menu window.

7.6 | Tools

Once the *Tools* option has been selected, the Fig. 7-9 window appears. 7-9. The functions described in that figure can be accessed from there. A fast way to access this window is by pressing the **[Menu]** key three times in a row. If it is pressed a fourth time, it goes back to the main *MENU* window.



Fig. 7-9 TOOLS window.

7.6.1 | Autoscale

The *Autoscale* function automatically adjusts the scale of the curves. This optimizes the size of the curves according to the size of the area assigned for each graph. The description of the *Autoscale* function is in the *Graphics management* chapter.

7.6.2 | Suction configuration

Entering **[Menu]>>Tools>>Suction configuration** gives access to the window where the Suction period and the %O₂ enrichment can be changed (see Table 7-4 Fig. 7-10).

The Suction period determines the time allocated to suction, during which the ventilator does not provide mandatory breaths.

The %O₂ enrichment is a value that is added to the O₂ concentration that is present in the current ventilation.

For example, if the breaths delivered have a 50% oxygen concentration and an

%O₂ enrichment of 20 is configured, the breaths delivered before and after suction will be delivered at a 70% O₂ concentration. If the Max option is selected, the O₂ concentration used during the operation will be 100%.

The values allowed by the configuration of these parameters can be found in Table 7-4.

Table 7-4 Suction configuration

Category	Suction period			(Absolute) O ₂ % enrichment		
	Range	Increase	Initial value	Range	Increase	Initial value
ADL/PED	10 – 40	5	20	5 –20 / Max	5	Max
NEO-INF	10 – 40	5	10	5 –20 / Max	5	10

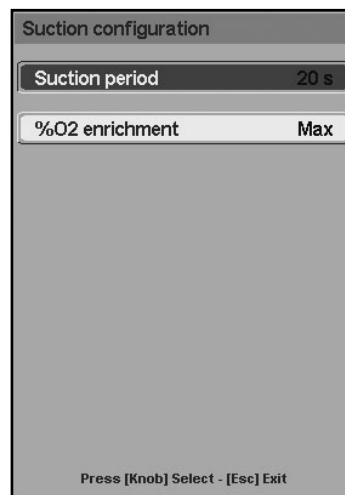


Fig. 7-10 SUCTION CONFIGURATION window.

7.6.3 | Calibrations

Fig. 7-11 shows the functions included in the CALIBRATIONS window.

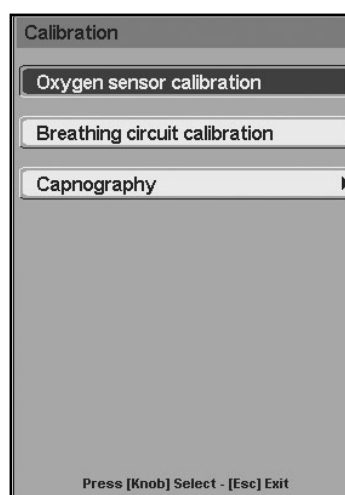


Fig. 7-11 CALIBRATIONS menu.

7.6.3.1 | Oxygen sensor calibration

Entering this option displays a submenu like the one found in Fig. 7-12.

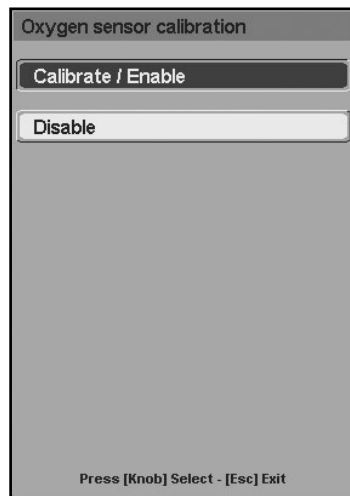


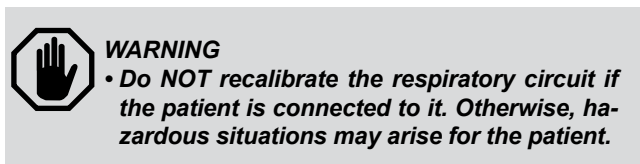
Fig. 7-12 OXYGEN SENSOR CALIBRATION window.

Three actions can be carried out from this window.

- Sensor calibration by simply accepting the first line on this menu.
- Disabling the sensor, accepting the second option (when the sensor breaks or wears out during ventilation). In this case, the O₂ value being monitored is replaced by two hyphens to indicate that it is not active.
- Finally, if the sensor is disabled, it can be reactivated from the first line of the Calibrate/Enable menu.

7.6.3.2 | Breathing circuit calibration

This function recalibrates the breathing circuit (patient circuit) without the equipment having to be turned off. The calibration must not be performed with the patient connected to the circuit. The Y piece must be disconnected and the free end of this connector must be covered to begin calibration. The screens displayed by the ventilator to guide the calibration are identical to those indicated in the *Start-up and Initial calibration* chapter.



7.6.3.3 | Capnography

All capnography related information has been included in the *Capnography* chapter.

7.6.4 | Settings

7.6.4.1 | Pressure units

From here, it is possible to change the units of pressure used in the readings and graphs involved in this measurement. The available units are cmH₂O, mbar, and hPa. The numeric values are not changed, since the ratios between these units is approximately 1:1.

7.6.4.2 | Mean ambient pressure

The flow and volume of the gas driven through and of the gas measured in the exhalation vary, depending on the atmospheric pressure (which is affected by the altitude) of the location where the ventilator is operating. For the flows and volumes to use the altitude of the location as point of reference, a correction must be made on the equipment current value, entering the average value of the ambient pressure. Following the sequence **[Menu]>>Tools>>Settings>>Mean ambient pressure** opens a window to enter the mean ambient pressure information for the place where the ventilator is located. The change is made in the highlighted field (mbar) and the torr value is automatically updated. The initial value for this parameter appears in Fig. 7-13.

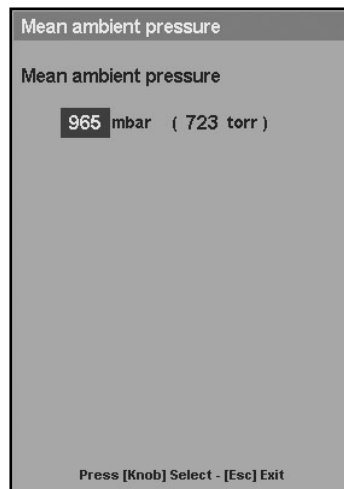


Fig. 7-13 MEAN AMBIENT PRESSURE.
From this window, it is possible to change the ambient pressure value to match the mean pressure level of the place where the ventilator is located.

Continuously entering new changes is not considered necessary because local barometric pressure fluctuations will not significantly affect the results unless the equipment is moved to a new location at a different altitude. Table 7-5 can be referred to as a general guideline.

Table 7-5 Atmospheric Standard
International Civil Aviation Organization (ICAO)

Altitude (m)	Atmospheric pressure	
	mbar	mmHg
0	1013	760
500	955	716
1000	899	674
1500	845	634
2000	795	596
2500	747	560
3000	702	525
3500	658	493
4000	616	462
4500	577	433

7.6.4.3 | Sound volume

The sound of the alarms can be regulated. From **[Menu]>>Tools>>Settings>>Sound volume** it is possible to change the sound level with which the auditory alarms are triggered on a percentage scale (20% - 100%). Sound volume cannot be completely eliminated.

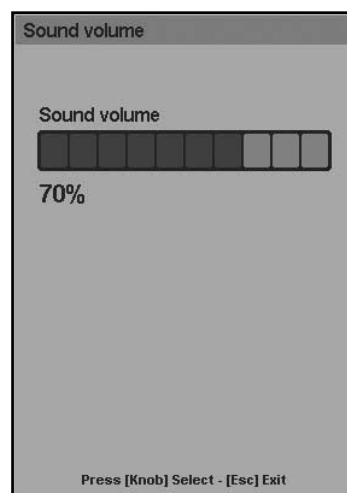


Fig. 7-14 SOUND VOLUME window. This window can be accessed from the Sound volume line in MENU

7.6.4.4 | Date and time setting

The **[Menu]>>Tools>>Settings>>Date and time setting** option displays a window that changes the date and time information displayed by the equipment. The changes are entered as in the other windows. To save changes, press the **[Menu]** key.

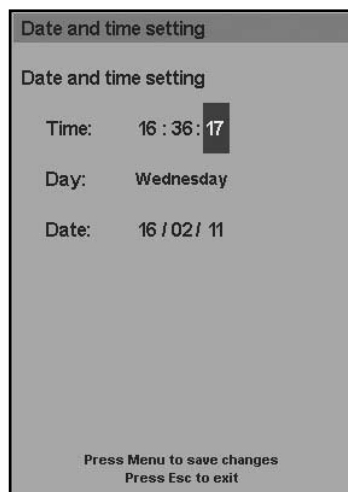


Fig. 7-15 Window enabled to change date and time. The lower area indicates that the **[Menu]** key must be pressed to save changes.

7.6.4.5 | Language

[Menu]>>Tools>>Settings>>Language changes the language of the ventilator program. When the language is changed, all functions and tags displayed on the *iTernIS ADV* screen will change to the new language. Available options are:

- SPANISH
- ENGLISH
- PORTUGUESE
- RUSSIAN
- CHINESE
- FRENCH
- TURKISH

7.6.5 | Time of use and soft version

This option leads to a window that shows the version of the ventilator software, the total number of hours used and the time elapsed since it was last serviced (in hours). A reminder is also included about having to perform preventive maintenance every 5000 hours of usage (see Fig 7-16).

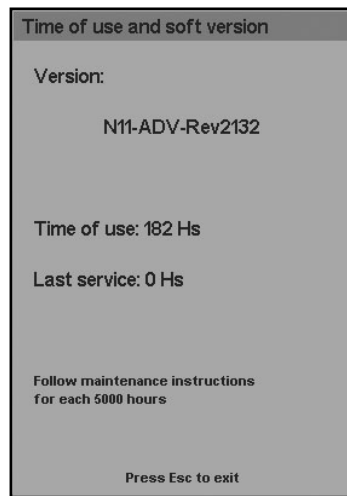


Fig. 7-16 TIME OF USE AND SOFT VERSION window..

7.7 | Intra Hospital Transport

The *Intra hospital transport* option was intended to be activated during intra hospital transfer of patients that must continue to receive ventilation support. Specifically, for transfers during which the ventilator is supplied only with O₂.

The Intra hospital transport function temporarily deactivate the Low air pressure and Power loss alarm signals. This is designed to avoid overloading the alarm signals, which indicate conditions the user knows that are due to the transfer.

The function can only be activated when the air supply is missing. The *Intra Hospital Transport* activation mechanism is as follows:

- Shut down the wall O₂ supply (the ventilator temporarily ventilates with air only) and remove the ventilator hose.
- Make the connections that feed the OXYGEN inlet into the ventilator from an O₂ tube.
- Shut down the wall air supply and remove the feed hose (this will trigger the Low air pressure alarm signals).
- Complete the following sequence: **[Menu]>>Intrahospital transport>>YES.**

This will fully enable the Intra hospital transport. This function is deactivated when the air pressure is restored in the rear panel AIR inlet or when the following is executed: **[Menu]>>Intrahospital transport>>NO.** While the option is active, the ventilator displays low priority alarm signals to indicate that condition.

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Graphics management

CHAPTER CONTENTS

- 8.1 Ventilator screens - [Graphics] Key
- 8.2 Freeze screen
- 8.3 Curve scaling
- 8.4 Autoscale
- 8.5 Horizontal axis position (zero line)
- 8.6 Reference loops

CHAPTER SUMMARY

Graphics management includes instructions to correctly configure pressure, volume and flow curve and pressure-volume and volume-flow loop graphs. The chapter descriptions include screen graphic layout configuration, scale management, units, reference loops, etc.

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8.1 | Ventilator Screens - [Graphics] Key

iTernIS ADV has 6 different screens to organize different curves and patient information.

To access the *GRAPHICS* menu (Fig. 8-1) where one of these 6 screens can be selected, press the **[Graphics]** key. All the screens keep the lower control adjustment bar, the upper monitored data bar, the right hand special function direct access button bar and the left hand bar (battery charge and pressure monitoring icon).

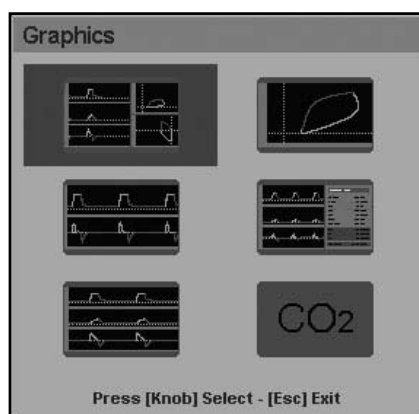


Fig. 8-1 *GRAPHICS* window. One of the six available screen options can be selected on this menu.

The pictures included in the Fig. 8-1 window represent the different screens. They are:

- **FIVE CURVES.** Pressure, volume and flow; and pressure/volume and flow/volume loops. This is the default *iTernIS ADV* screen. This is the screen displayed at the start of ventilation, and pressing the **[Esc]** key brings the system back to this screen.
- **TWO CURVES.** Pressure and flow.
- **THREE CURVES.** Pressure, flow and volume.
- **LOOPS.** Pressure/volume, flow/volume and flow/pressure loops.
- **PATIENT'S DATA.** Pressure, volume and flow curves with patient data sheet (see the *Menu* chapter for further details about this screen).
- **CAPNOGRAPHY.** Pressure, volume, flow and partial CO₂ pressure curves. Capnography data sheet and CO₂/volume curve.

8.1.1 | Five curves



Fig. 8-2 FIVE CURVES screen.

8.1.2 | Two curves



Fig. 8-3 TWO CURVES screen.

8.1.3 | Three curves



Fig. 8-4 THREE CURVES screen.

8.1.4 | Loops

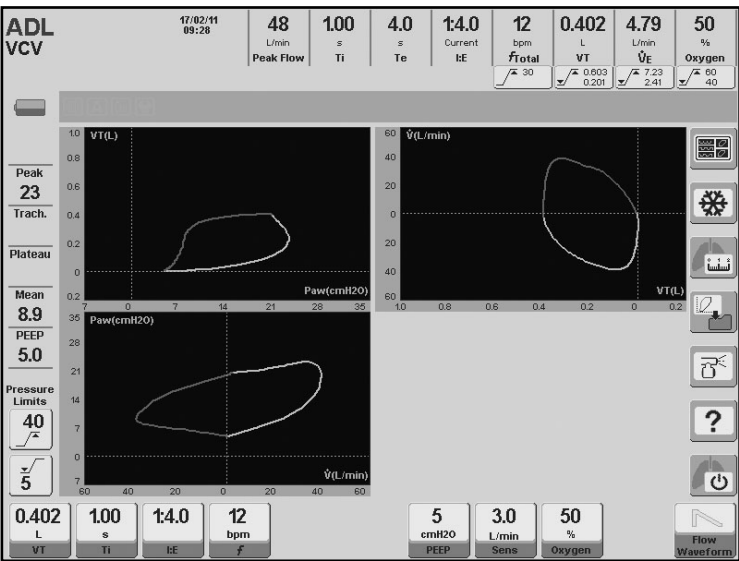


Fig. 8-5 LOOPS screen

8.1.5 | Patient's data



Fig. 8-6 PATIENT'S DATA screen.

8.1.6 | Capnography

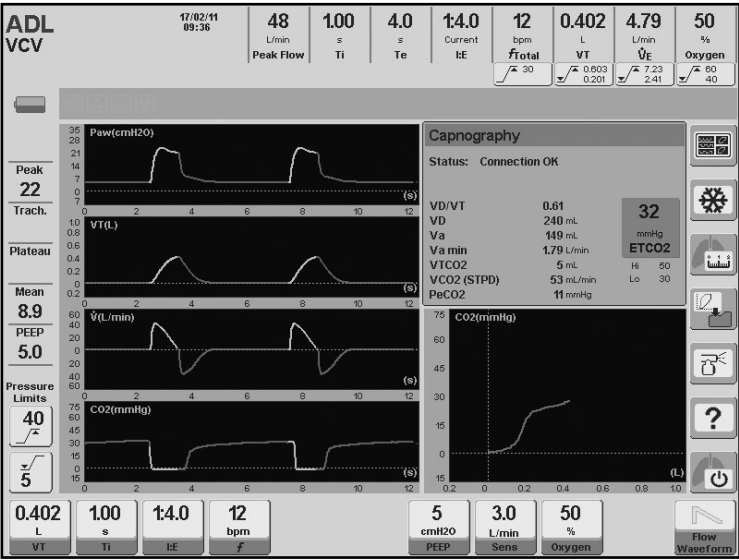


Fig. 8-7 CAPNOGRAPHY screen.

8.2 | Freeze Screen

By pressing the **[Freeze]** button on the touch screen, it is possible to freeze the current screen. This means that the curves are frozen, but the monitored data continues to be updated.

To cancel screen freezing, press the **[Freeze]** button again.

8.3 | Curve Scaling

The scale at which the curves are charted can be changed. Graph scale modification is a tool that allows fitting the size of the curves to the area that is available for each graph.

Steps to change graph scale:

- Press the touch screen on the axis of the magnitude to be changed. The selected axis changes color, indicating that its scale can be changed.
- The rotary knob changes the scale.
- Once the most convenient scale has been determined, press the knob again. This keeps the new scale that has been entered.
- This process can be repeated until all the scales have been changed. The way to change scales is the same for all screen graphs.
- The change in progress can be aborted at any time by pressing the **[Esc]** key.

When the scale of a given magnitude is changed, all the axes that show that magnitude are simultaneously changed. For example, if the Pressure axis on the first FIVE CURVES graph is changed, the volume/pressure loop pressure axis is also changed.

8.4 | Autoscale

An alternative to graph manual scaling is the Autoscale function. This function allows the ventilator to select a scale automatically so that the curve shown is the largest size allowed by the graph area. To activate this function, execute the following string: **[Menu]>>Tools>>Autoscale>>YES**.

Autoscale monitors the curves and operates permanently while activated. If any of the curves increases or decreases in height during ventilation, the Autoscale will adjust the scale to fit again the curve that has changed.

When this function is activated, an icon appears on the Icons and messages bar reporting that condition.

8.5 | Horizontal Axis Position (Zero Line)

The position of the graph horizontal axis can be changed (zero line level). To do that, follow the following steps:

- Press the touch screen on the vertical axis of the graph in question.
- Press the **[Ctrl]** key.
- Turn the knob until the most convenient horizontal axis position is reached. Press the knob.
- Repeat for other graphs, as desired.
- The change in progress can be aborted at any time by pressing the **[Esc]** key.

When the position of the horizontal axis of a graph is changed, the position of the horizontal axes that represent the same magnitude change simultaneously.

8.6 | Reference Loops

A reference loop is one that has been frozen on the graph and is kept there for purposes of comparison with consecutive breaths.

The **[Save loop]** button is on the right area of the touch screen. Pressing this button freezes the current loop in another color on screen, showing the date and time it was recorded, over the V_T/P_{aw} loop area. Four loops with dates and times can be stored in the ventilator memory by repeatedly pressing the **[Save loop]** button. They remain in the memory until the ventilator is turned off. To access them, execute the following string: **[Menu]>>Records>>Saved loops**. Once in the **SAVED LOOPS** window (Fig. 8-8), it is possible to select any of the saved loops for display on screen.

To delete the reference loop on screen, press **[Ctrl]>>[Graphics]**.

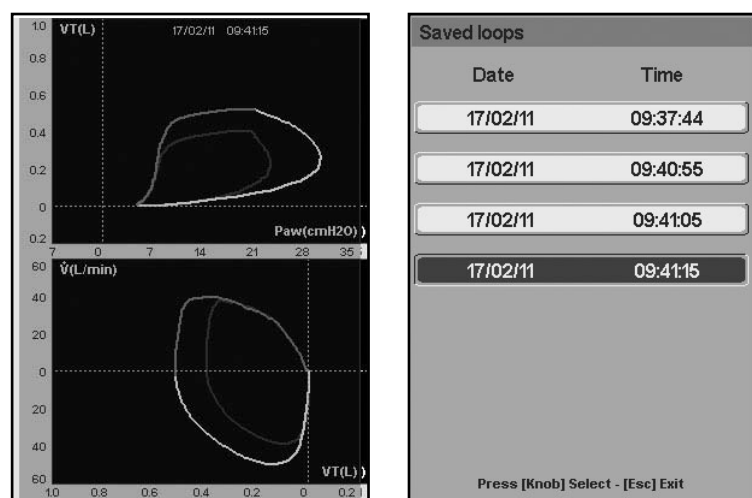


Fig. 8-8 Left, picture of the loops on the **FIVE CURVES** screen, with reference loops. The lightly drawn loop is the reference loop, which remains on screen until the delete string is executed. Right, **SAVED LOOPS** picture. When one of the four saved loops is selected, it will be displayed on the screen as shown in the picture on the left.

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ADL/PED Operative modes

CHAPTER CONTENTS

- 9.1 VCV - Volume Controlled Ventilation
- 9.2 PCV - Pressure Controlled Ventilation
- 9.3 PSV - Pressure Supported Ventilation
- 9.4 CPAP – Continuous Positive Airway Pressure
- 9.5 SIMV (VCV) + PSV
Synchronized Intermittent Mandatory Ventilation
- 9.6 SIMV (PCV) + PSV
Synchronized Intermittent Mandatory Ventilation
- 9.7 MMV with PSV
Mandatory Minute Ventilation with Pressure Supported Ventilation
- 9.8 PSV with assure VT
- 9.9 APRV - Airway Pressure Release Ventilation
- 9.10 NIV - Noninvasive Ventilation
- 9.11 PRVC - Pressure-regulated, volume-controlled ventilation
- 9.12 Backup Ventilation

CHAPTER SUMMARY

iTermIS ADV uses the same operative modes for the ADL and PED patient categories. Therefore, a brief description of the modes found in these categories is shown here, with the default values for the ventilation parameters corresponding to ADL and PED, and a list of additional features enabled in each of the described modes.

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9.1 | VCV - Volume Controlled Ventilation

9.1.1 | Overview

Volume controlled ventilation involves the delivery of a set tidal volume with each breath. In this mode, the inspiratory pressure is not regulated and is the result of the volume and flow, delivered by the ventilator and the completed breathing circuit impedance (including the patient).

During this mode, the ventilator operates as a flow controller. The selected flow wave remains unchanged, even when changing the patient's respiratory compliance or resistance. The ventilator calculates the necessary flow to meet the demands of the set tidal volume and inspiratory time. Cycling is performed by time (determined by the configuration of the inspiratory time).

The beginning of the breathing in VCV is controlled by the respiratory rate control. If the patient generates enough respiratory effort (greater than or equal to the configured inspiratory sensitivity), the start of the inspiratory periods is determined by these efforts, rather than by the respiratory rate. For this reason, the VCV mode is also known as an assisted mode. The inspiratory sensitivity can be configured by pressure or by flow.

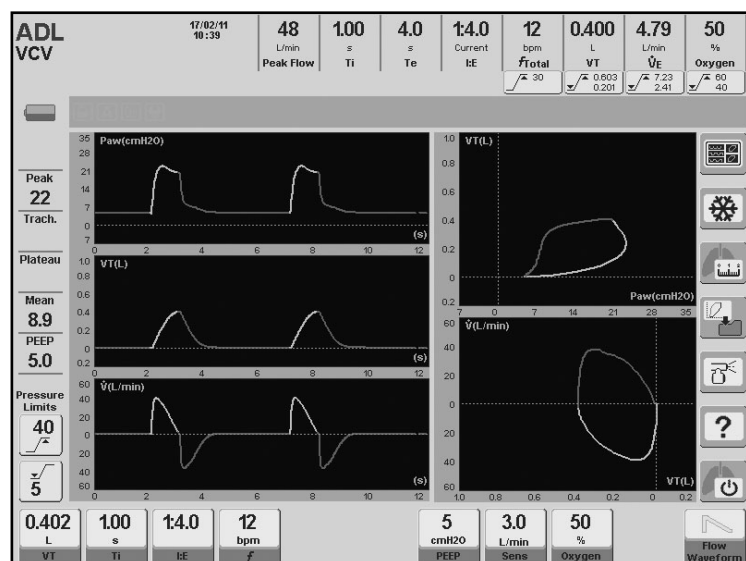


Fig. 9-1 Image of the VCV mode main screen.

9.1.2 | Flow waveform

In volume-controlled mode, or tidal volume target mode, it is possible to configure the flow waveform. You can choose between a flow wave in descending ramp (predetermined wave) and a constant wave (rectangular). By choosing one or the other, the ventilator adjusts automatically the calculations necessary to deliver the selected volume (more details in the *Basic Operations* chapter).

9.1.3 | Enabled ventilatory parameters (preset values)



Fig. 9-2 Image of the VCV-enabled controls, ADL category. Shown with the preset values for each of them.



Fig. 9-3 Image of the VCV-enabled controls, PED category. Shown with the preset values for each of them.

The preset tidal volume values will depend on the configuration of *IBW-based VT* (see *Start-up and Initial Calibration* chapter). The images of Fig. 9-2 and Fig. 9-3 show the initial values resulting from the preset *IBW-based VT* configuration.

9.1.4 | Enabled additional functions

The following list contains additional functions that can be selected optionally in VCV (for further details on their behavior, see the *Menu* chapter):

- Nebulization.
- %O₂ suction.
- Manual inspiration.
- Manual inspiratory/expiratory pause.
- Programmed inspiratory pause.
- Sighs.
- Volume compensation.
- Leak compensation.

9.2 | PCV - Pressure Controlled Ventilation

9.2.1 | Overview

In the Controlled Pressure mode (PCV), the *iTernIS ADV* ventilator functions as a positive pressure controller. In this mode, the pressure is set from the PCV parameter, and this value remains unchanged regardless of the patient compliance and resistance. The PCV value is applied above PEEP (peak pressure = PCV + PEEP).

The regulated control pressure is kept constant during the set inspiratory time. In order to maintain constant pressure, the flow delivered follows a decelerated wave profile.

The progressive flow decrease is determined entirely by the mechanics of the respiratory system. Consequently, the volume delivered will also be variable, depending on the characteristics of the patient's respiratory system.

The beginning of breathing is controlled similarly to the VCV mode. If the patient has no respiratory effort, the selected respiratory rate controls the start of inspiration.

If the patient has a demand equal to or greater than the configured inspiratory sensitivity level, then it will be the patient who triggers inspiration. In this case, the ventilator delivered breaths are identical to those initiated by time. The patient can only trigger the inspiratory phase, but the characteristics of the breathing respond to the mode configuration.



Fig. 9-4 FIVE-CURVE main screen during PCV operative mode.



WARNING

- The PCV configured value is above the selected PEEP level. This means that the inspiratory pressure (P_i) is the sum result of both pressure values.

$$P_i = PCV + PEEP$$

9.2.2 | Rise Time

In pressure-controlled modes (including PSV) a Rise Time control appears (Control Adjustment sector). This control allows changing the time it takes for achieving regulated control pressure. Changes to the rise times can be seen graphically as an increase or decrease in the slope of the initial portion of the inspiratory pressure trace.

9.2.3 | Enabled ventilatory parameters (preset values)



Fig. 9-5 Image of the PCV-enabled controls, ADL category. Shown with the preset values for each of them



Fig. 9-6 Image of the PCV-enabled controls, PED category. Shown with the preset values for each of them

9.2.4 | Enabled additional functions

The following list contains additional functions that can be selected optionally in PCV (for further details on their behavior, see the *Menu* chapter):

- Nebulization.
- %O₂ suction.
- Manual inspiration.
- Manual inspiratory/expiratory pause.
- Volume compensation.
- Leak compensation.
- Tube compensation.

9.3 | PSV - Pressure Supported Ventilation

9.3.1 | Overview

The PSV ventilation mode is in the *OPERATIVE MODES* menu under the name of PSV/CPAP, given that the configuration of the two ventilatory variables is possible from the same module (the next section describes CPAP). Support pressure is a spontaneous operative mode where the patient starts and stops the inspiratory phase. This means maintaining control of respiratory rate, inspiration duration and delivered tidal volume. Then delivered tidal volume is variable, depending on the regulated support pressure, the effort of the patient (demand), and respiratory impedance thereof.

Support pressure can be analyzed in three segments of the respiratory cycle:

- **BREATHING BEGINNING:** the inspiratory phase is always initiated by the patient's inspiratory effort. With Inspiratory Sensitivity control, it is possible to configure different trigger conditions that imply more or less effort for the patient.
- **INSPIRATION COURSE:** once the inspiration is triggered, it is necessary to produce the pressurization of the respiratory system, and that the support pressure value is maintained throughout the patient's demand. The pressurization can be changed quickly with Rise time control, as explained for PCV. Once the pressure value is reached, it remains stable while flow demand is greater than the one selected as inspiration-end (see 9.3.2 Expiratory Sensitivity).
- **END OF INSPIRATION:** the inspiratory phase ends when during its course any of the following events occurs:
 - The progressive decrease of the inspiratory flow reaches a specified percentage of the peak flow (expiratory sensitivity). This is the inspiration-end natural mechanism. The following two mechanisms exist as patient safety mechanisms.
 - The inspiration is prolonged up to 3 s in ADL category or 2 s in PED (for NEO-INF patient category, inspiration ends if this is prolonged during 1 s).
 - Inspiratory pressure exceeds abruptly a value of 14% of the set pressure plus 5 cmH₂O, for all categories.



Fig. 9-7 Image of the iTernIS ADV screen in PSV operative mode.

9.3.2 | Inspiratory sensitivity

It is important to configure an appropriate value for Inspiratory sensitivity. The value of this parameter determines the effort that the patient must perform to trigger an inspiration on his own. The *Basic Operations* chapter offers a more detailed description of this parameter.

9.3.3 | Expiratory sensitivity

This control adjusts the criterion for completion of the inspiratory period depending on the magnitude of flow in progress. The Expiratory Sensitivity is programmed as a percentage of peak flow. The inspiration end is produced then, when the instantaneous flow has reached a level equal to the configured peak flow rate.

9.3.4 | Rise time

Rise Time may be adjusted in breaths with support pressure (see *Basic Operations* chapter).

9.3.5 | Enabled ventilatory parameters (preset values)



Fig. 9-8 Image of the PSV-enabled controls, ADL and PED category. Shown with the preset values for each of them.

9.3.6 | Enabled additional functions

The following list contains additional functions that can be selected optionally in PSV (for further details on their behavior, see the *Menu* chapter):

- Nebulization.
- %O₂ suction.
- Manual inspiration.

- Volume compensation.
- Leak compensation.
- Tube compensation.

9.4 | CPAP - Continuous Positive Airway Pressure

9.4.1 | Overview

This is a spontaneous mode where the patient breathes in a system with continuous positive pressure. There are no mechanical impulses with positive pressure, but the inspiration of the patient makes the ventilator generate a flow proportional to the demand in order to maintain the level of continuous positive pressure. Any patient effort to open valves that provide the flow is regulated by controlling the Inspiratory Sensitivity.

The ventilator maintains an active pneumatic control of the continuous positive pressure through the action of a proportional valve on the expiratory valve diaphragm.

During ventilation, the charting of the airway pressure during inspiration shows a slight decrease compared to the continuous positive pressure baseline and, during expiration, an increase of this pressure, that is, a curve shape reverse to that observed during pressure-controlled breaths, or even support pressure breaths.

When the ventilator does not detect valid inspiratory efforts, it assumes an apnea state, starting *Backup Ventilation*.

9.4.2 | Enabled ventilatory parameters

CPAP is a particular way to set the PSV operative mode. Therefore, achieving ventilation with CPAP features only requires configuring a PSV level of 0 cmH₂O so that there are no breaths with support pressure.



Fig. 9-9 Image of the PSV/CPAP mode controls configured to deliver breaths with CPAP features. Except PSV, the rest of the parameters use the preset values of the PSV/CPAP mode.

9.4.3 | Enabled additional functions

The same functions as those stated in 9.3.5. are enabled.

9.5 | SIMV (VCV) + PSV Synchronized Intermittent Mandatory Ventilation

9.5.1 | Overview

This is a synchronized intermittent mandatory operative mode that delivers a controlled volume for the mandatory breaths. This volume can be set, and delivered with a user-set fixed inspiratory rate and time. During spontaneous breathing, the patient breathes with pressure supported ventilation (PSV).

It is possible to adjust the rate and inspiratory time for breaths imposed by the ventilator. The resulting expiratory time (of the mandatory breaths) has a period during which the patient can start a spontaneous inspiration with the same characteristics

and considerations for the PSV mode. This period is extended for the first $\frac{3}{4}$ of the total expiratory time. The remaining $\frac{1}{4}$ is used to synchronize the patient's inspiratory efforts with the mandatory breaths. When an inspiratory effort is detected during the final $\frac{1}{4}$ of expiration, the ventilator triggers breathing with VCV characteristics. That is, the ventilator uses the patient's effort to deliver a breath with the characteristics of the mandatory breaths. For this reason, the regulated rate for mandatory breaths can be altered if there are patient's respiratory efforts requiring the ventilator to synchronize this effort with mandatory breaths.

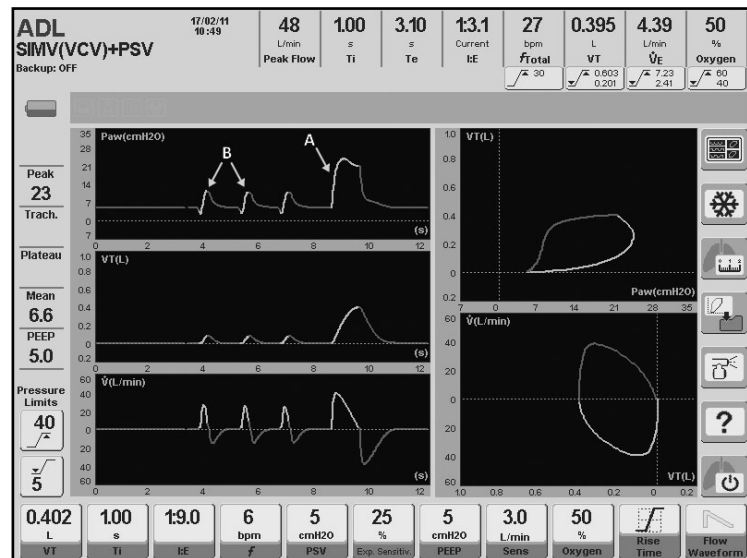


Fig. 9-10 Mode SIMV(VCV)+PSV. Captured image during ventilation in ADL category. A breath of VCV type (A) has been highlighted, and two spontaneous breaths (B).

9.5.2 | Rise time and flow wave

The configuration of the Rise Time affects spontaneous breaths that are delivered with support pressure, while changing the flow waveform only affects the mandatory breaths (VCV).

9.5.3 | Enabled ventilatory parameters (preset values)



Fig. 9-11 Preset controls for ADL category.



Fig. 9-12 Preset controls for PED category.

The predetermined tidal volume values will depend on the configuration of *IBW-based VT* (see *Start-up and Initial calibration* chapter). The images of Fig. 9-11 and Fig. 9-12 show the initial values resulting from the preset *IBW-based VT* configuration.

9.5.4 | Enabled additional functions

The following list contains additional functions that can be selected optionally in SIMV (VCV) + PSV (for further details on their behavior, see the *Menu* chapter):

- Nebulization.
- %O₂ suction.
- Manual inspiration.
- Manual inspiratory/expiratory pause.
- Programmed inspiratory pause.
- Volume compensation.
- Leak compensation.
- Tube compensation.

9.6 | SIMV (PCV) + PSV Synchronized Intermittent Mandatory Ventilation

9.6.1 | Overview

This operative mode is another variant of synchronized intermittent mandatory ventilation. The operating principle is similar to SIMV (VCV) + PSV with the difference that the mandatory breaths are thus supplied with controlled pressure. The synchronization of spontaneous and mandatory breaths is performed in the same manner as that described in 9.5. Inspiratory time and regulated rate control the mandatory breaths, which in this case, are of PCV type.

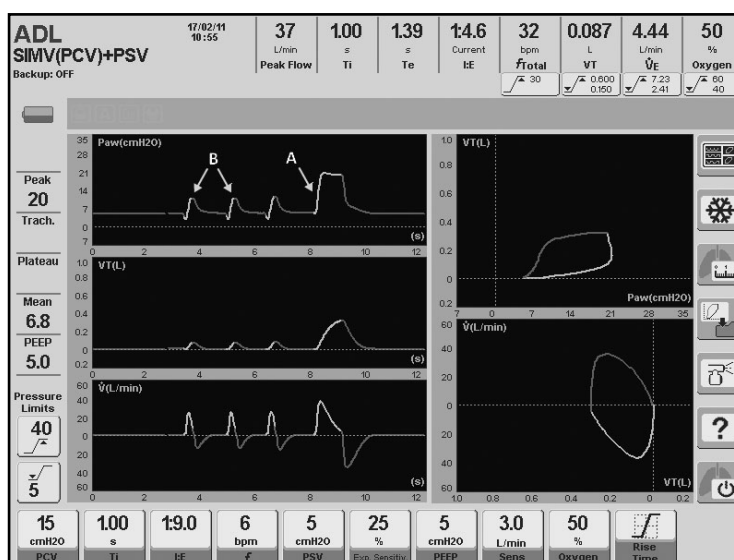


Fig. 9-13 SIMV (PCV) + PSV mode. Captured image during ventilation in ADL category. (A) Mandatory PCV breathing, and (B) spontaneous breathing with support pressure.

9.6.2 | Rise Time

Changes to the Rise Time thus affect spontaneous and mandatory breaths.

9.6.3 | Enabled ventilatory parameters (preset values)



Fig. 9-14 Preset controls for ADL category.



Fig. 9-15 Preset controls for PED category.

9.6.4 | Enabled additional functions

The following list contains additional functions that can be selected optionally in SIMV (VCV) + PSV (for further details on their behavior, see the *Menu* chapter):

- Nebulization.
- %O₂ suction.
- Manual inspiration.
- Manual inspiratory/expiratory pause.
- Volume compensation.
- Leak compensation.
- Tube compensation.

9.7 | MMV With PSV - Mandatory Minute Ventilation With Pressure Supported Ventilation

9.7.1 | Overview

This is an operative mode that delivers spontaneous breaths with support pressure and regulation of a configurable target minute volume.

Ventilation begins with an initial support pressure value (configurable), and if the target minute volume is not reached, the ventilator adjusts the PSV value, breath by breath, to achieve the required target ventilation. PSV variations are progressive, and do not represent abrupt changes between consecutive breaths (not exceeding 2 cmH₂O between breaths).

Because it is a spontaneous mode, the rate of breaths, and the magnitude of patient demand can vary continuously. Naturally, the minute volume demanded by the patient accompanies these variations, and the ventilator is continuously pursuing the planned target. Therefore, recurrent differences can be verified between the set minute volume and the monitored volume without causing a malfunction.

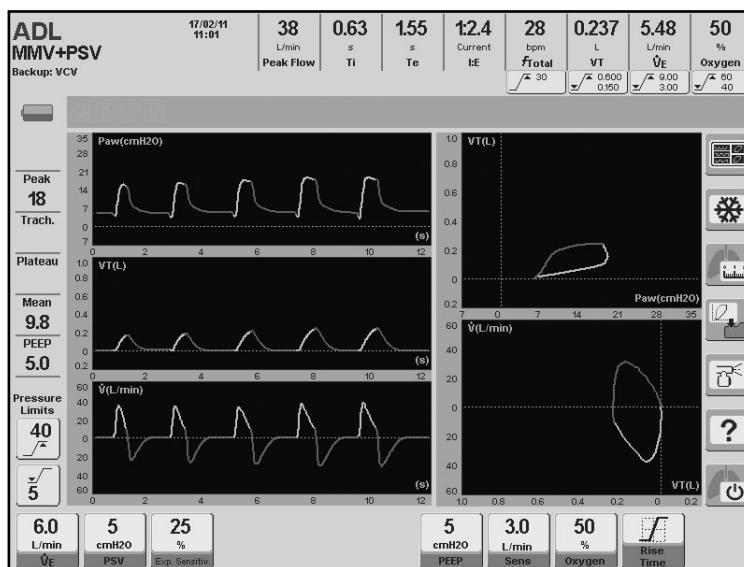


Fig. 9-16 MMV + PSV.

9.7.2 | Target Volume not reached Alarm

In the event that inspiratory pressure values are closer to the pressure alarm limits (maximum or minimum), and target minute volume has not been reached, then two events occur simultaneously:

- The ventilator ceases the changes in the support pressure and maintains the current level not to exceed the pressure alarm limits.
- Warning signals are triggered notifying this event. The alarm is for Target Volume not reached, and is of medium priority (see *Alarms* chapter).

9.7.3 | Enabled ventilatory parameters (preset values)



Fig. 9-17 Preset controls for ADL category.



Fig. 9-18 Preset controls for PED category.

9.7.4 | Enabled additional functions

The following list contains additional functions that can be selected optionally in MMV + PSV (for further details on their behavior, see the *Menu* chapter):

- Nebulization.
- O₂ suction %.
- Manual inspiration.
- Volume compensation.

- Leak compensation.
- Tube compensation.

9.8 | PSV + VT Assured

9.8.1 | Overview

This is a spontaneous operative mode where the patient breathes with support pressure, aiming at ensuring the delivery of a minimum tidal volume. The inspiration takes place similarly to what happens in PSV, generating support pressure with a decelerating flow up to the set expiratory detection value, where the inspiration end is produced. In the event that the inspiration-end condition occurs and the delivered tidal volume has not reached the minimum selected, the flow changes immediately to a constant flow in order to complete the target volume. When the minimum tidal volume is reached, the cycling is produced.

The constant flow is maintained until the target volume is reached, or until inspiratory times of 3.0 s for ADL and of 1.5 s for PED have elapsed. This is added as a safety mechanism to prevent excessive inspiratory times.

Table 9-1 summarizes the behavior of the ventilator, if it reaches the inspiration-end condition, whether the target tidal volume has been met or not.

Table 9-1 Managing the inspiratory phase in PSV with assured VT

Variable	Driven VT > Target VT	Driven VT < Target VT
Control	Pressure	Volume
Limit	Pressure	Flow
Cycling	Flow	Volume or Time



Fig. 9-19 PSV + VT Assured screen image.

9.8.2 | Enabled ventilatory parameters (preset values)



Fig. 9-20 Preset controls for ADL category.



Fig. 9-21 Preset controls for PED category.

The predetermined tidal volume values will depend on the configuration of *IBW-based VT* (see *Start-up and Initial calibration* chapter). The images of Fig. 9-20 and Fig. 9-21 show the initial values resulting from the preset *IBW-based VT* configuration.

9.8.3 | Enabled additional functions

The following list contains additional functions that can be selected optionally in PSV + VT Assured (for further details on their behavior, see the *Menu* chapter):

- Nebulization.
- O₂ suction %.
- Manual inspiration.
- Volume compensation.
- Leak compensation.

9.9 | APRV - Airway Pressure Release Ventilation

9.9.1 | Overview

This is a mode that uses two adjustable levels of continuous positive pressure (high and low PEEP) for extended regulated periods of time (upper Ti and lower Ti).

The two levels of positive pressure produce passive and intermittent distention and decompression of the lungs.

At all times, the patient can perform spontaneous breathing with or without support pressure (PSV). According to the regulation of the times for upper and lower pressure, ventilation may be administered with an inversion of the I:E ratio.

The *Backup Ventilation* configuration is optional for this mode.

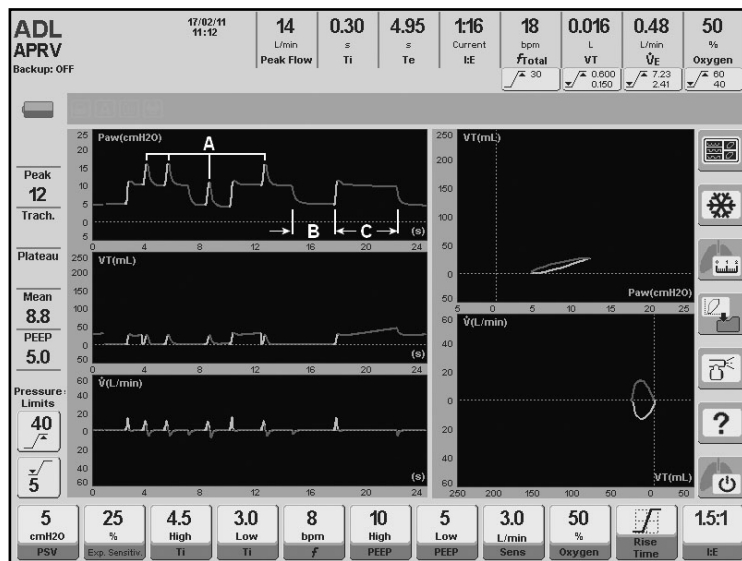


Fig. 9-22 Screen with standard curves in APRV mode. Spontaneous breathing was simulated during high and low PEEP (A) and a period of low PEEP (B) was left and one of high PEEP (C) without coupled breathing..

9.9.2 | Rise Time

Changes to the Rise Time only affect spontaneous breaths with support pressure. The transitions between high and low PEEP levels are not changed when the Rise Time is changed.

9.9.3 | Enabled ventilatory parameters (preset values)



Fig. 9-23 Preset controls for ADL and PED categories.

Four special parameters exist already for this mode setting. High and low PEEP, and high and low Ti. These 4 parameters are used to define the levels of continuous positive pressure, and the duration of each of these levels.

9.9.4 | Enabled additional functions

The following list contains additional functions that can be selected optionally in APRV (for further details on their behavior, see the *Menu* chapter):

- Nebulization.
- %O₂ suction.
- Manual inspiration.
- Volume compensation.
- Leak compensation.
- Tube compensation.

9.10 | NIV - Noninvasive Ventilation

9.10.1 | Overview

This is a pressure controlled mode that combines PCV and PSV characteristics. Spontaneous breathing with support pressure is allowed, with the same characteristics as those provided in PSV mode. In addition, the ventilator allows the configuration of a respiratory rate to ensure minimum ventilation, whose characteristics are identical to the breaths with support pressure, with the difference that they are not triggered by the patient, but by time.

The ventilator operates with leakage compensation. The magnitude of the leakage compensation depends on the patient category (see Table 17-7). This is one of the mechanisms which assure the stability of the regulated pressure, the stabilization of the trigger sensitivity avoiding auto triggering, and the control of respiratory synchronization.

The end of the inspiration has two criteria for implementation. The first addresses the expiratory detection configuration. If this criterion is not met, the inspiration may end during a predetermined maximum inspiratory time.

The expired tidal volume reading is an estimate that the patient receives by a calculation which takes into account the leakage.

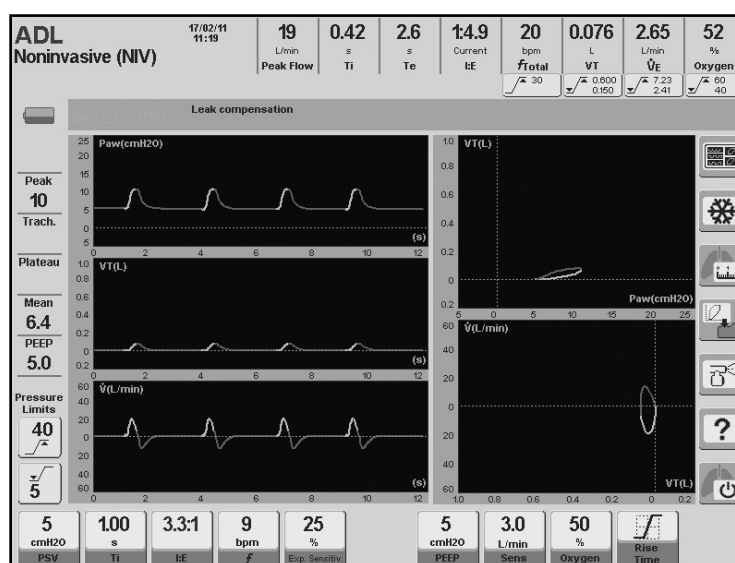


Fig. 9-24 Appearance of the graphics in Noninvasive Ventilation.

9.10.2 | Enabled ventilatory parameters (preset values)

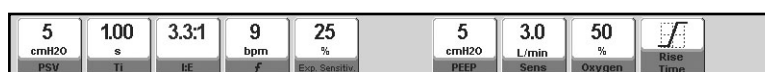


Fig. 9-25 Preset controls for ADL category.

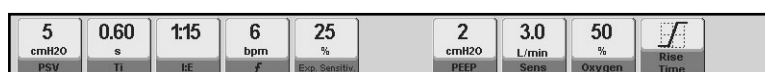


Fig. 9-26 Preset controls for PED category.

9.10.3 | Enabled additional functions

The following list contains additional functions that can be selected optionally in NIV (for further details on their behavior, see the *Menu* chapter):

- Nebulization.
- %O₂ suction.
- Manual inspiration.
- Volume compensation.
- Leak compensation.

9.11 | PRVC - Pressure-Regulated, Volume-Controlled Ventilation

9.11.1 | Overview

This is a controlled assisted mode, whose function is to achieve a target tidal volume by automatic regulation of pressure-controlled breaths.

At the beginning of this mode, the ventilator delivers a VCV breath to the patient with a set target volume, and an inspiratory pause of 0.5 s. For this first breath, a constant flow wave is used (rectangular). With this maneuver, the ventilator can calculate the system compliance, and based on that, it determines the pressure level needed to achieve the target tidal volume. The ventilator then begins to deliver pressure-controlled breaths with the calculated value. If tidal volume is not reached, the ventilator causes automatically progressive pressure changes to try to reach the target volume. These pressure increases or decreases do not exceed 3 cmH₂O per breath.

The mechanism for determining the necessary pressure (first breath with VCV and inspiratory pause) will occur whenever:

- PRVC mode is accessed.
- The target tidal volume is changed.
- A standby state is restored.
- The VT obtained by the patient exceeds by 100% the target VT for the same pressure.

The pressure self-adjusts in a permitted range from a minimum of 5 cmH₂O above the PEEP value, up to 5 cmH₂O below the Maximum inspiratory pressure alarm limit. If this maximum or minimum regulated pressure is reached, and the target tidal volume is not reached, the Target Volume not reached alarm signals will be activated.



WARNING

- *The maximum pressure limit must be regulated accurately, because it is responsible for determining the maximum level of automatic pressure regulation. It must not be set below: PEEP + 10 cmH₂O. The PEEP must not be set above: 10 cmH₂O below the alarm limit.*

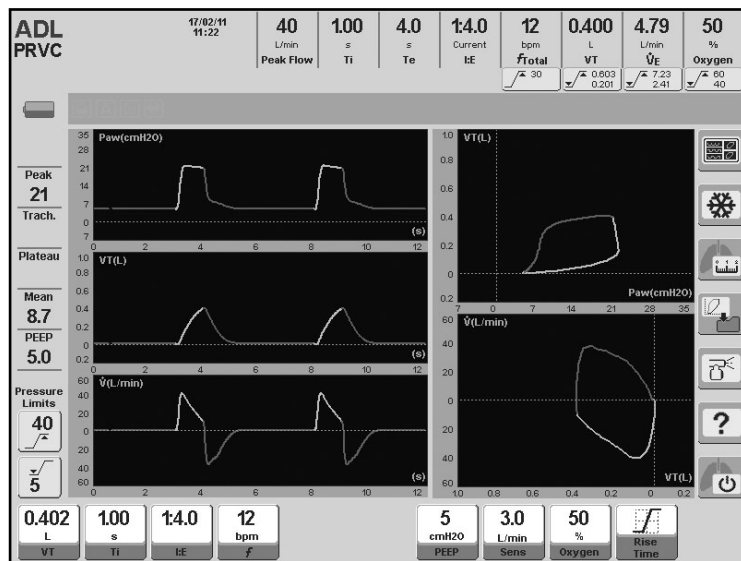


Fig. 9-27 Five-curve screen in PRVC mode, ADL patient category.

9.11.2 | Enabled ventilatory parameters (preset values)



Fig. 9-28 Preset controls for ADL category.



Fig. 9-29 Preset controls for PED category.

The predetermined tidal volume values will depend on the configuration of *IBW-based VT* (see *Start-up and Initial Calibration* chapter). The images of Fig. 9-28 and Fig. 9-29 show the initial values resulting from the preset *IBW-based VT* configuration.

9.11.3 | Enabled additional functions

The following list contains additional functions that can be selected optionally in PRVC (for further details on their behavior, see the *Menu* chapter):

- Nebulization.
- %O₂ suction.
- Manual inspiration.
- Manual inspiratory/expiratory pause.
- Volume compensation.
- Leak compensation.
- Tube compensation.

9.12 | Backup Ventilation

9.12.1 | Overview

The *Menu* chapter describes the characteristics of this type of ventilation and its configuration. It is not strictly an operative mode such as those described in this chapter. This is a safety tool that is used in conjunction with the spontaneous modes to provide ventilation in the event of apnea, or decreased ventilatory effort.

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NEO-INF Operative modes

CHAPTER CONTENTS

- 10.1 VCV - Volume Controlled Ventilation
- 10.2 PCV - Pressure Controlled Ventilation
- 10.3 PSV/CPAP - Pressure Supported Ventilation / CPAP
- 10.4 SIMV (VCV) + PSV
Synchronized Intermittent Mandatory Ventilation
- 10.5 SIMV (VCV) + PSV
Synchronized Intermittent Mandatory Ventilation
- 10.6 APRV - Airway Pressure Release Ventilation
- 10.7 TCPL - Time-Cycled Pressure-Limited Ventilation
- 10.8 SIMV (VCV) + PSV
Synchronized Intermittent Mandatory Ventilation
- 10.9 Continuous flow CPAP
- 10.10 PRVC - Pressure-Regulated Volume-Controlled Ventilation
- 10.11 Backup Ventilation

CHAPTER SUMMARY

This chapter describes the operative modes available for neonatal-infant patients. In NEO-INF there are modes that are not available for ADL/PED patients and it also lacks others that are available to ADL/PED patients. On the other hand, modes that are common to all categories have some differences in NEO-INF. These are all reasons to provide the information included in this chapter.

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10.1 | VCV - Volume Controlled Ventilation

This operative mode operates similarly to its ADL counterpart. The differences between them have to do with the ability to program ventilation parameters in different ranges. The functional description found in the *ADL/PED Operative Modes* chapter for the VCV mode applies for this mode in NEO-INF.

The most important points that must be kept in mind in this mode are:

- This mode is intended to deliver a regulated tidal volume. The ventilator works as a flow controller, where the flow wave is maintained in spite of respiratory impedance variations. The configured volume is obtained by integrating this flow.
- Cycling is based on time, and the flow is calculated and regulated based on the selected VT and Ti.
- The airway pressure varies and depends on the mechanical characteristics of the respiratory system.
- If there is a spontaneous requirement from the patient (Inspiratory sensitivity), the ventilator helps the patient by synchronizing the start of the inspiratory phase with the respiratory effort.



NOTE

- The ADL/PED Operative Modes chapter has a more detailed description of the VCV mode and its typical parameters



Fig. 10-1 Standard screen in VCV mode in NEO-INF category

10.1.1 | Enabled ventilation parameters (preset values)



Fig. 10-2 Picture of the VCV enabled controls, NEO-INF category. Shown with the preset values for each.

The preset values of the tidal volume will depend on the configuration of the *IBW-based VT* (see the *Start-up and Initial Calibration* chapter). Fig. 10-2 shows the initial value that result from an *IBW-based VT* default configuration.

10.1.2 | Enabled complementary functions

The following list has complementary functions that can be selected as an option in VCV (for further details regarding their behavior, see the *Menu* chapter):

- %O₂ Suction.
- Manual inspiration.
- Manual inspiratory/expiratory pause.
- Programmed inspiratory pause.
- Volume compensation.
- Leak compensation.
- Distal/proximal pneumotachograph.

10.2 | PCV - Pressure Controlled Ventilation

The NEO-INF pressure controlled ventilation works under the same principle as the pressure controlled ventilation in ADL or PED category patients. The *ADL/PED Operative Modes* chapter describes the functional basis for this mode.

The most important points in this mode are:

- This mode is intended to ventilate with a constant pressure that can be configured by the user. The ventilator works as a pressure controller, and the pressure wave stays unchanged by respiratory system impedance changes. It is the flow that adapts to these changes to ensure that the target pressure is maintained.
- It is time cycled.
- The tidal volume delivered for each breath is variable and depends on the respiratory system impedance and available inspiration time.
- If there is a spontaneous requirement from the patient (inspiratory sensitivity), the ventilator helps the patient by synchronizing the start of the inspiratory phase with the patient's effort.
- The configured pressure is added to the established PEEP level. Therefore, the resulting pressure is obtained by adding the PCV and PEEP values.

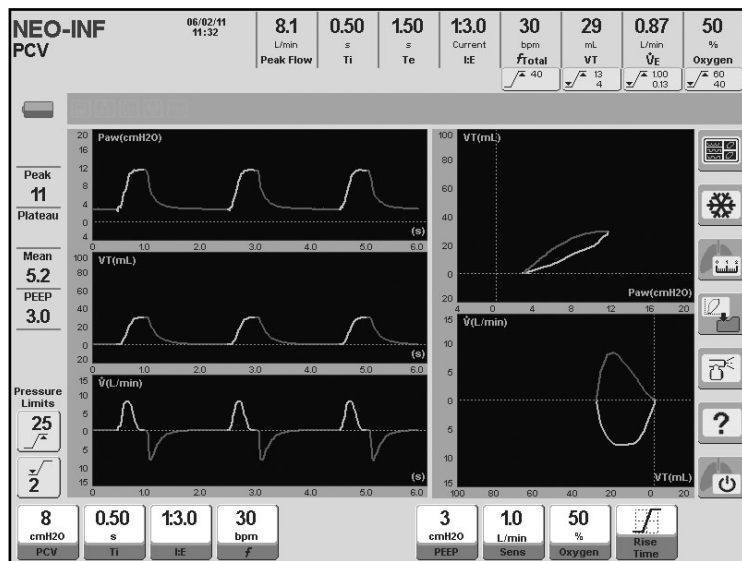


Fig. 10-3 PCV mode in NEO-INF

10.2.1 | Enabled ventilation parameters (preset values)



Fig. 10-4 Picture of the PCV enabled controls, NEO-INF category. Shown with the preset values for each.

10.2.2 | Enabled complementary functions

The following list has complementary functions that can be selected as an option in PCV (for further details regarding their behavior, see the *Menu* chapter):

- %O₂ Suction.
- Manual inspiration.
- Manual inspiratory/expiratory pause.
- Volume compensation.
- Leak compensation.
- Distal/proximal pneumotachograph.

10.3 | PSV/CPAP - Pressure Supported Ventilation / CPAP

This is a spontaneous mode where the patient can start and terminate the inspiratory phase. The operation and configuration characteristics of this mode are identical to those described in the *ADL/PED Operative Modes* chapter. See that chapter for specific details regarding the PSV/CPAP mode. That chapter breaks them down into two independent operative modes. Both descriptions apply to this mode in NEO-INF.



Fig. 10-5 iTernIS ADV screenshot ventilating in NEO-INF category and PSV/CPAP mode.

10.3.1 | Enabled ventilation parameters (preset values)



Fig. 10-6 Picture of the PSV/CPAP enabled controls, NEO-INF category. Shown with the preset values for each.

10.3.2 | Enabled complementary functions

The following list has complementary functions that can be selected as an option in PSV (for further details regarding their behavior, see the *Menu* chapter):

- %O₂ suction.
- Manual inspiration.
- Volume compensation.
- Leak compensation.
- Distal/proximal pneumotachograph.

10.4 | SIMV (VCV) + PSV Synchronized Intermittent Mandatory Ventilation

It operates under the same operative principles as SIMV (VCV) + PSV in ADL or PED category. A mandatory ventilation is configured, controlled by the ventilator, while spontaneous breaths are allowed. The two types of breaths are synchronized to eliminate inspiration efforts during mandatory breaths.

The important characteristics of this mode are:

- VCV mandatory breaths. The VT, respiratory rate and inspiratory time are configured. Mandatory respiration rate and expiratory time can vary slightly due to the synchronization process. (See the description of the equivalent mode in the *ADL/ PED Operative Modes* chapter).
- Spontaneous breaths are carried out following the support pressure breathing

principles. It is, therefore, necessary to configure the PSV parameters to ensure that support is present in spontaneous breaths.

- *Backup Ventilation* is disabled by default. In this case it must, at least, be ensured that the patient will receive ventilation that is equal to the configuration of the mandatory VCV. It can be enabled by configuring the Backup Ventilation line in the MENU window.

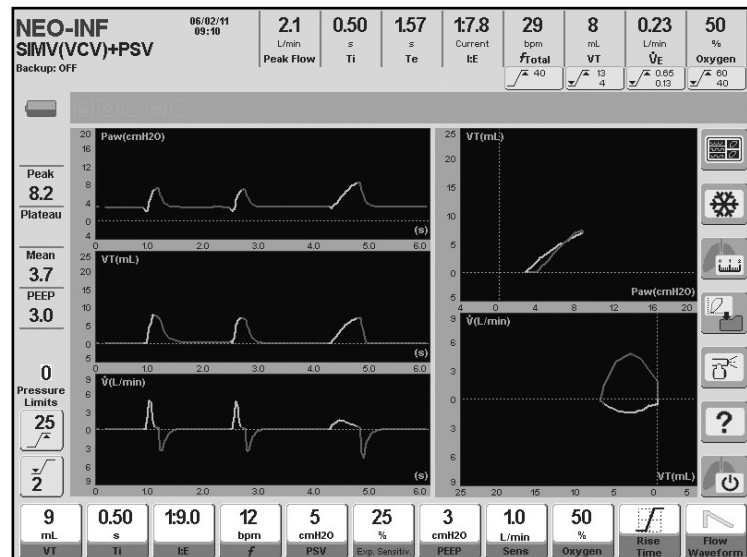


Fig. 10-7 SIMV (VCV) + PSV mode screen in NEO-INF patient category. The difference between VCV and support pressure breaths is noticeable.

10.4.1 | Enabled ventilation parameters (preset values)



Fig. 10-8 Picture of the SIMV (VCV) + PSV enabled controls, NEO-INF category. Shown with the preset values for each.

The preset values of the tidal volume will depend on the configuration of the *IBW-based VT* (see the *Start-up and Initial Calibration* chapter). Fig. 10-8 shows the initial value that result from a *IBW-based VT* default configuration.

10.4.2 | Enabled complementary functions

The following list has complementary functions that can be selected as an option in SIMV (VCV) + PSV (for further details regarding their behavior, see the *Menu* chapter):

- %O₂ suction.
- Manual inspiration.
- Manual inspiratory/expiratory pause.
- Programmed inspiratory pause.
- Volume compensation.
- Leak compensation.
- Distal/proximal pneumotachograph.

10.5 | SIMV (PCV) + PSV
Synchronized
Intermittent
Mandatory Ventilation

This synchronized intermittent mode delivers controlled pressure ventilation (PCV) breaths to abide by the mandatory ventilation. The spontaneous respirations are carried out with support pressure like the rest of the synchronized intermittent modes.

The *ADL/PED Operative Modes* chapter has a more detailed description of this same mode that also applies to this patient category. The specific characteristics of this mode are:

- PCV mandatory breaths. PCV positive pressure level, respiratory rate and inspiratory time are enabled for configuration. The mandatory respiratory rate can be affected if breaths are synchronized (see 10.4 SIMV (VCV) + PSV where this behavior is explained).
- Spontaneous breaths are carried out following the support pressure breathing principles. It is, therefore, necessary to configure the PSV parameters to ensure that support is present in the breath triggered by the patient.
- Backup Ventilation is disabled by default. In this case it must be ensured that the patient will receive ventilation that is at least equal to the configuration of the mandatory PCV breaths. It can be enabled by configuring the Backup Ventilation line in MENU.

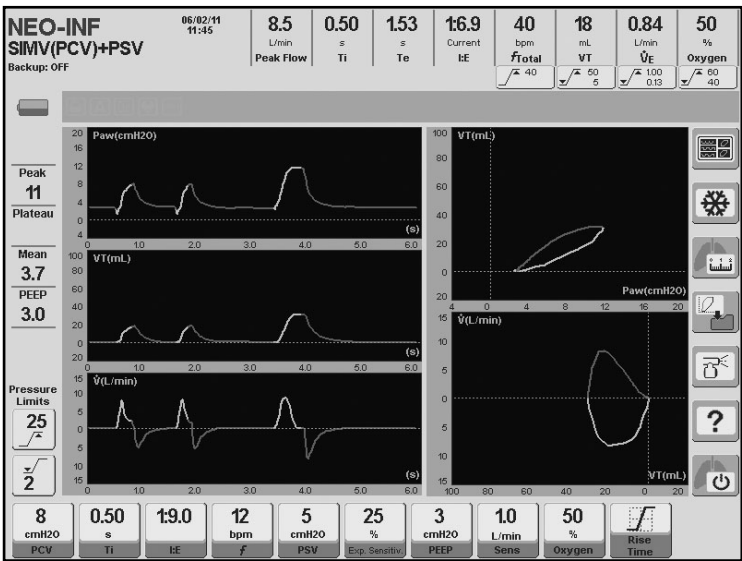


Fig. 10-9 Typical SIMV (PCV) + PSV mode curves in NEO-INF.

10.5.1 | Enabled ventilation
parameters (preset values)



Fig. 10-10 Picture of the SIMV (PCV) + PSV enabled controls, NEO-INF category. Shown with the preset values for each.

10.5.2 | Enabled complementary
functions

The following list has complementary functions that can be selected as an option in SIMV (PCV) + PSV (for further details regarding their behavior, see the *Menu* chapter):

- %O₂ suction.

- Manual inspiration.
- Manual inspiratory/expiratory pause.
- Volume compensation.
- Leak compensation.
- Distal/proximal pneumotachograph.

10.6 | APRV - Airway Pressure Release Ventilation

This mode applies two adjustable continuous positive pressure levels (high and low PEEP) during regulated periods of time (high Ti and low Ti).

The two positive pressure levels cause passive and intermittent distention and decompression in the lungs.

At any time the patient can carry out spontaneous breaths with or without support pressure (PSV). Based on high and low pressure time regulation, inverted I:E ratio ventilation can be administered.

Configuring *Backup Ventilation* is optional in this mode.



Fig. 10-11 APRV screenshot in NEO-INF. The picture shows that two spontaneous breaths have been carried out during the first high PEEP period, and another spontaneous respiration has been charted for the following low PEEP period.

10.6.1 | Enabled ventilatory parameters (preset values)



Fig. 10-12 Picture of the APRV enabled controls, NEO-INF category. Shown with the preset values for each.

10.6.2 | Enabled complementary functions

The following list has complementary functions that can be selected as an option in APRV (for further details regarding their behavior, see the *Menu* chapter):

- %O₂ suction.

- Manual inspiration.
- Distal/proximal pneumotachograph.

10.7 | TCPL - Time-Cycled Pressure - Limited Ventilation

This mode exists only in the NEO-INF category. This mode is time-cycled, and inspiratory pressure can be regulated. It can operate with an adjustable continuous flow.

During the entire respiratory cycle, the equipment drives a programmable flow through the patient circuit. During the inspiratory phase, the ventilator limits the inspiratory pressure with the expiratory valve.

In this mode, the programmed pressure determines the maximum limit it can reach. Therefore, the PEEP addition does not change the maximum pressure peak obtained. This way, the TCPL mode in the *iTernIS ADV* ventilator adheres completely to the classic programming style that this mode has followed for a long time.

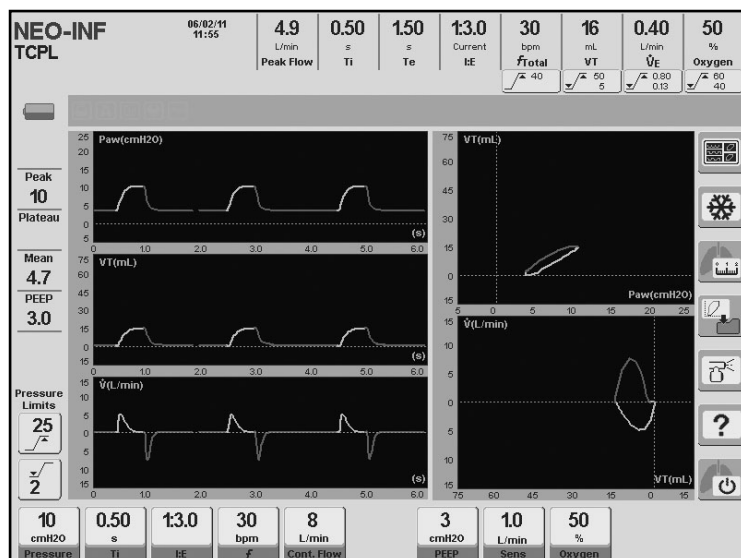


Fig. 10-13 TCPL screenshot.

10.7.1 | Enabled ventilatory parameters (preset values)



Fig. 10-14 Picture of the TCPL enabled controls, NEO-INF category. Shown with the preset values for each.

10.7.2 | Enabled complementary functions

The following list has complementary functions that can be selected as an option in TCPL (for further details regarding their behavior, see the *Menu* chapter):

- %O₂ suction.
- Manual inspiration.
- Nebulization.
- Volume compensation.

- Leak compensation.
- Distal/proximal pneumotachograph.



NOTE

- In this mode, the inhaled VT is a calculation based on the continuous flow being delivered and the patient's expiration, and it may, therefore, differ slightly from the results obtained through other means.

10.8 | SIMV (TCPL) + PSV Synchronized Intermittent Mandatory Ventilation

The SIMV (TCPL) + PSV mode is enabled only for the NEO-INF patient category. In this mode, the mandatory breaths delivered by the ventilator are time-cycled and the inspiratory pressure is limited; that is, its characteristics are identical to those of TCPL breaths. During the expiratory time, the patient can carry out regulated baseline continuous flow pressure supported spontaneous breaths.

The synchronization of the spontaneous and mandatory breaths is carried out with the same criterion as with the other SIMV modes. The patient's inspiratory effort can trigger spontaneous breaths and can also initiate breaths with mandatory characteristics (TCPL in this mode) if the patient's requirement is registered as being close to the moment a mandatory breath is about to start (as determined by the regulated frequency). This prevents patient-ventilator asynchrony, resulting in a more comfortable and efficient ventilation therapy.

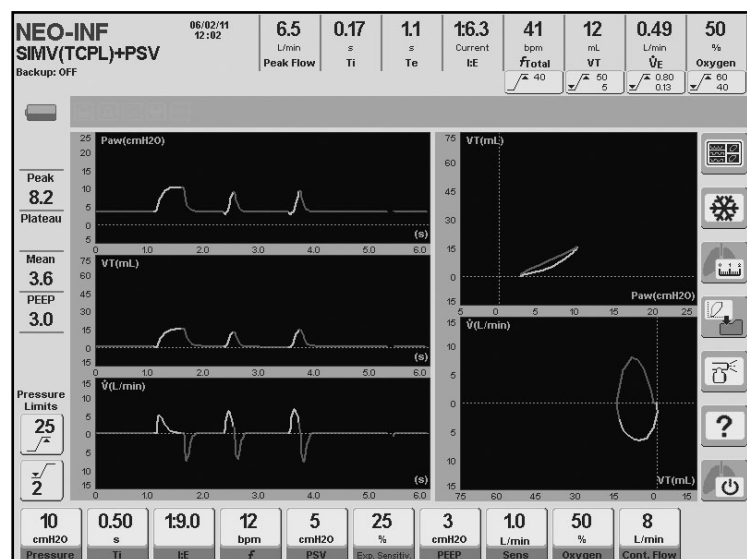


Fig. 10-15 SIMV (TCPL) + PSV mode screenshot. The curves show the difference between PSV and TCPL breaths.

10.8.1 | Enabled ventilation parameters (preset values)



Fig. 10-16 Picture of the SIMV (TCPL) + PSV enabled controls, NEO-INF category. Shown with the preset values for each.

10.8.2 | Enabled complementary functions

The following list has complementary functions that can be selected as an option in SIMV (TCPL) + PSV (for further details regarding their behavior, see the *Menu* chapter):

- %O₂ suction.

- Manual inspiration.
- Nebulization.
- Volume compensation.
- Leak compensation.
- Distal/proximal pneumotachograph.

10.9 | Continuous Flow CPAP

This mode has spontaneous ventilation and positive continuous airway pressure for noninvasive application to neonatal-infant patients (using a nasal prong).

There is continuous (adjustable) flow during CPAP breaths. This mode does not have ventilation support cycles. With each inspiratory effort, the patient receives part of the gas mixture circulating as continuous flow, in a magnitude that is proportional to the intensity required. The ventilator monitors the presence of these respiratory efforts and, if it does not detect them, it assumes an apnea condition to be present and enables Backup Ventilation, triggering the appropriate alarm signals.

In this mode, leakage compensation is enabled by default.

It must be understood that the selection of high continuous flows can raise the pressure baseline due to the more or less constant resistance presented by the entire respiratory system. Due to this resistance, a flow increase results in an increase in the difference in ingoing/outgoing pressure. Therefore, the ability of the professional in charge to determine the PEEP and continuous flow levels is very important.



WARNING

- ***In Continuous Flow CPAP ventilation, a competent professional must always be present to control the patient and the ventilator. Because of the high resistance of the nasal prongs for NEO-INF patients and the large leaks that usually occur in this ventilation mode, nasal prong disconnection warning conditions may not be detected.***



NOTE

- The tidal volume and minute volume alarms are disabled in this mode.

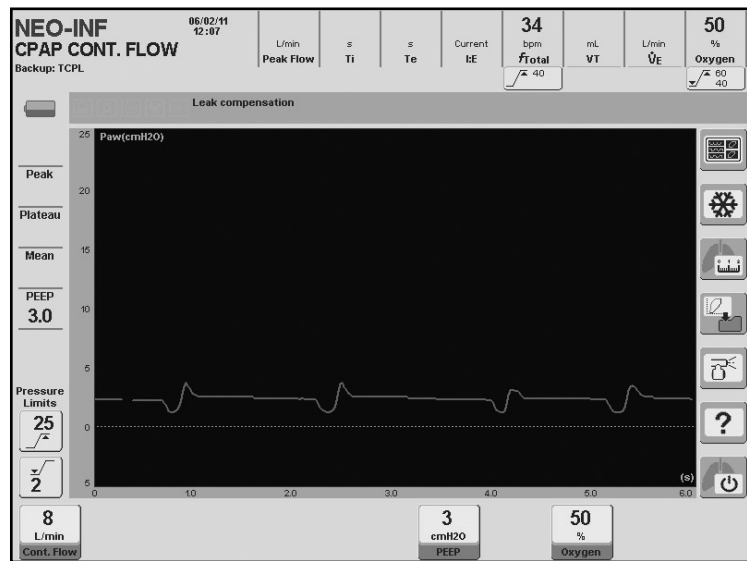


Fig. 10-17 Curva de presión predeterminada en CPAP flujo continuo.

10.9.1 | Enabled ventilation parameters (preset values)



Fig. 10-18 Picture of the Continuous Flow CPAP enabled controls, NEO-INF category. Shown with the preset values for each.

10.9.2 | Enabled complementary functions

The following list has complementary functions that can be selected as an option in Continuous Flow CPAP (for further details regarding their behavior, see the *Menu* chapter):

- %O₂ suction.
- Volume compensation.
- Leak compensation.
- Distal/proximal pneumotachograph.

10.10 | PRVC - Pressure-Regulated Volume-Controlled Ventilation

10.10.1 | Overview

It is a controlled assisted mode whose purpose is to reach a target tidal volume by automatically regulating pressure controlled breaths.

At the beginning of this mode, the ventilator provides the patient with a programmed target volume VCV breath and a 0.5 s inspiratory pause. A constant (rectangular) flow wave is used for this first breath. This way, the ventilator can calculate the system compliance and, from there, establish the pressure level needed to reach the target tidal volume. Then, the ventilator starts delivering pressure controlled breaths with the calculated value. If the tidal volume is not reached, the machine automatically starts progressive pressure variations to try to reach the target volume. These pressure rises or falls do not exceed 3 cmH₂O per breath.

The mechanism that determines the necessary pressure (first breath with VCV and inspiratory pause) will come into play whenever:

- The PRVC mode is accessed.
- The target tidal volume is changed.
- A standby state is restored.
- The VT received by the patient exceeds the target VT by 100% for the same pressure.

The pressure self-adjusts within a permissible range from a minimum of 5 cmH₂O above the PEEP value to a maximum of 5 cmH₂O under the Maximum inspiratory pressure alarm. If this regulated pressure maximum or minimum is reached and the target tidal volume has not been reached, the Target volume not reached alarm signals will be activated.



Fig. 10-19 PRVC mode five curve screen.

WARNING

• A correct decision must be made at the time of regulating the maximum pressure alarm limit because it determines the maximum automatic pressure regulation level. It cannot be configured below: PEEP + 10 cmH₂O. The PEEP cannot be configured above: 10 cmH₂O below the alarm limit.

10.10.2 | Enabled ventilation parameters (preset values)



Fig. 10-20 PRVC enabled controls. Shown with the preset values for each.

The preset values of the tidal volume will depend on the configuration of the *IBW*-based VT (see the *Start-up and Initial Calibration* chapter). Fig. 10-20 shows the initial value that result from a *IBW*-based VT default configuration.

10.10.3 | Enabled complementary functions

The following list has complementary functions that can be selected as an option in PRVC (for further details regarding their behavior, see the *Menu* chapter):

- %O₂ suction.

- Manual inspiration.
- Manual inspiratory/expiratory pause.
- Volume compensation.
- Leak compensation.
- Distal/proximal pneumotachograph.

10.11 | Backup Ventilation

The *Menu* chapter describes the characteristics of this type of ventilation and its configuration. Strictly speaking, it is not an operative mode like those described in this chapter. It is a safety tool used along with the spontaneous modes to ensure ventilation in case of apnea or a ventilation effort decrease.

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Alarms

CHAPTER CONTENTS

- 11.1 General characteristics
- 11.2 Alarm events record
- 11.3 Alarm signals
- 11.4 Audio paused 30/60 s
- 11.5 Alarm configuration
- 11.6 Inop. Vent. Alarm (Inoperative ventilator)
- 11.7 High priority alarms
- 11.8 Medium priority alarms
- 11.9 Low priority alarms

CHAPTER SUMMARY

The *Alarms* chapter has the information needed to know and manage the *iTernIS ADV* alarm system. This includes information about the structure of the alarm system, how to manage its configuration, the notification and message system, and the specific characteristics of each alarm condition.

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11.1 | General Characteristics

All the alarms that are part of the *iTernIS ADV* alarm system have visual light and audible signals with a screen message that indicates the name of the activated alarm condition.

The alarm system is organized following an alarm condition priority ranking. There are three alarm priority groups: HIGH PRIORITY, MEDIUM PRIORITY, and LOW PRIORITY. The way to recognize the priority of an alarm is by the signals the ventilator uses to indicate the presence of that alarm condition (priority codes based on signals are described in 11.3 Alarm signals). In turn, alarm conditions are organized so as to follow internal priorities within each priority. That is, there are alarms that are more serious than others within each PRIORITY. This is useful for screen message purposes. As indicated in 11.3 Alarm signals, if two or more alarm conditions are activated, the screen will only display the message with the name of the higher priority condition.

Some alarms have limits that can be set by the user. For example, maximum pressure, volume and minute volume values. Other alarms cannot be configured and have been preset by the manufacturer. Examples of this type of alarms are low battery charge, lack of supply for one or both gases, loss of patient circuit integrity (disconnection).

When the alarm signals for a given condition are active, it is possible to access a help message for that alarm by pressing the **[Ctrl] >> [Alarm Limits]** key. The message lists the possible causes and, in some cases, includes a recommendation for corrective action.

11.2 | Alarm Events Record

All alarm events occurring while the ventilator is in operation are stored in the machine memory and are available even after the machine has been turned off. This lets the user know at all times (with date and time):

- Triggered Alarms (YES)
- Reset Alarms (NO)
- Deactivated Alarms (Disable)
- Activated Alarms (Enable)
- Other events (Start-up, Ventilation start, Standby).

This information can be copied into a PC using the Visual Net® software.

The *ACTIVATED ALARMS* window where those events are recorded can be accessed with the following string: **[Menu]>>Records>>Activated alarms**. The events are displayed on a window that shows one of several pages of records. The lower part of the screen has the buttons used to scroll through the pages. Pressing the buttons on the ends accesses the first or last page. The buttons located in the middle allow scrolling the pages one by one. The rotary knob can also change the page being displayed (after pressing the **[Ctrl]** key, it is possible to access the first or last page, depending on the direction in which the knob is being turned).

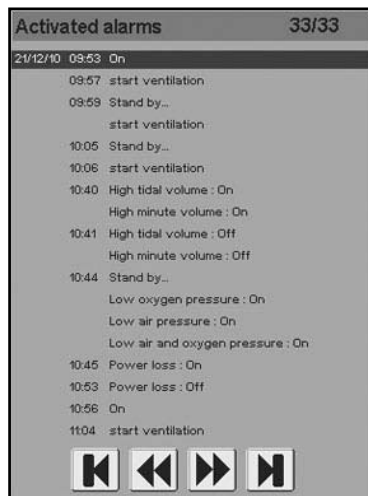


Fig. 11-1 ACTIVATED ALARMS window where the alarm record is saved. Each alarm has the time of the occurrence, and the date, if it is the first alarm triggered that day. The current record page out of the total available pages appears on the lower right corner. In this case, it is on page 33 of 33 available pages.

11.3 | Alarm Signals

iTermIS ADV has three different types of alarm signals to indicate the presence of an alarm condition, regardless of priority.

- Visual light signals.
- Auditory signals.
- Screen warnings (visual signal).

11.3.1 | Types of signals

11.3.1.1 | Visual light signals

Table 11-1 Colors and flashing frequency based on priority.

Priority	Color	Flashing frequency
High	Red	Fast
Medium	Yellow	Slow
Low	Yellow	Steady (no flashing)

Table 11-2 Light indicators

Indicator	Location	Color	Meaning
Alarm Signals - upper LED	Front panel	Red	It lights up to indicate an Inoperative Ventilator condition.
Alarm Signals - middle LED	Front panel	Red	It lights up to indicate high priority alarm conditions.
Alarm Signals - lower LED	Front panel	Yellow	It lights up to indicate medium/low priority alarm conditions.
Upper light indicator	Upper side of the console	Red/Yellow	It lights up at the same time as the Alarm Signals sector indicators. The color depends on the priority of the condition of the alarm that has been triggered.

The light indicators indicate alarm condition priority. They do not indicate which of the conditions has been triggered. If different priority alarm conditions are activated, the LED will light up, indicating each of them. Since the second LED is used for medium and low priority signals, the current light signal will indicate medium priority if both priority signals occur at the same time. The upper light indicator operates in the same way.

11.3.1.2 | Auditory signal

The auditory signals can be identified by the number of sound impulses of each burst of impulses. A burst of impulses is a set of sounds that occur periodically and that can be temporarily and easily identified.

Table 11-3 Auditory signal

Priority	Burst impulses
High	10 (2 x 5)
Medium	3
Low	1

Auditory signals cannot co-exist. Therefore, if several alarms have been triggered, only the sound that belongs to the higher priority alarm condition is present.

11.3.1.3 | Screen warning (visual signal)

The screen displays text indicating the name of the alarm condition on a colored background. This color is the same as the one used for light visual signals. That is, red for high priority and yellow for medium and low priority. This is the name with which the alarm condition is recorded in the ACTIVATED ALARMS window.

Unlike the visual light signal, these signals make it possible to recognize each specific alarm condition.

The Inop. Vent. Alarm is the only one that does not have this kind of signal because when it is triggered, the ventilator becomes inoperative and the screen stops working.

11.3.2 | Maintained alarm signals

Once the alarm condition has disappeared, the alarm signals behave differently. When an alarm condition has stopped and the alarm signals persist, they are called maintained signals. On the other hand, if the signal ends at the same time as the condition, it is a non-maintained signal.

If there are one or more maintained signals, the same procedure is always followed to deactivate that signal or those signals. Press the **[Esc]** key.

11.3.2.1 | Visual light signal

In *iTernIS ADV* light alarm signals have maintained signal characteristics. The signals are maintained with the characteristics indicated on Table 11-4.

Table 11-4 Maintained visual signal - Alarm Signals.

Priority	Color	Characteristic of the maintained signal
High	Red	The LED stays on, without flashing
Medium	Yellow	The LED stays on, without flashing
Low	Yellow	The LED stays on, without flashing

The upper light indicator does not behave like a maintained alarm signal. Therefore, when the cause of the alarm condition disappears, the indicator turns off.

11.3.2.2 | Auditory signal

The signals stop when the alarm condition that originated them stops, but they adhere to what appears on Table 11-5.

Table 11-5 Auditory signal (non-maintained).

Priority	Signal behavior at the end of the alarm condition that originated it.
High	The auditory signal completes half of a whole burst (5 sound impulses).
Medium	The auditory signal completes a whole burst (3 sound impulses).
Low	The auditory signal cuts off as soon as the event that generates the alarm condition stops.

11.3.2.3 | Screen warning (visual signal)

The alarm signal screen warnings disappear immediately.

11.4 | Audio Paused 30/60 s

The auditory signal in progress can be paused for 30 s or 60 s. Pressing the audio paused key (bell with the broken line across it) only once, the auditory signal cuts off for 30 s, and the pause lasts for 60 s if the key is pressed twice in a row. The auditory pause temporarily keeps the auditory signal from being generated.

All auditory signals can be paused except for the signal generated during Emergency Ventilation and the Inop. Vent. signal.

At the beginning of an alarm signal audio paused period, an icon appears on the screen with the same symbol characteristics found on the audio paused key.

11.5 | Alarm Configuration

11.5.1 | Alarm limit adjustment

Alarm limits are adjusted with an alarm regulation direct access key. This key can be found under Alarm Limits on the right of the front panel. Pressing this key displays the menu shown in Fig. 11-2.

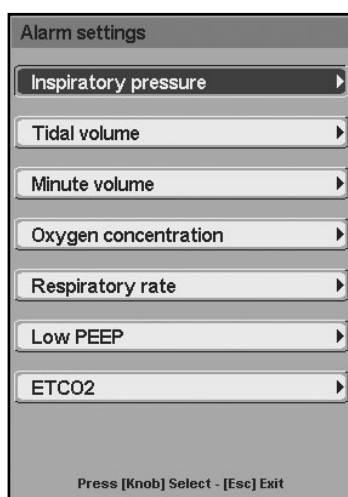


Fig. 11-2 The ALARMS SETTINGS menu is displayed when the [Alarm Limits] key is pressed.

The ALARMS SETTINGS menu is used like the other ventilator menus, with a touch screen or the rotary knob. Alarm limit changes are made by first accessing the desired alarm and then selecting the limit to be configured.

There are alarms that are not enabled for certain operative modes. In those cases, access to those alarm configurations is not allowed.

It is possible to access the configuration of some alarms through touch screen direct accesses. See Fig. 11-3. When the direct access buttons on the upper part of the screen are pressed, the configuration window that goes with that alarm is displayed. The limits of these alarms correspond to the monitored variable above the button. When the pressure alarm direct access buttons (on the left of the screen) are pressed, the value above the button is also changed.



Fig. 11-3 Picture where the touch buttons used to access some alarm configurations directly have been highlighted.

11.5.2 | Alarm signal deactivation

The *iTermIS ADV* alarm system can deactivate some alarms. A deactivated alarm generates no alarm signals and cannot configure its limits. When an alarm is deactivated, a record of the **ACTIVATED ALARMS** screen is kept (see 11.2 Alarm event record).

11.5.2.1 | VT and VM alarms

In ADL patient category, it is possible to deactivate the following alarms in NIV (Non-Invasive Ventilation) mode:

- Tidal Volume
- Minute Volume

When one of these two alarms is deactivated, the other one is automatically deactivated, and the direct access buttons for these alarms show the Deactivated alarm symbol instead of the alarm limits. Fig. 11-4 shows the configuration window of the TIDAL VOLUME alarm. The third configuration line is for the Activation / Deactivation of this alarm. To deactivate, select the NO option on this line. The YES option (default option) must be selected to activate the alarm.

Tidal volume

Hi	0.600 L
Lo	0.150 L

Alarm: Yes

Press [Knob] Select - [Esc] Exit

Fig. 11-4 VT alarm configuration window.

11.5.2.2 | Apnea Alarm

In ADL and PED patient categories, it is possible to deactivate the Apnea alarm in SIMV and APRV modes. The Apnea alarm is deactivated together with *Backup Ventilation*.

In NEO patient category, in addition to being able to deactivate the Apnea alarm in SIMV and APRV, it is also possible to deactivate it in Continuous Flow CPAP operative mode.

The string that must be executed to deactivate the *Backup Ventilation* and the Apnea alarm in continuous flow CPAP mode is: **[Menu]>>Backup Ventilation>>Backup CPAP>>NO**. *Backup Ventilation* and the Apnea alarm are deactivated by default for this mode. If the backup has been deactivated and it must be reactivated, execute the same string as before and select the YES option.

To activate *Backup Ventilation* and the Apnea alarm in SIMV and APRV, execute the string **[Menu]>>Backup Ventilation>>Backup SIMV/APRV>>YES**. *Backup Ventilation* and the Apnea alarm are deactivated by default for these modes.

11.6 | Inop. Vent. Alarm (Inoperative Ventilator)

This alarm is described apart from the other alarm conditions because it has specific characteristics.

It is the highest priority condition because the triggering of the signals of this alarm means that the ventilator has become inoperative. The ventilator is not capable of providing ventilation for a patient, and it must be replaced with an alternative ventilating mechanism.

It happens when the microprocessor detects that the installed software is not operating appropriately and loses control over it. The ventilator turns off and the alarm signals are triggered.

11.6.1 | Inop. Vent. alarm signals

The alarm signals for this condition are different from those in the other alarm conditions. This is because the Inoperative ventilator condition takes place when the software of the machine has stopped working. For that reason, the control for this alarm is independent from the software and has to be controlled by other means.

Table 11-6 Inop. Vent. alarm signals.

Signal	Characteristics
Visual	A triangular LED indicator permanently lights up in the Alarm Signals sector. The same thing happens to the upper light indicator.
Auditory	A continuous sound (different from alarm system sounds) is triggered.
Screen warning	There is no screen warning (the screen is off).

11.7 | High Priority Alarms

This type of alarm requires immediate action on the part of the operator. The alarms activated with high priority signals are listed on Table 11-7. They are listed from high to low priority within the group of high priority alarms.

Table 11-7 High priority alarms

ALARM	Definition	Enabled	Ventilator action
Continuous high pressure (Cannot be adjusted by user)	Maintaining 5 cmH ₂ O above the PEEP level for more than 15 s.	In all modes.	Signal activation 15 s after PEEP has been exceeded.
High pressure	Maximum permissible airway pressure limit	In all modes.	Instant signal activation when the limit is exceeded. Opening of the exhalation valve to decompress the circuit to the PEEP level.
Low pressure	Minimum permissible airway pressure limit	In all modes.	Instant signal activation when the patient circuit pressure is below the adjusted limit.
Low air and oxygen pressure (Cannot be adjusted by user)	Both supply gas pressures are simultaneously low (O ₂ and air).	In all modes.	Immediate signal activation when both supply gas pressures fall below 200 kPa (2 bar).
Low oxygen (or air) pressure (Cannot be adjusted by user)	Low pressure in one of the O ₂ (or air) supply gases.	In all modes.	Immediate signal activation when the supply pressure of one of the gases drops below 200 kPa (2 bar). The gas that has appropriate pressure replaces the one that lacks it.
Low battery (Cannot be adjusted by user)	Very low internal battery charge. Very short charge time left.	In all modes.	Immediate signal activation when the event occurs. If it occurs when the machine is started, the machine becomes inoperative.
Disconnection (Cannot be adjusted by user)	Important loss in patient circuit integrity.	In all modes.	Signal activation 5 s after the loss of integrity is detected.
Oxygen concentration below 18% (Cannot be adjusted by user)	Mixture of gases provided by the ventilator with an O ₂ concentration below 18%.	In all modes.	Instant signal activation after the O ₂ cell detects a concentration of below 18%.
Maximum and minimum ETCO₂	Maximum and minimum partial exhaled CO ₂ pressure limit.	In all modes, if the capnograph is connected.	Immediate alarm signal activation.
Emergency ventilation	It warns of an Emergency Ventilation condition (see Technical specifications).	Always.	This alarm goes with the Emergency Ventilation condition activated as a safety mechanism when there is software failure or when no options are selected for 30 s on the previous initial calibration screens.

11.8 | Medium Priority Alarms

These are alarms that require the operator to respond quickly. The alarms activated with medium priority signals are listed on Table 11-8. They are listed from high to low priority within the group of medium priority alarms

Table 11-8 Medium priority alarms

ALARM	Definition	Enabled	Ventilator action
Maximum minute volume	Exhaled minute volume higher than configured limit.	In all modes.	Alarm signals are activated 10 s after the alarm condition is manifested and sustained.
Minimum minute volume	Exhaled minute volume lower than configured limit.	In all modes.	Alarm signals are activated 10 s after the alarm condition is manifested and sustained.
Maximum tidal volume	Maximum exhaled tidal volume limit.	In all modes, except in Continuous flow CPAP.	It activates the signals after 10 s when the tidal volume of successive breaths stays above the regulated limit.
Minimum tidal volume	Minimum exhaled tidal volume limit.	In all modes, except in Continuous flow CPAP.	It activates the signals after 20 s when the tidal volume of successive respirations stays below the regulated limit.
Power Loss (Cannot be adjusted by user)	It is activated when the machine switch is in the ON position and one of the following events occurs: - There is no main line power - The cord that connects the machine to the main line is unplugged - Burnt out intake fuse	In all modes.	Instant alarm signal activation. Simultaneously switches to internal battery supply.
High/low O₂ concentration	Maximum or minimum O ₂ limit concentration in the mixture of gases delivered by the ventilator.	In all modes.	Alarm signal activation when the O ₂ concentration stays outside the limits for more than 30 s.
Apnea condition	Time elapsed equal to the time selected as apnea time without detecting spontaneous inspiratory efforts.	Spontaneously	Alarm signal activation after the regulated apnea time has elapsed. At the same time, the ventilator switches to Backup Ventilation.
Non-compensable leak (Cannot be adjusted by user)	Leak that exceeds the maximum that can be compensated according to mode and category.	In all modes.	Alarm signal activation after the non-compensable leak condition has been detected.
Blower failure (Cannot be adjusted by user)	The blower (rear cooler) shows high consumption (excessive current) because it has encountered high resistance when turning.	In all modes.	Alarm signal activation when the blower stops working.
Target volume not reached. (Cannot be adjusted by user)	VT or VM not reached, with one of the established pressure limits (max. or min.) having been reached.	In PRVC and MMV + PSV.	Alarm signal activation when it is detected that pressure level limits have been reached and the target has not been reached.

11.9 | Low Priority Alarms

They are alarms intended to make the operator aware of the event that has occurred. The alarms activated with low priority signals are listed on Table 11-9. They are listed from high to low priority within the group of low priority alarms.

Table 11-9 Low priority alarms

ALARM	Definition	Enabled	Ventilator action
High frequency	Respiratory rate that exceeds the maximum configured limit.	In all modes.	Alarm signal activation when it stays out of the configured limit for at least 30 s.
PEEP Loss	Sustained pressure drop below the selected PEEP level. The pressure drop needed to activate the alarm can be set.	In all modes.	Alarm signal activation after the pressure drop stays below PEEP for 15 s.
Nebulization interrupted (Cannot be adjusted by user)	Nebulization interruption due to the absence of enough flow of gases.	It operates in modes where nebulization is enabled, and only when this function is active.	Alarm signal activation when insufficient flow is detected. This is accompanied by the effective interruption of the nebulization.
Transporting	Ventilator fed only with O ₂ during intra hospital transfer.	When there is no air supply and the Transfer function is activated.	Transfer alarm signal activation and Low air pressure and Loss of power signal suppression.
Standby	Condition during which the machine does not ventilate, but is charged.	From the start of ventilation.	The ventilator stops ventilating and stays on, maintaining the last configuration.

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Respiratory mechanics

CHAPTER CONTENTS

- 12.1 auto-PEEP
- 12.2 Compliance and resistance
- 12.3 Trapped Volume
- 12.4 Slow Vital Capacity
- 12.5 P0.1
- 12.6 PV flex (inflection points)
- 12.7 $P_{i_{\max}}$
- 12.8 VD/VT Physiologic

CHAPTER SUMMARY

iTermIS ADV allows testing standards for characterizing the patient's respiratory mechanics. This chapter describes the concept and how to carry out each test.

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12.1 | auto-PEEP

12.1.1 | Concepts

Auto-PEEP, or intrinsic PEEP, is the dynamic pulmonary hyperinflation, unintentional, occurring on mechanical ventilation when the time interval between successive breaths is insufficient to restore the equilibrium position of the respiratory system.

The auto-PEEP is a phenomenon that cannot be observed with a simple inspection of the patient. It is possible to measure it by special maneuvers when its existence is suspected. One way to predict it is by analyzing the flow curve during mechanical ventilation. If during expiration, the flow curve does not return to the baseline before the next inspiration, it is very likely that auto-PEEP exists. With auto-PEEP test, it is possible to confirm or dismiss this idea, and if so, determine its magnitude.



NOTE

- Assisted and spontaneous modes are not studied. If the patient performs spontaneous breaths, the auto-PEEP calculation is not performed.

12.1.2 | Procedure

With the *iTernIS ADV* ventilator, the auto-PEEP measurement is performed through a static maneuver. The patient must be kept in controlled ventilation (volume or pressure). Respiratory efforts may alter the measurement, therefore, if the patient is alert, it is important to instruct him/her on the procedure to obtain maximum relaxation during the maneuver.

On the first step, the ventilator closes the expiratory valve for 0.75 s at the end of the expiratory phase. This pause is used to measure alveolar pressure. In Fig. 12-1, it is possible to observe the start of the test, as determined by the expiratory pause.

Test enabled in the following modes:

- VCV
- PCV
- PRVC

12.1.3 | Implementation

[Respiratory Mechanics]>>auto-PEEP. After implementing this string, the test window appears. To start the measurement, it is necessary to press the rotary knob. When the maneuver is completed, the result is displayed on the screen as shown in Fig 12-1. The test can be repeated by pressing the knob again. The last measurement is saved in memory, and displayed in the window when accessing the test window.

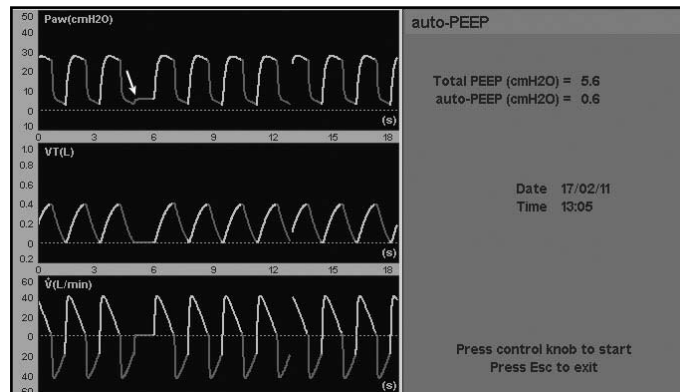


Fig. 12-1 Auto-PEEP test window appearance. The white arrow is used to indicate the start of the test (expiratory pause).

12.2 | Compliance and Resistance

12.2.1 | Concepts

Compliance of the respiratory system is one of the variables most commonly measured during mechanical ventilation. This maneuver determines static and dynamic compliance.

Inspiratory and expiratory resistances are defined as the difference in pressure required to generate a set inspiratory or expiratory flow, and they are the expression of resistance to flow opposed by the airways (from the patient, artificial, and ventilator circuit).

Compliance and resistance tests are performed in the same maneuver.

12.2.1.1 | Dynamic Compliance

Dynamic compliance is calculated according to the change in pressure that occurs during the insufflation of a known volume according to the following formula:

$$\text{Dynamic Compliance} = \frac{VT}{P_{\max} - PEEP}$$

Dynamic Compliance is a global index that refers to the patient's respiratory impedance in general, without distinction of its elastic and resistive components.

In this ventilator, dynamic compliance is shown in real time, breath by breath, in the screen corresponding to *PATIENT'S DATA* (see *Menu's* chapter).

12.2.1.2 | Static compliance

Static Compliance is equal to the pressure change required to produce a change in volume (dV/dP). This ventilator calculates it as follows:

$$\text{Static Compliance} = \frac{VT}{P_{\text{plateau}} - PEEP_{\text{TOTAL}}}$$

The calculation takes into account the compliance of the ventilator circuit. Both the compliance and resistance are parameters of respiratory mechanics that are closely linked with the pulmonary volume for which they were measured. This is

important when interpreting the results, since the value obtained in the measurement is absolute and is not expressed in relation to the pulmonary volume for which it was measured.

12.2.1.3 | Inspiratory resistance

Inspiratory resistance is calculated using the following formula:

$$\text{Inspiratory resistance} = \frac{P_{\text{max}} - P_{\text{plateau}}}{\frac{VT}{T_i}}$$

Where VT/T_i is the mean inspiratory flow.

Like other measures of respiratory mechanics, inspiratory resistance requires passive inflation from the patient with a known tidal volume, rectangular flow wave, and inspiratory pause. The above conditions are important for validation of the measurement.

The inspiratory resistance measurement is omitted during pressure-controlled operative mode (PCV), because inspiratory flow is not constant. The same happens in VCV mode with a downward flow wave.

12.2.1.4 | Expiratory resistance

Measuring Expiratory Resistance is useful in assessing response to bronchodilators in ventilated patients suffering from obstructive respiratory diseases.

The formula used for calculation is as follows:

$$\text{Expiratory resistance} = \frac{CT_{\text{est}}}{\text{Static compliance}}$$

Expiratory resistance evaluates the resistive characteristics of the airways during expiration so that is not affected by the type of inspiratory flow wave used. This allows it to be measured also during pressure modes.

12.2.2 | Procedure

The measurements of both compliance and the two resistances described in the previous section are implemented in the same maneuver.

The compliance measurement is performed through a static maneuver. This means that the patient must be instructed on the procedure to achieve his/her maximum relaxation during the maneuver.

Test enabled in the following modes:

- VCV
- PCV
- PRVC

12.2.3 | Implementation

[Respiratory Mechanics]>>Compliance and Resistance. Once implemented, this string appears on the test window. Pressing the rotary knob starts the compliance and resistance measuring maneuver. When the result is available, it is shown on the same window, and the test may be performed again to obtain a new reading.

During the implementation of the test, it is possible to cancel the maneuver by pressing **[Esc]**.

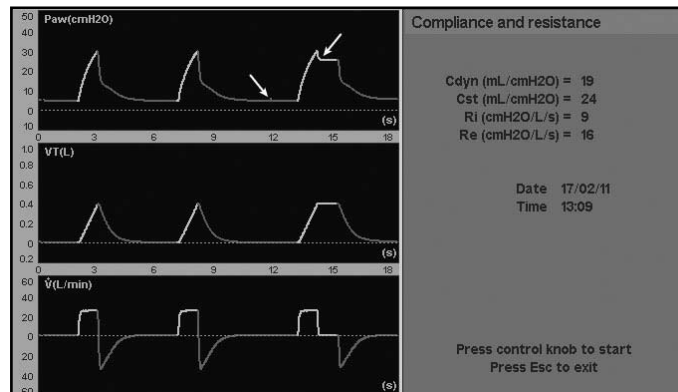


Fig. 12-2 COMPLIANCE AND RESISTANCE window. The times when the pauses are carried out are indicated with arrows.

12.3 | Trapped Volume

12.3.1 | Concepts

Trapped Volume is the amount of air remaining within the lungs due to dynamic pulmonary hyperinflation, unintentional, occurring in mechanical ventilation when the time interval between successive breaths is sufficient to restore the equilibrium position of the respiratory system. The trapped volume can be measured when its presence is suspected or auto-PEEP (intrinsic PEEP) has been detected.



NOTE

- Assisted and spontaneous modes are not studied. If the patient performs spontaneous breathing, the trapped volume calculation is not performed.

12.3.2 | Procedure

To make the measurement, the *iTernIS ADV* ventilator performs a static maneuver. The patient must be kept in controlled ventilation (volume or pressure). Respiratory efforts alter the measurement; therefore, if the patient is alert, it is important to instruct him/her on the procedure to obtain maximum relaxation during the maneuver.

The ventilator insufflates a volume known during inspiration and expiration and allows one expiration that extends until the expiratory pneumotachograph shows a zero flow reading (at which time the patient no longer produces expiratory flow). The tidal volume reading is compared to the monitoring of expiratory volume of the last expiration before the test. The difference between these volumes allows characterizing the magnitude of the volume remaining in the patient's respiratory system during ventilation in progress.

Test enabled in the following modes:

- VCV
- PCV
- PRVC

12.3.3 | Implementation

[Respiratory Mechanics]>>Trapped volume. After implementing this string, the test window appears on the screen. Pressing the rotary knob starts the trapped volume measurement maneuver. When the result is available, it is shown on the same window, and the test may be performed the same way again to obtain a new reading.

During the implementation of the test, it is possible to cancel the maneuver by pressing **[Esc]**.

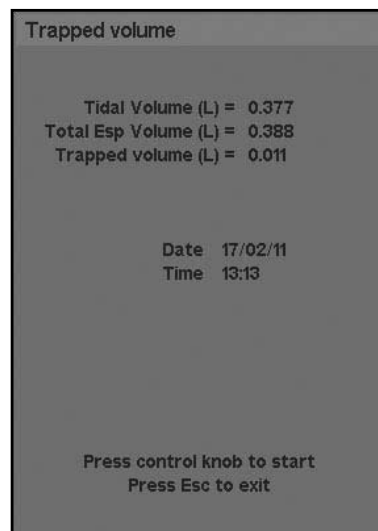


Fig. 12-3 TRAPPED VOLUME test window. Here, the appearance of the window is shown after having implemented a test with the latest obtained values. For the first time after turning the equipment on, this will not show any results.

12.4 | Slow Vital Capacity

12.4.1 | Concepts

Vital capacity is the amount of air that can be expired after a maximal inspiration, serving as a ventilatory reserve assessment. This test is only enabled for ADL and PED patient categories.

12.4.2 | Procedure

To perform the maneuver the ventilator automatically selects the PSV/CPAP operative mode with $PSV = 0 \text{ cmH}_2\text{O}$.

Encourage the patient to perform a maximal inspiration and then expire slowly to the maximum extent possible. It should be noted that the maneuver must be slow.

Test enabled in the following modes:

- VCV
- PCV

- PSV/CPAP
- SIMV (VCV) + PSV
- SIMV (PCV) + PSV
- MMV +PSV
- PSV + assured VT
- APRV
- NIV
- PRVC

12.4.3 | Implementation

[Respiratory Mechanics]>>Slow vital capacity. After implementing this string, the test window appears on the screen. Pressing the rotary knob starts the measurement maneuver slow vital capacity, which has a duration of 30 s.

As the patient performs successive breaths, the value obtained in each of them is displayed on-screen, along with the maximum value obtained until the last measurement (see Fig. 12-4).

During the implementation of the test, it is possible to cancel the maneuver by pressing **[Esc]**.

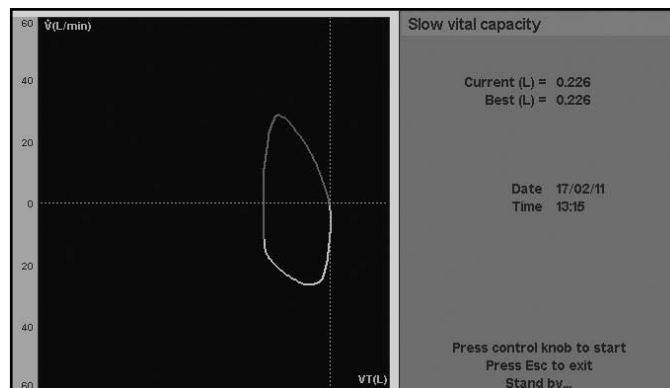


Fig. 12-4 Slow vital capacity test. On the left side a Flow/Volume loop is plotted, and on the right side the values obtained in the test are displayed. In this case, with the last breath, the full slow capacity has been achieved, so the Current and Better values match.

12.5 | P0.1

12.5.1 | Concepts

The objective of this test is to help determine the ventilatory demand and the capacity of the patient to resume spontaneous ventilation. By definition, the P0.1 determines the pressure drop generated by the patient's effort during the first 100 ms after the last known pressure threshold is below the base pressure.

P0.1 determination does not require patient cooperation, and the patient must not be notified of the time the test starts. This test is only enabled for the ADL and PED patient categories.

12.5.2 | Procedure

At the start of the maneuver, the ventilator analyzes the breathing cycle during two breaths, identifying inspiration and expiration. During the last expiration, inspiratory occlusion of the inspiratory valve occurs, and the expiratory valve is left open.

P0.1 measuring begins when the ventilator detects a pressure drop of $-0.5 \text{ cmH}_2\text{O}$ in relation to the base pressure level. From this moment, the count of 100 ms starts, during which the extent of pressure drop generated (P0.1) is measured.

The result is expressed as an absolute value, taken as a reference at the baseline pressure level.

Test enabled in the following modes:

- VCV
- PCV
- PSV/CPAP
- SIMV (VCV) + PSV
- SIMV (PCV) + PSV
- MMV +PSV
- PSV + assured VT
- APRV
- NIV
- PRVC

12.5.3 | Implementation

[Respiratory Mechanics]>>P0.1. After implementing this string, the test window appears on the screen. Pressing the rotary knob starts the maneuver to finish at the P0.1 measurement. Once the result is displayed on-screen, it is possible to perform the test again.

During the implementation of the test, it is possible to cancel the maneuver by pressing **[Esc]**.

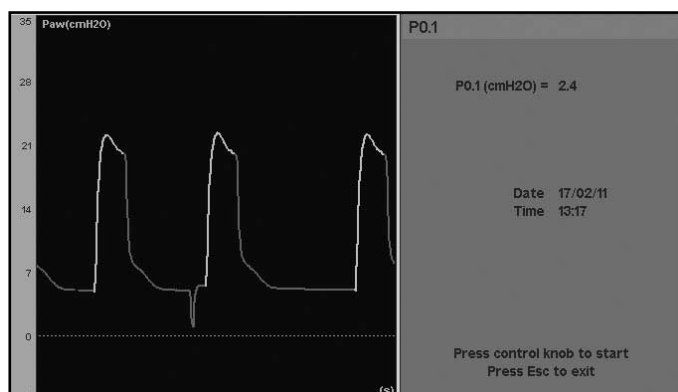


Fig. 12-5 Picture of the window and graph of the P0.1 test. At the end of the first breath displayed on-screen, the occlusion and measure have been performed.

12.6 | PV flex (Puntos de Inflexión)

12.6.1 | Concepts

Changes in pulmonary mechanics that occur in acute respiratory failure can be monitored by serial measurement of the inflection points in the Pressure/Volume curve. The method used by the *iTernIS ADV* ventilator for this analysis, is pulmonary insufflation with low flow. Thus, it is possible to determine the lower inflection point (Lip) and upper inflection point (Uip). The data provided by the first one is used to assist in determining the optimal PEEP level, able to prevent alveolar collapse or injury by the opening and subsequent closure of the alveoli (atelectrauma).

The Uip represents the transition to pulmonary overdistension, indicating the maximum usable pressure and volume limit during pulmonary ventilation.

As additional data, during this maneuver, the value of pulmonary compliance can also be obtained from the middle section of the curve (Cmax).

This test is only enabled for the ADL and PED patient categories.

12.6.2 | Procedure

The patient must be intubated, and without exerting inspiratory efforts during the test.

The ventilator injects a low flow into the patient and monitors the pressure behavior of the respiratory system in relation to the entered amounts. The inflection points are located at the site of the curve where the slope changes (changes in the system compliance).

Each measuring maneuver has the following sequence of steps:

- Expiration of 3 s with PEEP = 0 cmH₂O.
- Start of pulmonary disinflation, with low oxygen flow (100%).
- Start of the curve plotting, until the end of the test.
- The maneuver ends when the maximum pre-regulated pressure or volume is reached (whichever occurs first; see 12.6.3 Implementation).
- Ventilation is resumed with the operative mode and values existing prior to the start of the test.
- The numerical data window shows the results of the measurement.

Test enabled in the following modes:

- VCV
- PCV
- PRVC

12.6.3 | Implementation

[Respiratory Mechanics]>>PV flex. After implementing this string, the test window appears on the screen. Pressing the rotary knob starts the maneuver for the measurement. As can be seen in Fig. 12-6, there is a maximum pressure parameter and a maximum volume parameter. These two values are the maximum allowed during the procedure, and are used as a criterion for completing the delivery of the flow. Whichever value is reached first, it will signal the end of the test. The configuration of these values is performed using the **[Menu]** key.

By pressing this key once, the Pmax limit changes color, indicating that it can be changed by turning the rotary knob. It is accepted by pressing the knob, or the value is resumed by pressing **[Esc]**. Press the **[Menu]** key again to change the Vmax limit. The change is performed the same way as that described for Pmax.

Once the result is displayed on screen, it is possible to perform the test again.

During the implementation of the test, it is possible to cancel the maneuver by pressing **[Esc]**.

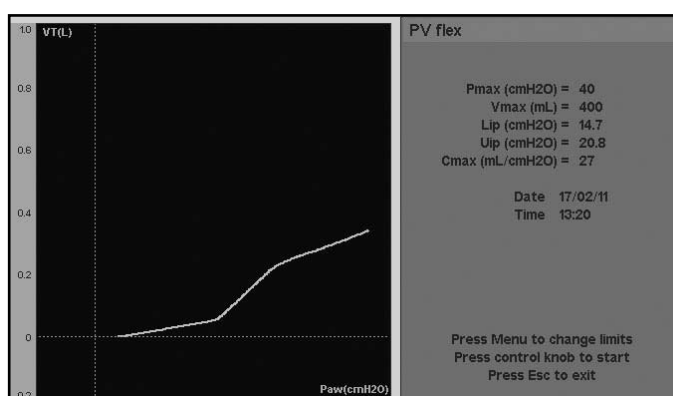


Fig. 12-6 Picture of a PV flex test. The graph shown was generated from a test mechanical lung with a compliance change simulator. As a result, the changes in the curve can be seen very clearly defined.

12.7 | Pi_{max}

12.7.1 | Concepts

The Pimax is an index that evaluates the maximum contractile capacity of the inspiratory muscles, especially the diaphragm.

The Pimax is not only a reflection of the respiratory muscle function in isolation, but it can also be affected by changes that occur anywhere in the genesis of muscle contraction (central nervous system, conduction pathways, neuromuscular junction, muscle mechanical situation, peripheral receptors, etc.).

This test is only enabled for the ADL and PED patient categories.

12.7.2 | Procedure

The Pimax can be performed with or without the cooperation of the patient. By selecting *RESPIRATORY MECHANICS* in the test menu, the ventilator continues in the selected mode and removes the PEEP.

The maneuver starts by analyzing the breathing cycle during two breaths, identifying inspiration and expiration. During the last expiration, an inspiratory occlusion

of the inspiratory valve occurs during 20 s, and the expiratory valve is left open. This allows free expiration, but during the inspiration, the patient demands air in an enclosed system. This causes the pressure inside the patient circuit to decrease as the magnitude of the patient's effort increases.

La Pimax is calculated as the greatest drop in airway pressure that occurs during the occlusion period. The result is stated as an absolute value, taken as a reference at the base pressure level.

Test enabled in the following modes:

- PSV/CPAP
- SIMV (VCV) + PSV
- SIMV (PCV) + PSV
- MMV +PSV
- PSV + assured VT
- APRV
- NIV

12.7.3 | Implementation

[Respiratory Mechanics]>>Pimax. After implementing this string, the test window appears on the screen. Pressing the rotary knob starts the maneuver that performs the measurements of maximal inspiratory pressure during 20 s. At this time all inspiratory efforts are monitored, and in the numerical data window, the highest value obtained in the series of efforts is recorded. Once the test concludes, it is possible repeat it.

If the patient is cooperative, he/she can be encouraged to achieve maximum inspiratory effort. If the patient is not cooperative, the most negative pressure achieved is taken as valid.

After the maneuver, the breathing returns to the original operative mode and the screen freezes showing the value obtained.

During the implementation of the test, it is possible to cancel the maneuver by pressing **[Esc]**.

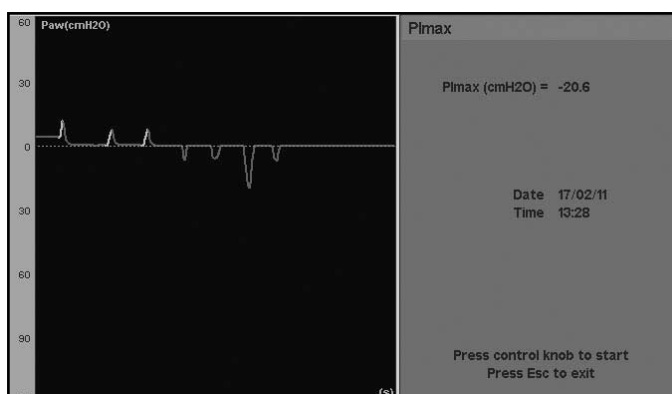


Fig. 12-7 Detail of the Pimax test screen.

12.8 | VD/VT Physiologic

12.8.1 | Concepts



NOTE

- To perform this calculation, it is essential that the capnograph is connected.

This option allows the measurement of the Physiological Dead Space. This uses the Bohr-Enghoff equation.

This test is only enabled for the ADL and PED patient categories.

12.8.2 | Procedure

To perform the calculation, the data in PaCO_2 is needed. Therefore, it is required to take a sample of arterial blood, to perform a gas-in-blood analysis and obtain this information. The remaining steps are shown in 12.8.3 Implementation and include the acquisition of new data to complete the equation used for the calculation.

Test enabled in the following modes:

- VCV
- PCV
- PSV/CPAP
- SIMV (VCV) + PSV
- SIMV (PCV) + PSV
- MMV + PSV
- PSV + assured VT
- APRV
- NIV
- PRVC

12.8.3 | Implementation

[Respiratory Mechanics]>>VD/VT physiologic. After implementing this string, the test window appears on the screen. From here, the steps to obtain the value of the physiological dead space are:

- Press the rotary knob to record the current PECO_2 of the patient.
- Perform sampling of the arterial blood that would allow, through the relevant analysis, obtaining the PaCO_2 value. It is possible to leave the test screen by pressing **[Esc]** until obtaining the results of the gas-in-blood analysis.
- After obtaining the PaCO_2 value, re-enter the test menu, and enter the PaCO_2 result obtained.
- By accepting the PaCO_2 value entered, the display shows the calculated VD/VT physiologic value, and the result is saved with date and time, until a new measurement is performed (or the unit is turned off).

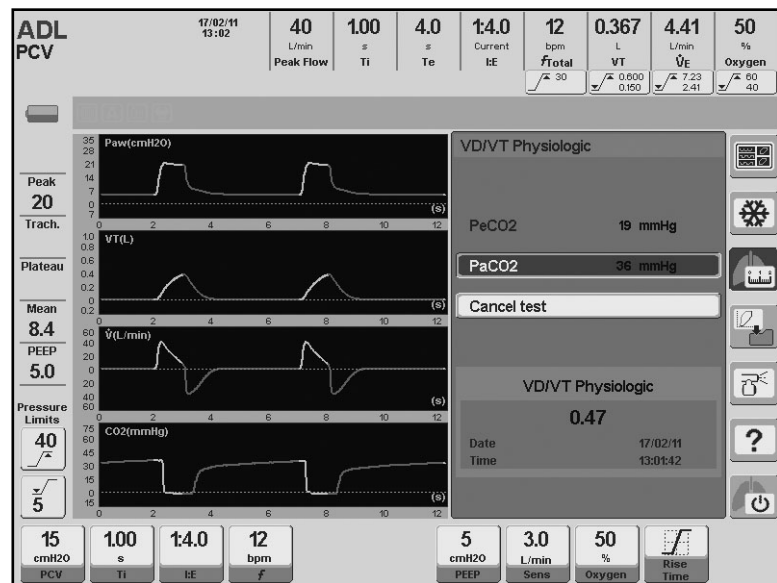


Fig. 12-8 VD/VT physiologic test screen.

Trends

CHAPTER CONTENTS

- 13.1 Overview
- 13.2 Access to trends
- 13.3 Settings
- 13.4 Trend curves management

CHAPTER SUMMARY

This chapter summarizes the information needed to know the features of the trend system that has been implemented in *iTermIS ADV*. The trend history system of the monitored parameters can be viewed at any time, and the user can configure the information it shows. These operations are explained in this chapter.

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13.1 | Overview

The trends module is a tool used to control the value history of the main ventilating parameters during the last 72 h of ventilation.

iTermIS ADV has activated the trends feature for the three patient categories: ADL, PED and NEO-INF. The information is presented the same way for all categories, using three graphs on screen that show the evolution of three parameters that can be chosen by the user (see Fig. 13-1).

The trend menu provides three groups of parameters organized as TREND 1, TREND 2 and TREND 3. This allows having three preset trend options. Section 13.3 Configuration explains how to change the parameters shown in each of these groups.

The different variables are followed up with updates in steps every one minute. Each new value added to the trend graphs represents the average value of the parameter during that minute. The curves tracing changes its color when a new ventilation day begins (date update). This allows to quickly identify the trends that have been recorded for different days.

The parameters whose trends can be followed up are:

- Peak pressure.
- PEEP.
- Respiratory rate.
- Peak flow.
- Tidal volume.
- Minute volume.
- C_{Tex}p (expiratory time constant).
- ETCO₂ (available only if the capnograph is connected).
- Dynamic compliance.
- O₂ concentration.
- Mean pressure.



Fig. 13-1 TRENDS Menu. From this stage on, it is possible to select one of the three trend groups or configure these groups by selecting the parameters the user wants for each of them.

13.2 | Access to Trends

The following sequence must be executed to access the trends function: **[Menu]>>Records>>Trends**. When the ventilator shows the trend graphs, the **[Graphics]** key can be used as a shortcut to reach the trends menu.

Once the trends menu window has been accessed, it is possible to select one of the three preset trend groups.

The last line on the TRENDS window allows access to the trend configuration menu.

13.3 | Settings

The trend menu (Fig. 13-1) has an option to select the parameters shown for each trend group. The Settings option can be found above the last line of the menu. The submenu shown in Fig. 13-2 is displayed through this option.

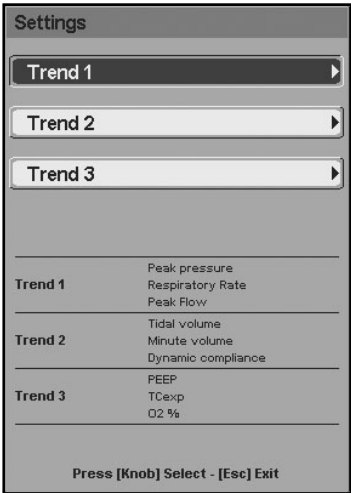


Fig. 13-2 Trend settings submenu. Each trend line can be configured to show any of the 9 parameters available for trends.

Each trend group can be configured from this submenu. There are 9 possible parameters to set in trends. Any of them can occupy the first, second or third position in TREND 1, 2, or 3. The positions in which the parameters appear in the menu correspond to the location of the graphs.

The way of changing the parameters for each trend is very simple. You must be placed over one of the 3 trends, and, by pressing the knob, a third window is accessed where it is possible to change the parameters for each line (Fig. 13-3).

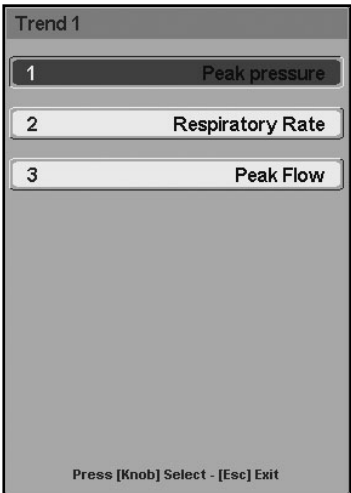


Fig. 13-3 Trend 1 configuration window.

13.4 | Trend Curve Management

Regarding curve management, the following features are particularly useful:

- By moving the rotary knob, the cursor (vertical dotted line) shown on the screen is moved (Fig. 13-4). Each position occupied by the cursor corresponds to one of the values of the parameter in each graph and the time at which it was recorded. This data appears on the upper section of the graph area.
- The cursor can be moved at a small (one minute) or a big step (3, 6, 12, 24 or 72 minutes, depending on the horizontal scale that has been selected). Pressing the rotary knob before moving the cursor modifies the path to be followed by the curves.
- Pressing the horizontal axis of one of the trends (so as to change the horizontal scale of the graph) and the **[Ctrl]** key (the order does not matter) makes it possible to move along the time axis without changing the scale. This aims at allowing to view data recorded a long time ago. Turning the rotary knob generates time movements.
- It may be useful to change the vertical or horizontal scales. Scales are managed in the same way as in the standard graphs (see *Graphics management* chapter).
- The trends can be downloaded to a computer through the *Visual iTermIS®* program to be filed or analyzed in detail. This program can be requested at no additional charge.



Fig. 13-4 TREND screen appearance.

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Capnography

CHAPTER CONTENTS

- 14.1 Capnograph
- 14.2 Connection of the capnograph
- 14.3 Monitoring
- 14.4 Capnography Menu
- 14.5 Messages

CHAPTER SUMMARY

The chapter includes information on how to enable the optional module of capnography, how to interpret the information provided by the ventilator, how to manage its menu settings and information about the equipment used to assess data.

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14.1 | Capnograph

The *iTermIS ADV* ventilator accepts the capnography sensor *CAPNOSTAT 5®* of Respirationics Inc. The capnograph is an optional accessory that is delivered upon demand.



NOTE

- The capnograph is a maintenance-free device that requires no calibration or use of certified gases.
- Capnography is not available when the equipment main power source is lost. When the ventilator is being powered by internal battery, no connection will be established with the capnograph.

14.1.1 | Components of the capnograph

- 1 CO₂ sensor.
- 2 Capnograph cable connector (for connection to the ventilator).
- 3 Adapter (part belonging to the capnograph which links the Y-shaped piece with the connection elements to the patient).

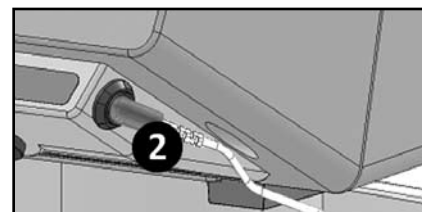
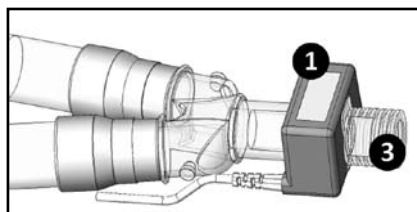


Fig. 14-1 Left: capnograph connected to the Y piece of the patient circuit. Right: capnograph cable connected to the ventilator.

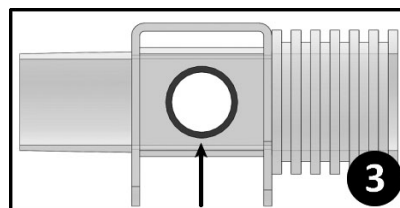


Fig. 14-2 Capnograph adapter. The image shows one of the two circular windows featuring this device (arrow).



PRECAUTION

- Keep windows of the capnograph adapter free from dirt to assure correct reading. For this reason, if nebulization is administered, the aerosolized drug deposit on the windows of the adapter may alter the proper functioning of the device.
- In the case of using a passive humidifier, this must be connected between the patient and the adapter in order to reduce water condensation on the windows of the adapter.

14.2 | Connection of the Capnograph

- Locate the adapter onto the sensor (a click will be heard when both devices are attached).
- Place one end of the adapter into the Y piece of the respiratory circuit. The other end is reserved for the connection of the final step of the patient circuit.
- Place the cable connector of the capnograph in the ventilator as shown in the right Fig. 14-1.

By connecting the capnograph to the ventilator, a warm up period of the sensor begins. When this ends, a message saying 'SENSOR OK' will appear on the screen. During the heating period, abnormal shifts of the CO₂ curves can be observed and warning signals of low CO₂ may be triggered. These situations disappear when the sensor warm up finishes.

14.3 | Monitoring

Access to the CAPNOGRAPHY screen is achieved by pressing the **[Graphics]** key and selecting the CO₂ screen.

14.3.1 | Curves

On the *CAPNOGRAPHY* screen, it is possible to display the following curves in a continuous form:

- PCO₂ vs. Time (under the pressure, volume and flow curves).
- Volumetric capnography (on the right, below the box showing the monitored parameters).

14.3.2 | Derived parameters

iTernIS ADV allows continuous monitoring of these parameters on the Capnography screen:

- ETCO₂: partial pressure of CO₂ at the end of exhalation.
- Ratio VD/ VT: ratio of dead space and tidal volume.
- Serial dead space (VD): physiological dead space (anatomical + alveolar).
- Current alveolar volume (AV): volume reaching the alveoli with each breath.
- Alveolar minute volume (Va min): volume reaching the alveoli every minute.
- Current volume of CO₂: volume of CO₂ contained in every expiration.
- Elimination of CO₂ (VCO₂): volume of CO₂ expired per minute.
- PeCO₂: partial pressure of CO₂ of the expired gas mixture (alveolar gas + gases of anatomical dead space).

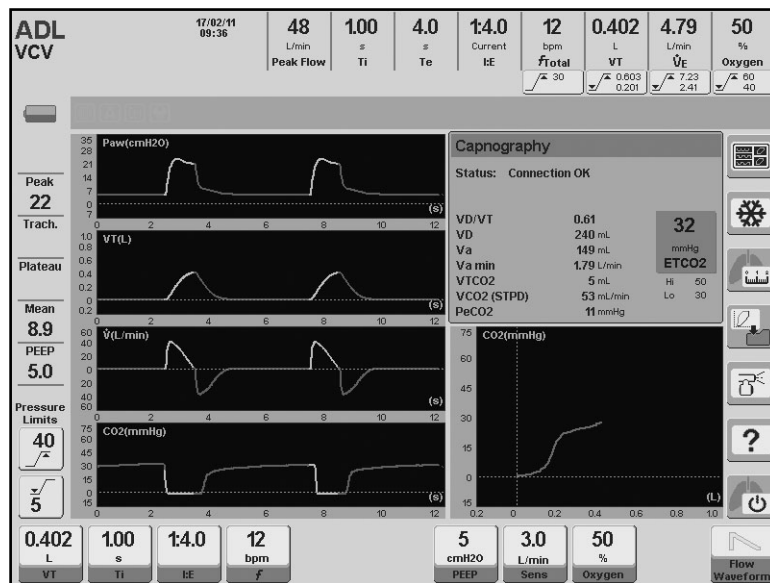


Fig. 14-3 Screen of Capnography. It incorporates two curves and one page of monitored data.

14.4 | Capnography Menu

To access the CAPNOGRAPHY menu (Fig. 14-4) it is necessary to follow the following string: **[Menu]>>Tools>>Calibration>>Capnography**

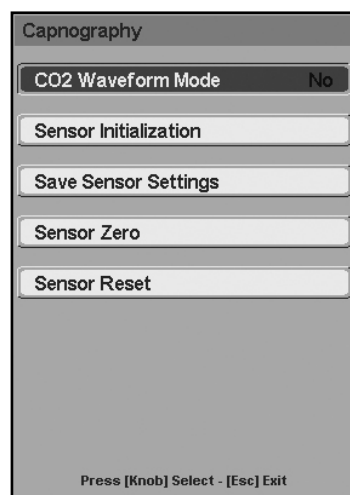


Fig. 14-4 Window of CAPNOGRAPHY.

14.4.1 | CO₂ waveform mode

This option enables (option YES) or disables (option NO) the plotting of the CO₂ curves on the capnography screens. This is enabled by default (YES).

14.4.2 | Activate sensor

If the sensor is connected to the ventilator, but the status message is 'ERROR (Activate Sensor)' it should then be activated manually. **[Menu]>>Tools>>Calibration>>Capnography>>Sensor Initialization**. During the activation process, data of barometric pressure is sent as well as oxygen compensation of the mixture.

14.4.3 | Save sensor settings

If the message 'Sensor not activated' is received, use this CAPNOGRAPHY menu option. The ventilator will send barometric pressure and oxygen compensation values to the capnography system. This will initiate the sensor without the need for a new activation.

14.4.4 | Zero

In case the message 'Zero required' is received, a calibration of the sensor from zero must be executed.

In the case of replacing the sensor adapter, it is recommended to perform a reset to zero of the sensor.

To perform the sensor reset to zero, follow these steps:

- Disconnect the sensor from the patient circuit.
- Expose the assembly to ambient air (the adapter should not contain residues of CO₂ while calibrating).
- Execute the following string: **[Menu]>>Tools>>Calibration>>Capnography>>Sensor zero.**
- Check the message 'Zero activated' (on the CAPNOGRAPHY screen, the message 'Zero in progress' also appears). The procedure takes 30 s (maximum).

14.4.5 | Reset

This is used in extraordinary situations when it is necessary to restart the sensor. This function allows for the reset, without having to disconnect and reconnect the sensor.

14.5 | Messages

Next, messages which may appear during the use of the capnography module are defined, as well as detailed recommendations on necessary actions.

- 'CO₂ NO BREATH DETECTED'

This message appears in the case of failing to detect breaths containing CO₂.

- 'CO₂ OUT OF RANGE'

Appears when the value of CO₂ is detected as being superior to that of 150 mmHg. If this error persists, a reset to zero must be executed.

- 'CHECK PATIENT AIRWAY ADAPTER'

This usually appears when the sensor is removed from the adapter or when there is an optical blockage of those same windows. A flaw may also be caused by a failure in the reset to zero (during the change of adapter or when there has been CO₂ inside it at the time of reset to zero). Cleaning of the adapter is recommended, or if it is clean, execute a new reset to zero.

- 'SENSOR FAILURE'

This may appear when a deviation of the source current outside the factory calibration occurs or if it is out of the performance specifications. Check if the sensor is properly connected to the ventilator. If the error persists, contact the Authorized Service.

- 'SENSOR NOT ACTIVATED'

This occurs when the barometric pressure or compensations due to gases were not executed at the time the ventilator was turned on. Activate the sensor or save the sensor parameters by using the options in the CAPNOGRAPHY menu.

- 'ZERO IN PROGRESS'

Appears when a reset to zero is being executed

- 'ZERO REQUIRED'

This is displayed when problems occur during a reset to zero (dirty adapter, for example). Repeating the reset to zero of the adapter is suggested.

- 'SENSOR WARM UP'

The sensor has not yet reached the operating temperature, or temperature is unstable, which can occur at the beginning of the operation.

- 'OVERHEATED SENSOR'

Internal temperature of the sensor is above the operating range. Check to see if the sensor is not exposed to external heat sources (lamps or stoves). In case this persists, contact the Service.

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Operational verification

CHAPTER CONTENTS

- 15.1 Necessary items
- 15.2 Ventilator preparation
- 15.3 Functional verification
- 15.4 Alarms Verification
- 15.5 Operative Verification

CHAPTER SUMMARY

This chapter lists a series of tests to be performed on the ventilator in order to determine whether it is in good operating condition.

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**NOTE**

- This chapter includes a series of tests that the user must run in order to verify the proper functioning of the ventilator. These tests should be carried out as a preliminary step to the first use of the ventilator, and it is recommended that these tests be run before connecting the ventilator to a patient.

15.1 | Necessary Items

In order to perform the tests listed below, the following items are necessary:

- Ventilator *iTermIS ADV* with patient circuit for the patient category of ADL, PED or NEO-INF.
- Test lung provided with the unit (suitable for verifying the patient category).
- Gaseous oxygen analyzer.
- Clock with second hand.

15.2 | Ventilator Preparation

- Connect the air supply and oxygen hoses, as well as the electric power source cable, to the appropriate sources.
- Verify the presence of O₂ cell.
- Turn on the ventilator and choose the appropriate corresponding patient category.
- Begin the patient circuit calibration as indicated in the chapter Ignition and initial calibration.
- When the programming screen appears, select the operative mode VCV.
- Ventilation begins by accepting the default parameters.
- Allow the ventilator to operate for at least two minutes with the default parameters.
- The ventilator is able to carry out the tests.

15.3 | Functional Verification

The functional verification tests are presented in Table 15-1. These tests are designed to be carried out in the suggested order, and require that the value of a modified ventilator parameter or alarm limit be restored to its original value once the test has been concluded.

Table 15-1 Functional verification

TEST	ACTION	VERIFICATION
Frequency	Monitor the amount of breaths in one minute using the clock second hand.	The value obtained from the previous action must coincide with the one monitored by the ventilator.
Tidal volume (VT)	Contrast the VT value regulated with the monitored one for the preset value. Repeat for a VT of 50% higher and for a VT of 50% lower.	The monitored value must be within $\pm 10\%$ of the regulated value.
PEEP	Keep the preset value.	Verify that the base pressure line remains stable.
Sensitivity	Apply pressure on the test lung in order to generate an inspiration.	The inspiration must be generated.
Sensitivity	Regulate the sensitivity to 0.5 L/min.	The autocycling should not be verified (allow for at least five mandatory breaths).
Sensitivity	Regulate the sensitivity to -0.5 cmH ₂ O.	The autocycling should not be verified (allow for at least five mandatory breaths).
Manual inspiration	Press [Manual Insp.] .	The ventilator should initiate a mandatory breath.
Flow waveform	Change the flow waveform.	On the flow chart, the profile change of the flow waveforms should appear.
Oxygen	Compare the monitored O ₂ concentration with the regular concentration.	The monitored value should be between 45% and 55%
Oxygen	Change the concentration of O ₂ up to a value of 100%.	The monitored oxygen concentration should be of at least 95% after ten breaths.



NOTE

- During the VT test, the alarm limit of maximum inspiratory pressure may be exceeded, and this will activate the corresponding alarm signals. In this case it is necessary to regulate the minimum inspiratory pressure limit, so that the set VT may be delivered correctly. Otherwise, this alarm will limit the delivered VT, and the test will not be executed.

15.4 | Alarms Verification

The alarm verification tests are presented in Table 15-2. These tests are designed to be carried out in the suggested order, and require that the value of a modified ventilator parameter or alarm limit be restored to its original value once the test has been concluded.

Table 15-2 Alarms Verification

TEST	ACTION	VERIFICATION
Disconnection	Disconnect the test lung from the circuit.	The Disconnection alarm signals should appear without delay.
Auditory alarm signal pause	During the active disconnection alarm, press the pause key of the auditory alarm signal.	The auditory alarm signal should pause for a period of 30 s.
Maximum pressure	Regulate the alarm limit level to 5 cmH ₂ O above the current pressure value. Then, during an inspiratory phase, squeeze the test lung.	The Maximum pressure should appear immediately and the peak pressure value should not exceed that of the established alarm limit.
Maximum VT	Regulate the VTmax alarm limit below the reading of the actual VT.	After 10 s the corresponding alarm signals should appear.
Minimum VT	Regulate the VTmin alarm limit to 20 mL above the current value.	After 10 s the corresponding alarm signals should appear.
Maximum rate	Regulate this alarm limit to 20 rpm. Simulate spontaneous breathing by squeezing and releasing the test lung at a rate greater than 20 times per minute.	After 30 seconds of having exceeded the 20 rpm, the maximum rate alarm signals should appear.
Apnea	Select the PSV ventilation mode without changing the menu Backup Ventilation. Squeeze the test lung, only once, to generate spontaneous breathing. Then suspend the generated spontaneous breathing.	15 s after the last spontaneous breath, Apnea alarm signals should appear, and the ventilation mode must change from PSV to the configured mode of Backup Ventilation.
Electric power failure.	Disconnect the electric power cable.	The corresponding alarm signals should appear immediately.
Maximum VM (For ADL and PED patient category)	Select the MMV+PSV mode and begin the ventilation using the default parameters. Regulate the VMmax alarm limit to 4.0 L/min. Exceed this limit by squeezing the test lung repeatedly.	The corresponding alarm signals should appear 10 s after the ventilation starts to exceed the limit.
Minimum VM	While in MMV +PSV, regulate the VMmin alarm limit to 8.0 L/min. Apply repeated pressure to the test lung so as not to exceed the alarm limit.	The corresponding alarm signals should appear 10 s after the ventilation starts to go under the limit.

15.5 | Operative Verification

The tests which require user intervention have already been covered in the previous sections. Operative verification is an automatic control performed by the ventilator during the initial calibration. For further information on the nature of these tests, refer to chapter *Start-up and Initial Calibration*.

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Cleaning and maintenance

CHAPTER CONTENTS

- 16.1 Cleaning and sterilization
- 16.2 Assembly of the patient circuit
- 16.3 Maintenance

CHAPTER SUMMARY

There are a number of recommendations as to the conditions of cleaning, sterility and maintenance to be met for the equipment and its accessories. This chapter is dedicated to presenting the necessary guidelines on the subject of maintenance, and key points which must be addressed in order to ensure the proper functioning of the ventilator.

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16.1 | Cleaning and Sterilization

16.1.1 | General instructions

The ventilator *iTermIS ADV* and the parts associated to the patient circuit (hoses, connectors, accessories, etc.) are delivered clean but not sterilized.

The parts which come into contact with the patient are easily disassembled for cleaning and subsequent sterilization, which should be done after every use.



PRECAUTION

- *The ventilator is not autoclavable and is not compatible with ethylene oxide. Do not subject the equipment to any of these methods of sterilization.*



NOTE

- The information provided to manage the cleaning and sterilization of the different components works as a guide. This can be adapted to the protocols of each department or service, so long as the warnings and cautions stated in this chapter are respected.
- To discard all of the equipment, parts, or elements provided by other suppliers, follow the requirements of the institutional authority.

16.1.2 | Touch screen



WARNING

- ***Do not clean the screen with harsh chemical solvents, nor acid-based or alkaline substances. Use a soft cloth soaked in a solution of neutral detergent and water. A solution containing 80% of isopropyl alcohol can also be used. Never use substances which contain ammonia.***
- ***Do not spray the cleaning product directly onto the screen. Apply the chosen substance onto a soft cloth with which to wipe the screen.***

16.1.3 | Patient circuit

All parts of the patient circuit must be in perfect aseptic conditions at time of use.

All items delivered by HEYER Medical AG. with the ventilator, which are not pertaining to the same manufacturing, must be cleaned and sterilized according to the specifications of their manufacturers. Read and adhere to these instructions, in order to always use the items duly equipped with the ventilator *iTermIS ADV*.

For cleaning prior to sterilization, the patient circuit must be completely disassembled in order to expose all surfaces. It is inadmissible that remnants of organic material be left stuck onto any segment of the circuit. See Fig. 16-1 showing a diagram of the patient circuit.

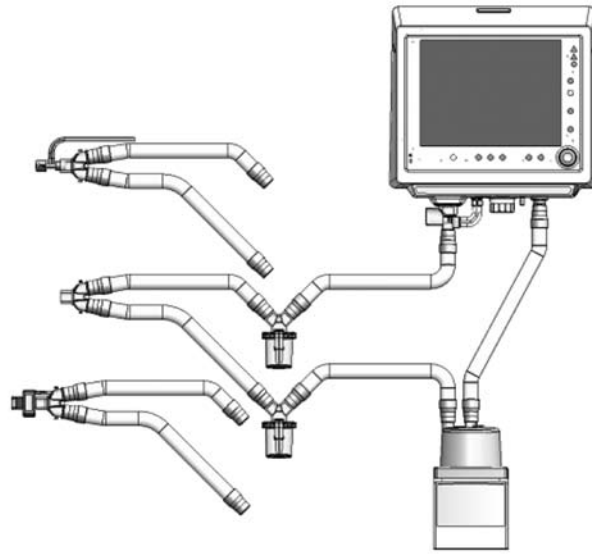


Fig. 16-1 Diagram of the patient circuit assembly (with accessories).



WARNING

- **No remnants of organic material must be left onto the walls of the parts which make up the patient circuit. It is important to conduct a proper cleaning of the items to be sterilized.**



PRECAUTION

- Do not use pure alcohol, cleaning solutions containing alcohol, or cleaning products containing conditioners, on any part.
- Ethylene oxide can alter the plastic surfaces and accelerate the wear of the rubber components.
- Do not use solvents, acetone, chloroform, or strong acid-based substances, nor chlorinated solvents to clean the plastic parts, hoses or patient circuit.
- Do not immerse the base of the humidifier/heater in any type liquid. Danger of short-circuiting may be present. Refer to the humidifier/heater manual for the cleaning and sterilization of the device.

16.1.4 | Expiratory set

To clean the set before the sterilization process, only use mild chlorine-free detergents. Instructions on how to remove the set from the ventilator, and on how to dismantle it, are found in the chapter *Assembly and installation*. The cleaning process should be executed carefully due to the presence of a fragile membrane found within the assembly body, belonging to part of the expiratory pneumotachograph. Do not introduce any sharp or trenchant objects through the openings of the assembly, or objects which, through their improper use, may threaten the internal membrane. The deterioration of this membrane can lead to the inadequate functioning of the ventilator.

**WARNING**

- **Completely dismantle the expiratory set for cleaning.**

- **A delicate transparent membrane is found within the pneumotachograph, incorporated into the expiratory set. This must not be damaged in order for the expiratory flow and volume measurements to be correct.**

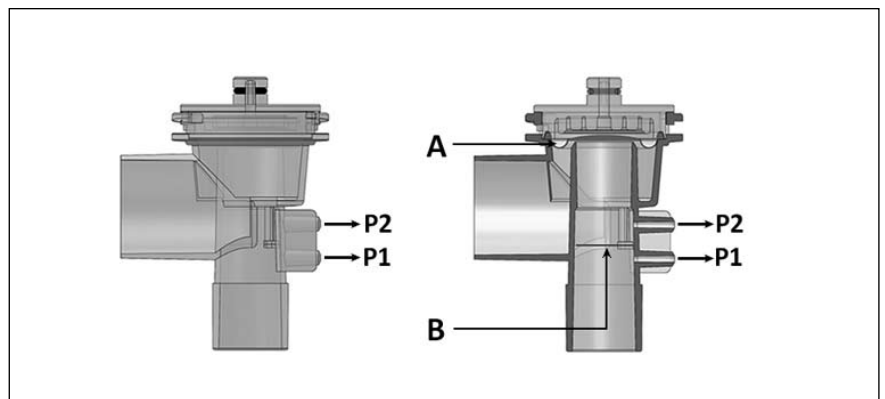


Fig. 16-2 Illustrations of the expiratory set. Left, front view of the set. Right, view of a frontal section of the set. The letter A indicates the position of the diaphragm, and the letter B indicates the position of the inner membrane found between the connectors linked to P2 and P1.

The expiratory set is autoclavable. It supports 50 autoclaving cycles if the following parameters are selected: 20 minutes at 121 °C - 2 hours; or 15 minutes at 134 °C - 1.5 hours.

16.2 | Assembly of the Patient Circuit

The components will be in proper working condition once they have been duly cleaned and sterilized. Pay particular attention to the assembly of all parts of the patient circuit, specially, to the expiratory set. The diaphragm of the set must be assembled correctly in order to function properly. For lingering doubts, please refer to the chapter *Assembly and Installation*.

**WARNING**

- **Always use authentic diaphragms. Non-authentic diaphragms may cause the malfunction of the expiratory valve while jamming the expiratory pathway.**

- **The positioning of the diaphragm onto the expiratory set is very important for the proper functioning of the ventilator. Ensure that it is properly adjusted.**

16.3 | Maintenance

16.3.1 | Suggested preventive maintenance



NOTE

- Preventive maintenance is essential for the structural and functional integrity of the ventilator. Neglecting the adequate maintenance may affect the quality of the mechanical ventilation received by the patients.
- The ventilator lifespan has been established in accordance with the performance of all the scheduled maintenance services to be implemented during this period (every 5000 hours of usage or every year).
- Scheduled maintenance can only be executed by HEYER or personnel authorized by HEYER Medical AG

Table 16-1 Suggested preventive maintenance

FREQUENCY	PART/ACCESSORY	PROCEDURE
Every 4 to 6 hrs.	Water traps of the patient circuit.	Check for presence of water in the traps. Drain if necessary.
With each new patient.	Patient circuit, including the expiratory set (valve + expiratory pneumotachograph).	Replace with a sterile circuit, and sterilize or discard the outgoing circuit, or the corresponding parts.
Daily.	Water filter for compressed air.	Check presence of water in the filter. Drain if necessary.
Daily.	Patient circuit.	Check status of overall circuit (hoses + accessories). Replace the parts or accessories that are not in optimal conditions, and recalibrate the patient circuit.
Every 3 months.	Internal battery.	Disconnect the main power cable. Verify that the icon Full battery charge remains for 10 minutes. If this does not occur, contact your authorized service.
Annually or every 5000 hrs. of usage (whichever comes first).	Complete ventilator.	Send the ventilator to an authorized technical service for scheduled maintenance of 5000 hrs.
Every 2 years or every 10000 hrs. of usage (whichever comes first).	Complete ventilator.	Send the ventilator to an authorized technical service for scheduled maintenance of 10000 hrs.
Every 3 years or every 15000 hrs. of usage (whichever comes first).	Complete ventilator.	Send the ventilator to an authorized technical service for scheduled maintenance of 15000 hrs.

16.3.2 | Compressed air filter

It is very important that the air filter is kept in optimal working conditions. The compressed air quality affects the working order of the ventilator, as well as the patient's health.

Consult the maintenance recommendations in the manufacturer usage instructions regarding the periodicity for replacing the filter unit. The ventilator should not ventilate when the air filter is not in optimal conditions.

It is also recommended to take the following cautions in order to ensure the proper working of the filter:

- Always keep the device in an upright position.
- If necessary, use a hose connected to the drain outlet in order to collect the condensation water in a bowl. Take care that the hose dimensions are correct. An excessive length may increase the drain resistance unnecessarily.
- If a water-catcher hose is used, check to see that this does not stretch in an upward direction, as this may hinder the drainage.

16.3.3 | Fuses

The fuse box is found near the main power source input. Located in the rear panel are two F 2L 250V fuses (Ø 5 mm x 20 mm - 250 V / 2 A). In the case of their replacement being necessary, use fuses of the same characteristics.

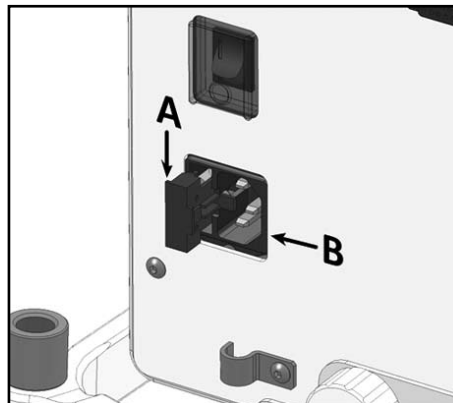


Fig. 16-3 Relative location of the fuse box (A) in relation to the main electric power source input (B).

16.3.4 | Scheduled Maintenance (every 5000 hours or every year)

The scheduled maintenance is performed every 5000 hours of usage, or every year, whichever comes first. This is a procedure performed in the factory or by an authorized service technician.

When the computer is sent out for maintenance, include a note explaining the atypical events which may have occurred. Thus, the assessments will also take these peculiarities into consideration.

When the 5000 hours of usage are met, the necessity to perform this maintenance is alerted by an icon, which will appear on the upper right-hand side of the screen. This icon will be deleted by the service technician once the maintenance protocol has finished, and will appear again after another 5000 hrs of usage, or after one year has elapsed since the last service.

The following list summarizes the verification of parts, accessories and consumables which are executed during a scheduled maintenance of the equipment.

- Expiratory set

- Oxygen cell
- Internal battery
- Closure gasket cabinet
- Blower (rear cooler)
- Porous Metal Filters
- Internal pneumatic lines
- Fuses
- Internal regulators pressure
- Sensors
- Gas inlet circuit
- Proportional valves/recalibration (if necessary)
- Cleaning of contacts and internal connections
- Software update (if necessary)
- Pneumatic system calibration
- Touch screen calibration
- Alarms: audible and visual signals
- User interface performance
- Watchdog System
- Final operational control

16.4 | Periodical Safety-Related Controls

The system must be checked by recurrent safety-related and metrological controls corresponding to manufacturer's instructions.

The safety-related controls (§6 MPBetreibV) and the metrological controls (§11 MPBetreibV) have to be conducted according the EU Guideline 93/42/EEC.

Periodical safety-related controls must be conducted according to the conditions of DIN EN 60601-1 based on the intervals prescribed by the manufacturer.

The safety relevant controls include the functional and operational safety.

Only authorized personnel must conduct the controls at least all 12 months.

With the background of practical activity such safety relevant controls must be conducted thoroughly.

For all safety-relevant controls a protocol must be prepared containing the date and results of the safety relevant control. This protocol has to be testified and kept with the product book – to be stored five years after final putting out of operation.

Technical Specifications

CHAPTER CONTENTS

- 17.1 Classification
- 17.2 Physical Characteristics
- 17.3 Screen
- 17.4 Environmental Requirements
- 17.5 Pneumatic Specifications
- 17.6 Electrical Specifications
- 17.7 Ventilatory Parameter Adjustments
- 17.8 Monitored Parameters
- 17.9 Alarm Adjustment
- 17.10 Data Collection for Control and Monitoring
- 17.11 Electromagnetic Compatibility
- 17.12 Basic Operation of the Ventilator
- 17.13 Safety Mechanisms
- 17.14 Diagram of the Pneumatic Circuit of the Ventilator
- 17.15 Lifetime

CHAPTER SUMMARY

This chapter summarizes the technical specifications that characterize *iTermIS ADV*. Some examples are: physical, electrical, and pneumatic specifications, environmental conditions, parameter setting, alarm tables, etc.

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17.1 | Classification

Table 17-1 Ventilator Classifications

Risk	Class IIb (Council Directive 93/42/EEC) Class III (MERCOSUR/GMC/RES. No. 40/00)
Electrical insulation	Class I – Type B (according to IEC 60601-1)
IP Protection	IPX1
Operational Mode	Continuous Operation (IEC 60601-1)

17.2 | Physical Characteristics

Table 17-2 Physical Characteristics

Height	35 cm (13.8 in)
Width	36 cm (14.2 in)
Depth	32 cm (12.6 in)
Height including the pedestal	131 cm (51.6 in)
Weight not including the pedestal	9.8 kg (21.6 lb)
Weight including the pedestal	23.8 kg (52.5 lb)
Width of the pedestal	51 cm (20.1 in) - 65 cm with lateral wheels (25.6 in).
Depth of the pedestal	52 cm (20.5 in) - 59 cm with in-line wheels (23.2 in)

17.3 | Screen

Table 17-3 Screen

Type	Resistive sensitive touch screen / color TFT-LCD
Size	12.1"
Resolution	800x600

17.4 | Environmental Requirements

Table 17-4 Environmental Requirements

	Temperature	Ambient pressure	Humidity
Operation	15 °C – 35 °C	560 – 1030 hPa	15 - 95% non-condensing
Storage	-5 °C – 70 °C	500 – 1060 hPa	< 95% non-condensing

17.5 | Pneumatic Specifications

Table 17-5 Pneumatic Specifications

Supply gas	Medical grade air and oxygen
Minimum supply pressure	3.5 kg/cm ² (343.2 kPa – 50 psi)
Maximum supply pressure	7.0 kg/cm ² (686.4 kPa – 100 psi)
Maximum limited pressure (relief valve)	120 ± 5 cmH ₂ O.
Inlet flow (gas source)	180 L/min (120 L/min for air compressor)
Peak flow delivered by the ventilator	0.2 – 180 L/min.
Maximum resulting minute volume	ADL: 130 L/min PED: 40 L/min NEO-INF: 17 L/min
Internal compliance (of the ventilator)	0.16 L/cmH ₂ O
Ventilator connectors for gas supply	<u>Air</u> : DISS 3/4" - 16 male connector. <u>Oxygen</u> : DISS 9/16" - 18 male connector
Connectors for gas supply hoses	<u>Air</u> : DISS 3/4" - 16 female connector (both ends). <u>Oxygen</u> : DISS 9/16" - 18 female connector (both ends)

17.6 | Electrical Specifications

Table 17-6 Electrical Specifications

Main Supply	Voltage: 100 – 240 V (automatic switching) Frequency: 50 – 60 Hz Maximum consumption 0.5 Amp. at 110 Volts – 0.3 Amp. at 220 Volts
Internal Battery	Voltage: 10.8 V (continuous) Electrical charge: 4.8 Ah (automatic recharge) Autonomy: 75 minutes (approximately). Data obtained for ADL patient category. VCV mode with preset parameter values.
Fuses	F2L250V (250 V / 2 A – 0,5 mm x 20 mm).
Connectivity	RS-232C.



NOTE

- When the ventilator is powered from the internal battery, it has the same operational capacities as when it is powered from the electrical network through the main power cable, except that capnography is disabled.

17.7 | Ventilatory Parameter Adjustment

Table 17-7 Ventilatory parameters adjustment

Parameter	Range	Increments ⁽¹⁾	Initial value
Tidal Volume (L)	ADL: 0,050 - 2,500 PED: 0,005 - 0,300 NEO-INF: 0,005 - 0,150	ADL: 0,010* PED: 0,001* NEO-INF: 0,001*	ADL: 0,402 ⁽²⁾ PED: 0,051 ⁽²⁾ NEO-INF: 0,009 ⁽²⁾
Minute Volume (MMV + PSV setting)(4) (L/min)	ADL: 1 - 50 PED: 1 - 50 NEO-INF: N/A	0,100	ADL: 6,0 PED: 4,0 NEO-INF: N/A
Controlled pressure (PCV) (cmH₂O)	PCV + PEEP = 2 - 100	1	ADL: 15 PED: 8 NEO-INF: 8
Support pressure (PSV) (cmH₂O)	PSV + PEEP = 0 - 100	1	ADL: 5 PED: 5 NEO-INF: 5
PEEP/CPAP (cmH₂O)	0 - 50	1	ADL: 5 ⁽³⁾ PED: 5 ⁽³⁾ NEO-INF: 3 ⁽³⁾
Limited pressure (in TCPL – NEO-INF) (cmH₂O)	3 - 70	1	10
Continuous TCPL flow (L/min)	2 - 40	1	8
Inspiratory time (s)	0,1 - 30 (APRV)	0,01*	ADL: 1,0 ⁽³⁾ PED: 0,6 ⁽³⁾ NEO-INF: 0,5 ⁽³⁾
I:E Ratio	5:1 - 1:599	0,1:0,1	Results of the inspiratory time and the initial rate.
Respiratory rate (rpm)	ADL: 1 - 100. PED and NEO-INF: 1 - 150.	1	ADL: 12 ⁽³⁾ PED: 25 ⁽³⁾ NEO-INF: 30 ⁽³⁾

Oxygen (concentration) (%)	21 - 100	1*	50
Inspiratory sensitivity (Flow = L/min; Pressure = cmH ₂ O)	<u>Triggering by flow:</u> 0.2 – 15 <u>Triggering by pressure:</u> -0.5 a -20	<u>By flow:</u> 0.1/0.5/1 according to the detection value. <u>By pressure:</u> 0.5	ADL: Flow=3; Pressure=-1.5 PED: Flow=3; Pressure=-1.5 NEO-INF: Flow=1; Pressure=-1.5
Expiratory sensitivity (for modes with PSV)	5% - 80% of the peak flow	5%	25%
Programmable inspiratory pause (in VCV) (s)	0 – 2	0,25	0 (NO)
Manual inspiratory pause (s)	7 (maximum)	N/A	N/A
Manual expiratory pause (s)	20 (maximum)	N/A	N/A
Sighs (in VCV)	<u>No. of sighs:</u> 1/2/3 <u>Rate:</u> 5/10/15/20 per hour <u>Added volume:</u> +0.1VT – +1.0VT (The volume is added to the configured VT)	N/A	<u>No. of sighs:</u> 1. <u>Rate:</u> 5 per hour <u>Added volume:</u> +30% (+0.3VT) <u>Activated:</u> No
Inspiratory flow waveform	Descending and constant ramp (rectangular)	N/A	Descending ramp
Leakage compensation in NIV (L/min)	Non adjustable	N/A	ADL: up to 50 PED: up to 30
Leakage compensation for the rest of the modes (L/min)	Non adjustable.	N/A	ADL: up to 15 PED: up to 15 NEO-INF: up to 10
Tube compensation	<u>Tube:</u> Endotracheal or tracheostomy <u>Diameter:</u> 4 – 12 mm <u>Compensate:</u> 10%-100%	N/A	<u>Tube:</u> Endotracheal <u>Diameter:</u> 8 mm <u>Compensate:</u> 50% <u>Activated:</u> NO

(1) An asterisk (*) next to some of the values in this column means that if you press **[Ctrl]** before making a parameter change, larger or smaller increments can be obtained according to the parameter in question.

(2) Initial factory values. By modifying mL/kg in setting IBW-based VT, these values may change (see chapter Initial Verification and Calibration).

(3) These values are shown as a reference, and are to be found in VCV and PCV modes. In order to know the initial values of each mode see the chapter ADL/PED and NEO-INF Operative Modes.

(4) The Minute Volume is programmed only in MMV + PSV. For the rest of the modes, the Minute Volume is the result of other parameters programming (see maximum values by category in Table 17-5).

17.8 | Monitored Parameters

Table 17-8 Monitored Parameters

Parameter	Accuracy
Peak Pressure	±2 cmH ₂ O or ±10%
Plateau pressure	±2 cmH ₂ O or ±10%
Mean Pressure	±2 cmH ₂ O or ±10%
Base pressure	±2 cmH ₂ O or ±10%
Expired tidal volume	±10% if VT < 20 mL; ±2 mL + 10% if VT > 20 mL
Minute volume	±10%
Inspiratory flow	±10%
Respiratory rate	±1 rpm
Inspiratory time	±0.06 s
Expiratory time	±0.06 s
I:E ratio	NA
O ₂ concentration	±3%

17.9 | Alarm Adjustment

Table 17-9 Alarm Adjustment

Alarm	Limits	Increment	Initial Value
Maximum inspiratory pressure (cmH ₂ O)	10 (or >min - 120)	1	ADL: 40 PED: 30 NEO-INF: 25
Minimum inspiratory pressure (cmH ₂ O)	1 - 99 (or <max)	1	ADL: 5 PED: 5 NEO-INF: 2
Maximum tidal volume⁽²⁾ (L)	ADL: >VTmin - 3,0 PED: >VTmin - 0,500 NEO-INF: >VTmin - 0,250	ADL: 0,010 ⁽²⁾ PED: 0,005 ⁽¹⁾ NEO-INF: 0,005 ⁽¹⁾	ADL: 0,600 PED: 0,075 NEO-INF: 0,015
Minimum tidal volume⁽²⁾ (L)	ADL: 0,010 to <VTmax PED: 0,001 to <VTmax NEO-INF: 0,001 to <VTmax	ADL: 0,010 ⁽²⁾ PED: 0,001 ⁽¹⁾ NEO-INF: 0,001 ⁽¹⁾	ADL: 0,150 PED: 0,025 NEO-INF: 0,005
Maximum minute volume (expired)⁽⁴⁾ (L/min)	ADL: >VMmin - 55 PED: >VMmin - 55 NEO-INF: >VMmin - 55	0,01/ 0,05/ 0,1/ 0,5/ 1,0 according to the alarm limit value	ADL: 7,23 (9,0 en MMV+PSV) PED: 1,91 (6,0 en MMV+PSV) NEO-INF: 0,40
Minimum minute volume (expired)⁽⁴⁾ (L/min)	ADL: 0,01 – <VMmax PED: 0,01 – <VMmax NEO-INF: 0,01 – <VMmax	0,01/ 0,05 /0,1 /0,5/ 1,0 according to the alarm limit value	ADL: 2,41 (4,5 in MMV+PSV) PED: 0,63 (3,0 in MMV+PSV) NEO-INF: 0,13
Concentration of O₂ (%)	High: 25 – 110 Low: 19 – 95	1	High: 60 Low: 40
Inadequate oxygen (%)	18 or less (not configurable)	N/A	N/A
Disconnection	N/A (not configurable)	N/A	N/A
Leakage out of range (L/min)	N/A (not configurable)	N/A	ADL: 50 ⁽³⁾ PED: 30 ⁽³⁾ NEO-INF: 10

Apnea (s)	5 - 60	5	15
Low PEEP (cmH₂O)	0 - 6	2	ADL/PED/NEO-INF: 2
Maximum respiratory rate (rpm)	3 - 160	1	ADL/PED: 30 NEO-INF: 40
ETCO₂ (mmHg)	Max: >Min to 150 Min 1 to <Max	1	Max: 50 Min: 30
Continuous high pressure	Alarm condition: 5 cmH ₂ O above the configured PEEP level for over 15 s. Not configurable.		
External power failure	Not configurable. Whatever the cause of the event may be, the ventilator automatically switches to battery operation.		
Dead battery	Null or very low charge level. Replace by an alternative respiratory method. Not configurable.		
Inop. Vent.	When the operation of the ventilator is suspended, replace by an alternative ventilatory method. Not configurable.		
Blower failure	Not configurable. Alarm signals are triggered when excessive power consumption by the blower is detected (caused by increased resistance at the rotation of the blades).		

(1) From 1 to 30 mL it increases per 0.001 L; from 30 to 100 mL it increases per 0.005 L, and >100 mL it increases per 0.010 L.
 (2) In modes of control or target volume, the VTmax is 1.5 IBW-based VT, and the initial VTmin is 0.5 IBW-based VT.
 (3) The values declared for ADL and PED correspond to the NIV mode. For the rest of the modes the Leakage out of range is triggered starting at 15 L/min. In NEO-INF the leakage within range is the same for all modes.

17.10 | Data Collection for Control and Monitoring

Table 17-10 Data collection for control and monitoring

Parameter	Method	Involved Variables	Accuracy
Accuracy	Relative pressure transducers	Control, support and monitored pressures	±2 cmH ₂ O
Controlled flow	Mesh pneumotachograph related to differential pressure transducers	Continuous flow, flow for controlled volume generation	±10%
Monitored flow	Variable opening pneumotachograph related to the pressure differential transducer (optional fixed opening pneumotachograph for the NEO-INF category)	Monitored and plotted flows, and expired volumes	±10%
Volume	It is derived from the corresponding flow measurements	Controlled, monitored and plotted volumes	±10%
Time	Quartz crystal.	Inspiratory and expiratory times, respiratory rate, and I:E ratio. Internal clock.	±0,06 s ± 1 rpm
Concentration of O₂	Galvanic cell	Concentration of O ₂ .	±3% Vol.

17.11 | Electromagnetic Compatibility



WARNING

• The replacement of cables (main power supply or internal cabling) of the equipment by anyone other than those approved by HEYER may result in decreased immunity, or increased emissions reported for iTernIS ADV.

17.11.1 | Manufacturer

Statement:

Electromagnetic Emissions

Table 17-11 Electromagnetic Emissions Statement

<i>iTernIS ADV</i> is intended to be used in the specified electromagnetic environment. The customer and/or user of <i>iTernIS ADV</i> must ensure it is used in an electromagnetic environment as stated in this Table.		
Emission Test	Compliance	Electromagnetic Environment
RF CISPR 11 Emissions	Group 1	<i>iTernIS ADV</i> uses RF energy only for its internal operations. Therefore, its RF emissions are very low and they are unlikely to cause any interference in nearby electronic equipment. <i>iTernIS ADV</i> can be used in all establishments, except in households, and those that are connected directly to the public low voltage power supply network feeding buildings used for domestic purposes.
RF CISPR 11 Emissions	Class A	
IEC 61000-3-2 harmonic emissions	Class A	
IEC 61000-3-3 Voltage fluctuations / discontinuous emissions	According to specifications	

17.11.2 | Manufacturer

Statement:

Electromagnetic Immunity

Table 17-12 Electromagnetic immunity Statement

<i>iTernIS ADV</i> is intended to be used in the electromagnetic specified environment. The customer and/or user of <i>iTernIS ADV</i> must ensure it is used in an electromagnetic environment as stated in this Table.			
Immunity test	IEC 60601-1-2 Test level	Compliance level	Electromagnetic environment
IEC 61000-4-4 Electrostatic Discharge (ESD)	Contact: ± 6 kV. Air: ± 8 kV.	Contact: ± 6 kV. Air: ± 8 kV.	Floors must be wood, concrete, or ceramic. If floors are covered with synthetic material, the relative humidity must be at least 30%.
IEC 61000-4-4 Fast electrical transient in bursts	± 2 kV for power lines. ± 1 kV for input/output lines.	± 2 kV for power lines. ± 1 kV for input/output lines.	The quality of the electrical network must be equivalent to that of a typical commercial or hospital environment.
IEC 61000-4-5 Shock waves	Differential mode: ± 1 kV. Shared mode: ± 2 kV.	Differential mode: ± 1 kV. Shared mode: ± 2 kV.	The quality of the electrical network must be equivalent to that of a typical commercial or hospital environment.
IEC 61000-4-11 Voltage dips, short interruptions and voltage variations on line power input	< 5% UT (low > 95% of UT) for 0.5 cycles. 40% UT (low of 60% of UT) for 5 cycles. 70% UT (low of 30% of UT) for 25 cycles. < 5% UT (low > 95% of UT) for 5 s.	< 5% UT (low > 95% of UT) for 0.5 cycles. 40% UT (low of 60% of UT) for 5 cycles. 70% UT (low of 30% of UT) for 25 cycles. < 5% UT (low > 95% of UT) for 5 s.	The quality of the electrical network must be equivalent to that of a typical commercial or hospital environment. If the user of <i>iTernIS ADV</i> requires maintaining operation during power outages, we recommend connecting the system to an uninterrupted power supply or a battery.

IEC 61000-4-8 Supply frequency magnetic field (50-60 Hz)	3 A/m.	3 A/m.	The supply frequency magnetic field must be characteristic of the levels found in a typical commercial or hospital environment.
NOTE: UT is the voltage of the AC network before applying the test level.			

17.11.3 | Manufacturer

Statement:

Electromagnetic Immunity

Table 17-13 Electromagnetic immunity Statement

<i>iTernIS ADV</i> is intended to be used in the electromagnetic specified environment. <i>The iTernIS ADV</i> customer and/or user must ensure it is used in an electromagnetic environment as stated in this Table.			
Immunity Test	IEC 60601 Level test	Compliance Level	Electromagnetic Environment
			Do not use RF communications equipment, mobile and/or portable (including cables), at a distance from <i>iTernIS ADV</i> less than the separation distance calculated from the equation applicable to the transmitter frequency.
			Recommended separation distance
IEC 61000-4-6 conducted RF	3 Vrms 150 kHz – 80 Mhz outside ISM bands ⁽¹⁾ .	10 Vrms	$d = 0,35\sqrt{P}$
	10 Vrms 150 kHz – 80 MHz within the ISM ⁽¹⁾ bands.	10 Vrms	$d = 1,2\sqrt{P}$
IEC 61000-4-3 Radiated RF	10 V/m 80 MHz - 2,5 GHz	10 V/m	$d = 1,2\sqrt{P}$ for 80 MHz - 800 MHz $d = 2,3\sqrt{P}$ for 800 MHz - 2,5 GHz
			Where P is the maximum power output of the transmitter in Watts (W) according to the manufacturer, and d is the recommended separation distance stated in meters (m) ⁽²⁾. The strength of fields generated by fixed transmitters, as determined by local electromagnetic tests⁽³⁾ must be less than the compliance level for each frequency range⁽⁴⁾. Interference can occur in the vicinity of the equipment marked with the following symbol: 

NOTE 1: For 80 MHz and 800 MHz apply the higher frequency range.

NOTE 2: This guide may not apply to all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects, and people.

(1) The ISM bands (industrial, scientific and medical) between 150 kHz and 80 MHz are 6.765 MHz to 6.795 MHz; 13.553 MHz to 13.567 MHz; 26.957 MHz to 27.283 MHz; and 40.66 MHz to 40.70 MHz.

(2) Compliance levels in the ISM frequency bands between 150 kHz and 80 MHz and in the frequency range of 80 MHz and 2.5 GHz are designed to reduce the possibility that a portable/mobile communications device can cause interference if it is inadvertently introduced into the patient area. For this reason, an additional factor of 10/3 has been added to the formula used for calculating the recommended separation distance for transmitters in these frequency ranges.

(3) Field strengths from fixed transmitters, such as base stations for radio telephones (mobile or wireless) and land mobile radios, amateur radio, AM and FM and TV broadcasts cannot be predicted theoretically with accuracy. To assess the electromagnetic environment at the site, generated by fixed RF transmitters, consider conducting a test in situ. If the measurement of the field strength where *iTernIS ADV* is used exceeds the above RF applicable compliance limits, *iTernIS ADV* must be evaluated to ensure it can operate normally. If abnormal performance is observed, it may be necessary to take additional measures, such as reorienting or relocating the equipment.

(4) Over the frequency range between 150 kHz and 80 MHz, field strengths shall be less than 10 V/m.

17.11.4 | Manufacturer

Statement: Separation Distances

Table 17-14 Recommended Separation Distances Between the Ventilator and Mobile/Portable Communications Devices

iTernIS ADV is intended to be used in an electromagnetic environment in which radiated RF disturbances are controlled. The customer and/or user of *iTernIS ADV* can help prevent electromagnetic interference by maintaining a minimum distance from RF communication equipment, mobile and portable (transmitters) and the *iTernIS ADV* as recommended in this table, according to the maximum power output of the communications equipment.

Maximum Output Power of the Transmitter (W)	Separation Distance According to the Frequency of the Transmitter (m)			
	150 kHz – 80 MHz out of ISM Bands $d = 0,35\sqrt{P}$	150 kHz – 80 MHz Within ISM bands $d = 1,2\sqrt{P}$	80 MHz - 800 MHz $d = 1,2\sqrt{P}$	800 MHz 2,5 GHz $d = 1,2\sqrt{P}$
0,01	0,04	0,12	0,12	0.23
0,1	0,11	0,38	0,38	0.73
1	0,35	1,2	1,2	2.3
10	1,1	3,8	3,8	7.3
100	3,5	12	12	23

For transmitters whose maximum output power is not included in the list above, the recommended separation distance d in meters (m) can be determined using the equation applicable to the frequency of the transmitter, where P is the maximum transmitter output power in Watts (W) according to the manufacturer statement for the transmitter.

NOTE 1

For 80 MHz and 800 MHz, apply the separation distance for the wider range of frequencies.

NOTE 2

ISM bands (industrial, scientific and medical) between 150 kHz and 80 MHz are 6.765 MHz to 6.795 MHz; 13.553 MHz to 13.567 MHz; 26.957 MHz to 27.283 MHz, and 40.66 MHz to 40.70 MHz.

NOTE 3

An additional factor of 10/3 has been incorporated into the formula used for calculating the separation distance for transmitters operating in the ISM frequency band between 150 kHz and 80 MHz, and in the frequency range 80 MHz to 2.5 GHz to reduce the possibility that communication equipment, mobile and/or portable, can cause interference if they are inadvertently introduced in patient areas.

NOTE 4

These guidelines may not be applicable in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

17.12 | Basic Operation of the Ventilator

iTernIS ADV features a microprocessor control system that coordinates the tasks arising from the programming of the equipment. All actions performed by the ventilator are controlled by this system.

The gas flow to the patient is administered by two proportional valves, one for air and the other for oxygen. The valves operate simultaneously, providing adequate oxygen levels and the necessary characteristics of the flow wave.

The expiratory valve is governed by the operation of two attached valves. One of them, with ON/OFF features, controls its opening or closing, which determines the end and start of the inspiratory phase, respectively. The other valve is proportional and regulates the PEEP level, when this is configured.

The microprocessor is fed back with signals from the ventilator sensor system. This allows the program to control and adjust the configured ventilator program. The air pressure is measured with a transducer connected to a sensor at the end

of the patient circuit (expiratory set) or optionally at the connection to the patient for the NEO-INF category (on the proximal pneumotachograph). The signal from this transducer is also used to trigger inspirations when activating pressure detection, breath cycling, alarm levels, among others. Proximal pressure is measured with a transducer near the outlet to the patient. The most important task of this element is pressure control in pressure-controlled mode breathing or with support pressure.

Flow information is obtained by two differential pressure transducers connected to the output internal pneumotachograph and the expiratory pneumotachographs (distal or proximal). The internal pneumotachograph (Silverman mesh type) allows controlling the flow and volume driven by the ventilator in the inspiratory phase. Expired flows are measured through the expiratory pneumotachographs (distal and optionally proximal).

The equipment has a valve system that provides a communication channel between the pressure transducers and ambient pressure. This will allow zeroing the transducers. Simultaneously, air flow is driven to purge the lines of the expiratory pneumotachograph, and avoid water deposits and humidity in the measuring element.

17.13 | Safety Mechanisms

iTermIS ADV has a complete safety system, which includes the operating system that controls the microprocessor, and various components that act independently of these.

- **WATCHDOG:** this is a system that monitors the operation of the electronic circuit, and exerts its control regardless of the integrity of the latter. When it detects an anomaly in the ventilator function, it allows it to suspend, and enables the Emergency Ventilation mode.

Watchdog can activate Emergency Ventilation in two different situations:

- After 30 s elapsed from turning on the ventilator, without selecting a patient category on the first screen of initial calibration.
- When the microprocessor loses control of the sequence that regulates the ventilation program.
- **EMERGENCY VENTILATION:** Emergency Ventilation is a safety mechanism that is activated in conditions of extreme necessity to provide temporary ventilation to the patient until measures are taken to replace the ventilator with an alternative ventilatory mechanism. This is not a valid operating mode.

Emergency Ventilation enables the delivery of breaths with similar characteristics to those of the pressure controlled (PCV). During the course of this event, only peak pressure and respiratory rate are monitored. The preset values for ventilatory parameters are shown in Table 17-15. The alarm limits are not enabled for changes. Active alarms are for Maximum and Minimum pressure, and Maximum respiratory rate, whose limits are shown on screen. The only additional enabled function is Manual Insp.

Table 17-15 Ventilatory Parameters in Emergency Ventilation

Parameter	Initial Value	Range	Observations
Controlled pressure (PCV)	10 cmH ₂ O	2 – 30 cmH ₂ O	The pressure is limited by maximum pressure alarm at 30 cmH ₂ O. This limit cannot be changed.
Ti (inspiratory time)	0.70 s	0.10 – 3.00 s	Inspiratory time may be limited by the frequency value.
Respiratory rate	20 rpm	1 – 100 rpm	The frequency may be limited by the value of the inspiratory time.
Insp. Detection	-2 cmH ₂ O	-0.5 – 20 cmH ₂ O	Detection by flow is not enabled.
Concentration of O ₂	50	-	This parameter cannot be changed.
Rise Time	Same value as in PCV mode	Same range as PCV mode	



WARNING

• In the event that Emergency Ventilation is activated, provide the patient with an alternative ventilation mechanism, and find the cause that generated this event. If it was activated by the delay in accepting the first initial calibration screen, restart the unit to ventilate the patient.

- **SAFETY VALVE:** located immediately before the outlet to the patient. It opens when the pressure within the patient circuit reaches a value of 120 ± 5 cmH₂O. The gas mixture passes into an internal collector and is discharged to the outside.
- **INSPIRATORY RELIEF VALVE (ANTI-SUFFOCATION):** this valve allows the patient to inspire room air, when the unit is energized, or when the ventilator is in inoperative status.
- **OPERATING GAS LEAKAGE:** The gas that can seep into the unit is collected in a common manifold, and directed towards the outside.
- **LACK OF COMPRESSED AIR PRESSURE:** compressed air is used as a control gas of the pneumatic circuit. When this is lacking, oxygen can replace it. Furthermore, when the unit detects lack of air, it automatically switches to an O₂ concentration of 100%.
- **LACK OF OXYGEN PRESSURE:** in this case, the air takes the place of oxygen, and the breaths are delivered with an O₂ concentration of 21%.
- **AUTO-ZEROING:** every 10 minutes, or when the operator enables it (by pressing **[Ctrl] + [Ctrl]**) all pressure sensors are zeroed. This restarts the readings, avoiding offset errors of the measured pressures. During the first minutes of ventilation, the ventilator can implement resets with a frequency greater than the one stated. At each reset, a message is displayed in the Icons and messages bar indicating that this procedure is being performed.

- **CIRCUIT PURGE:** to avoid obstruction and humidity leakage in the pressure sensors, air is injected by the patient circuit, simultaneously with the resetting of pressure sensors.
- **ALARM SYSTEM:** *iTermIS ADV* has an alarm system to warn on situations that pose some degree of risk to the patient or to the unit itself. Some allow preventing the continuation of the condition that triggered it, others just trigger signals to report its presence. For further information on how the alarm system works, refer to the chapter *Alarms*.
- **PARAMETER SETTING:** to prevent inadvertent changes to the parameters, it is required to execute the established sequences on the ventilator controls. Thus, the pressure on a single key or knob, does not allow entering changes. Therefore, the operator is always aware of the actions executed on the unit.

17.14 | Pneumatic Circuit of the Ventilator

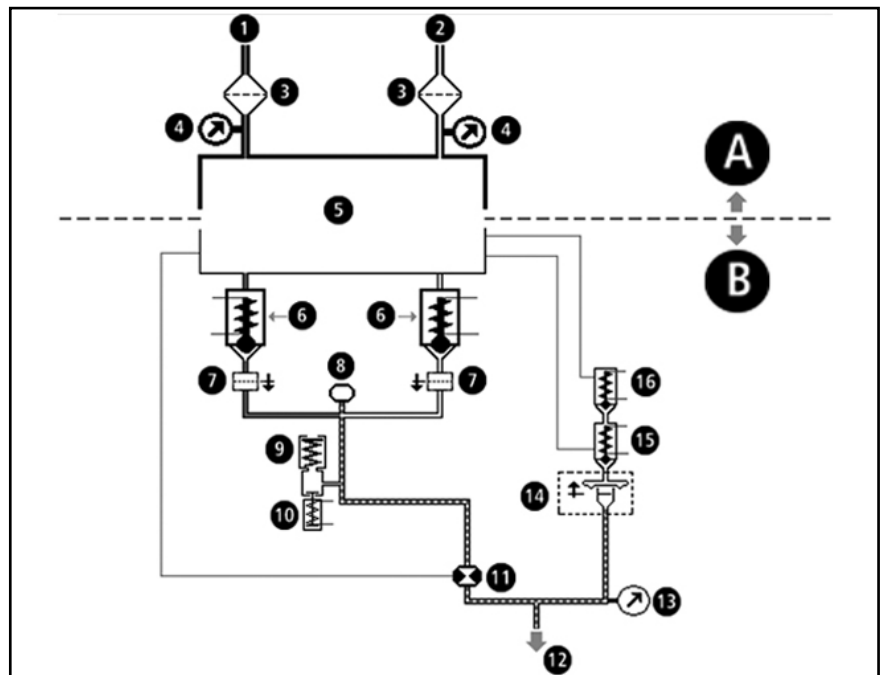


Fig. 17-1 Simplified schematic of the pneumatic circuit of the ventilator.

References for Fig. 17-1

- Ⓐ High pressure sector
- Ⓑ Low pressure sector
- ① Oxygen inlet
- ② Air inlet
- ③ Filter
- ④ High pressure sensors
- ⑤ Pressure regulation stage

- 6 Proportional solenoid valves
- 7 Flow sensor
- 8 Sensor of O₂
- 9 Safety valve
- 10 Inspiratory relief valve (anti-suffocation)
- 11 Nebulizer (optional)
- 12 Outlet "Towards Patient"
- 13 Low pressure sensor
- 14 Expiratory set (expiratory valve and pneumotachograph)
- 15 Cycling valve
- 16 PEEP proportional solenoid valve

17.15 | Lifetime

Table 17-16 Lifetime

Ventilator lifetime	10 (ten) years
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Appendices

CHAPTER CONTENTS

A.I Troubleshootings

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A.I | Troubleshooting

A.I.1 | Initial Calibration

Table A-1 Initial Calibration

Event	Possible Causes	Suggested Action
Leak smaller than 10 L/min	Faulty connections in the patient circuit. Malfunctioning elements of the circuit.	Check the integrity of the patient circuit hoses and accessories. Change the damaged segment, if any. Revise the overall status of the expiratory set, especially the expiratory valve diaphragm.
Leak greater than 10 L/min	Y-shaped connector end without adequate obstruction. Disconnected expiratory pneumotachograph hoses (P1 and P2). No O ₂ sensor. Faulty connections in the patient circuit. Malfunctioning elements of the circuit.	Verify the plug on the Y connector. Check connections on P1 and P2. Verify presence of the O ₂ sensor. Check the integrity of the patient circuit hoses and accessories. Replace the damaged segment, if any.
Defective expiratory set or airtightness loss	Poorly connected pneumotachograph hoses (P1 and P2). Inner membrane damage of pneumotachograph. Partially obstructed Y connector.	Check the cap on the Y connector. Check connections on P1 and P2. Check integrity of the pneumotachograph internal membrane. Solve the failure and execute a new calibration.
Failed calibration of O₂ sensor	Sensor exhausted, or presence of incorrect gas in the OXYGEN inlet.	Verify that the gas supply is actually oxygen and that its concentration is adequate. Verify the status of the O ₂ sensor.
Oxygen sensor not detected	The microprocessor does not receive electrical signals from the sensor.	Check the sensor connection. If the sensor were properly connected, this can signify that the sensor is exhausted, and if so, replace it.
ALARMS during calibration	Low oxygen or air pressure, or low pressure of both gases. Power loss.	See Table for corresponding alarm below.

A.I.2 | Inop. Vent. Alarm

Table A-2 High Priority Alarms

ALARM	Possible Causes	Suggested Action
Inop. Vent.	Microprocessor failure	Contact the authorized technical service

A.I.3 | High Priority Alarms

Table A-3 High Priority Alarms

ALARM	Possible Causes	Suggested Actions
Continuous high pressure	Obstruction in the patient circuit expiratory line and/or expiratory set	Verify that there are no obstructions in the patient circuit (including the expiratory set). Free the obstructions, if any. Otherwise, perform a reset to zero of the pressure sensors ([Ctrl] + [Ctrl]). If the condition persists, remove the service ventilator, replace with an alternative ventilation system and contact the authorized technical service.
High pressure	Changes in the patient's breathing mechanics. Obstruction of the patient circuit. Low alarm limit.	Examine the patient. Verify the limit of the configured alarm; modify this if it is too low. Look for obstructions in the patient circuit.
Minimum pressure	Changes in the patient's breathing mechanics. Leaks in the circuit. High alarm limit.	Examine the patient. Verify the limit of the configured alarm; modify this if it is too high. Look for possible leaks in the patient circuit.
Low air and oxygen pressure	Gas panel locks closed. Supply hoses obstructed. Exhausted O ₂ tube or closed regulator. Air compressor out of service.	Check all listed items as possible causes.
Low oxygen (or air) pressure	The possible causes of the preceding event, for gas with low supply pressure.	Follow the suggested recommendations for the aforementioned event.
Dead battery	Prolonged internal battery operation	Plug the electric power cable to an adequate network distribution. If the battery does not recharge, it may have to be changed. In that case, try an alternative ventilation system and contact the authorized technical service.
Disconnection	Disconnected patient circuit hoses or disconnected elements of intubation.	Check all junction points between the hoses, the ventilator, and the patient circuit accessories. Verify the status and position of the intubation element used.
Oxygen concentration less than 18%	Incorrect gas supply. Disconnected or depleted O ₂ sensor.	Verify that the O ₂ source supplies adequate gas. Check the sensor connections. After having identified and solved the problem, recalibrate the O ₂ sensor.
Maximum and minimum ETCO₂	Incorrectly established alarm limits. Sensor adapter in poor condition. Changes in the patient's breathing mechanics.	Check to make sure the sensor adapter is in optimal operating condition (free of dirt). Check conditions of the alarm limits and of the patient mechanics.

Emergency Ventilation	Activation of Watchdog operation	If emergency ventilation begins within 30 s of the time the power of the equipment has been turned on, and has not begun the initial calibration, turn it off and on again. If the aforementioned situation is repeated, or the Watchdog is triggered during the ventilation of a patient, replace the ventilator with an alternative ventilation system and contact the authorized technical service.
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A.I.4 | Medium Priority Alarms

Table A-4 Medium Priority Alarms

ALARM	Possible Causes	Suggested Action
Maximum minute volume	Incorrectly configured alarm limit. Changes in breathing mechanics.	Check the alarm limit. If this is correct, check the patient for changes in breathing mechanics. If necessary, set a new alarm limit.
Minimum minute volume	The possible causes are identical to the previous event.	Follow the suggested recommendations for the aforementioned event.
Maximum tidal volume	Changes in the patient's breathing mechanics. Very low alarm limit.	Check the configured alarm limit, and examine the patient in search of new conditions in the mechanical ventilation.
Minimum tidal volume	Look for possible leaks in the patient circuit. Changes in the patient's breathing mechanics. Very high alarm limit.	Check for the presence of leaks in the patient circuit. Check the configured alarm limit, and examine the patient in search of new conditions in the mechanical ventilation.
Power loss	Disconnected power cable Outage in the local electric power supply. Burned-out fuse.	Check power supply cord connection, and/or integrity of the fuses.
High/low concentration of O₂	Inadequate supply of O ₂ . Presence of O ₂ in the compressed air inlet. Sensor exhausted.	Verify the source of O ₂ supply. Check that the gas at the AIR inlet is compressed air. If the gas supply is correct, recalibrate the O ₂ sensor to rule out the option of empty cell (for low concentration). Otherwise, change the sensor.
Apnea condition	Cessation of patient's spontaneous activity. Very high inspiratory detection. Leaks in continuous CPAP waveform (NEO-INF).	Check the value of the configured inspiratory detection, and correct it if necessary. Check presence of the patient's inspiratory efforts. Check that there are no leaks in the patient circuit, nor at the patient/patient circuit interface level.
Leakage is not compensable	Presence of leaks in the patient circuit.	Check hoses and accessories of the patient circuit for cracks or defective connections.
Blower failure	Obstructed blower.	Verify that there is no object or dirt obstructing the movement of the blower.
Volume target not reached	Changes in the patient's breathing mechanics. Pressure alarm limits Incorrectly configured.	Review the pressure alarm limits. Check current status of the patient for changes in breathing mechanics.

A.I.5 | Low Priority Alarms

Table A-5 Low Priority Alarms

ALARM	Possible causes	Suggested action
Maximum rate	Low alarm limit. Leaks in the patient circuit.	Check the alarm limit, and correct it if necessary. In the case of major leaks, high frequency auto-triggering can be generated with the configured alarm limit. In this case, identify the possible areas of leakage and repair them.
PEEP loss	Incorrectly configured alarm limit. Leaks. Faulty expiratory valve diaphragm.	Review the alarm limits and identify the possible areas of leakage. Lastly, check the status of the valve diaphragm. If necessary to replace the diaphragm, use an authentic one.
Nebulization OFF	Insufficient peak flow, operate with nebulization.	The nebulization is reset if the peak flow is enough to be compatible with the nebulization.
Transporting	Lack of gas pressure at the AIR inlet, and activation of the Transfer function. This must be activated by the user.	No corrective action is suggested. When the air supply is reset, or when the user disables the Transfer function, the alarm signals disappear.

A.I.6 | Capnography Messages

Table A-6 Capnography Messages

Message	Possible Causes	Suggested Action
CO ₂ no breathing detected	Apnea condition Disconnected adapter of the sensor, or of the patient circuit. Damaged or dirty adapter.	Check the capnograph adapter connections. Clean if the windows are very dirty.
CO ₂ out of range	Measured value exceeds 150 mm Hg.	Perform a reset to zero.
Check the patient adapter	Sensor out of the adapter. Optical blocking of the adapter windows. Defective reset to zero.	Check the presence of the sensor in the adapter. Check that the adapter windows are free of dirt. In this case, clean the adapter, allowing the sensor to release any residual CO ₂ from its interior, and execute a new reset to zero.
Sensor failure	Possible disconnection.	Check the sensor electrical connection with the ventilator. If the error persists, contact the authorized technical service.
Sensor not activated	Poorly executed compensation of barometric pressure and gases during the initial calibration of the ventilator.	Activate sensor, or save parameters from the capnography menu.
Zero required	Problems with the reset to zero of the capnograph. Dirt, for example.	Repeat reset to zero.
Sensor overheated	Sensor exposed to external heat sources.	Check presence of heat sources within proximity of the sensor, such as lamps or stoves. If the message persists, contact the authorized technical service.

Warranty Declaration

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

1. Within the warranty period we will eliminate free of charge any defects or damages on the device that are shown to be caused by a manufacturing or material error. The warranty does not include easily breakable parts, e.g. glass or consumable parts.
2. Warranty services can only be claimed upon submission of a delivery note (bill of delivery or invoice); the type and method of damage remedy (repair or replacement) shall be at the discretion of HEYER Medical AG. Warranty services do not result in an extension of the warranty period, nor do they entail a new warranty being granted. There is no independent warranty period for installed spare parts.
3. Excluded from the warranty are: Damages caused by improper use, operating errors, mechanical stress or non-observance of the operating instructions, as well as damages caused by force majeure or by extraordinary environmental conditions.
4. Warranty services may only be claimed if proof is submitted to confirm that all service and maintenance work has been carried out by authorized staff.
5. The warranty includes all faults that impair a faultless functioning of the device on the basis of technical defects of individual components. The warranty obligation can only be recognized by us if the device has been used properly and according to its intended use and no repair attempts have been undertaken by the client himself or by third parties. The warranty claim does not include faults caused by mechanical damages or if the device is being operated with accessories originating from third parties.
6. The warranty is also void if changes, alterations or repairs are made to the device by persons not authorized to do this.
7. The warranty claim only applies to customers of HEYER Medical AG; it cannot be transferred to third parties.
8. The rejected device is to be shipped back to our plant postage free. In case of a request by our customer service department, the costs for shipping to the plant are to be initially generally borne by the customer. After successful repair, we will send the device back freight collect. If HEYER Medical AG confirms the existence of a warranty claim, the customer will receive reimbursement for the costs of delivery and/or transport of the apparatus. Repair parts that do not fall under the warranty claim will be billed by us. The shipping of the device to us always counts as a complete assignment to eliminate all faults and/or replace missing parts, unless the customer expressly excludes partial services. Additional claims to transfer or reduce and replace damages of any kind in particular also of damages not incurred on the object of delivery itself are excluded.

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