ResMed

Astral™ series

Clinical guide

English

Contents

Introduction 1
- Indications for use 1
- Indications for use (USA only) 1
- Contraindications 1
- Adverse effects 2
- General warnings and cautions 2

The Astral system 4
- The Astral device 5
- The Astral device interface 6
- Touch screen 7
- Information bar 8
- Menu bar 9
- Bottom bar 9
- Main screen 9
- Pressure bar 10
- Settings bar 10

Circuits and patient interfaces 11

Patient circuit accessories 11

Power accessories 11
- Power supplies 12
- Astral External Battery 12
- ResMed Power Station II (RPSII) 12
- Remote Alarm II 12
- Pulse oximeter 12

Optional accessories 13
- Astral Mobility bag 13
- Astral SlimFit Mobility bag 13
- ResMed Homecare Stand 13
- Astral Table Stand 13
- Aerogen® nebuliser 13
- ResMed Connectivity Module (RCM) 13
- ResMed Connectivity Module for Hospital (RCMH) 13

Using the Astral device 14
- Connecting to mains power 14
- Powering on the device 14
- Powering off the device 15
- Accessing Clinical mode 15
- Using the Setup Assistant 16
- Enhanced access feature 19
- Starting and stopping ventilation 20

Locking and unlocking the touch screen 21
Navigating the menus 21
Monitors menu 22
Setup menu 23
Alarms menu 23
Information menu 24
Programs 24
Working with programs 24
Setting up a new program 26
Adjusting patient settings 28
Monitoring ventilation 29
Device settings 31
Adjusting device settings 32
Copying device settings 32
Exporting device settings onto USB stick 33
Importing device settings from the USB stick 33
Service reminders 34
Using the Service reminders 34
Circuit options....35
Assembling patient circuits 35
Fitting the circuit adapter 37
Connecting a single limb circuit with intentional leak 37
Connecting a single limb circuit for invasive use 38
Connecting a single limb circuit with expiratory valve 39
Connecting a double limb circuit (Astral 150 only) 40
Connecting a mouthpiece circuit 41
Changing the circuit selection 42
Learn Circuit 42
Accessories 46
Attaching patient circuit accessories 46
Attaching a humidifier 46
Attaching a Heat Moisture Exchange (HME) 47
Attaching an antibacterial filter 48
Adding supplemental oxygen 49
Monitoring delivered oxygen 50
Attaching a nebuliser 51
Attaching other accessories 52
Attaching a pulse oximeter 52
Attaching a remote alarm 53
Astral Carry Bag 53
Travelling with the Astral device 54
Power management 55
Connecting to mains power 56
Connecting the Astral External Battery 57
Using the External Battery 57
Connecting to a ResMed Power Station (RPSII) 58
Connecting to an external DC power source 58

Using the internal battery 59
Battery run time 59
Storing and recharging 60
Device power source indicators 61
Using the Astral device for the first time 62
Ventilation modes 63
(A)CV mode - Assisted volume-controlled ventilation 64
P(A)CV mode - Assisted pressure-controlled ventilation 65
P-SIMV - Pressure Synchronised Intermittent Mandatory Ventilation 66
V-SIMV - Volume Synchronised Intermittent Mandatory Ventilation 68
PS mode - Pressure support 70
(S)T mode - Spontaneous Ventilation with backup rate 72
P(A)C mode 73
CPAP mode 74
iVAPS (intelligent Volume Assured Pressure Support) mode 75
Target alveolar ventilation 75
intelligent Backup Rate (iBR) 76
Configuring iVAPS 77
Adopting recently learnt targets 77
Adopting recently learnt targets 77
Entering the target values manually 79
AutoEPAP 81
Flow shape settings 82
Interdependence of controls 83
Dynamic settings limits 83
Making use of Astral's High Pressure limit 83
Triggering and cycling 84
Triggering with intentional leak circuits 85
Cycling with intentional leak circuits 85
Triggering with valve circuits 86
Changing the Trigger Type 87
Cycling with valve circuits 88
Triggering with mouthpiece circuits 89
Supplementary features 90
Manual breath settings 90
Sigh settings 92
Apnea Settings 92
Control settings for Apnea ventilation 93
(A)CV Breath pattern 93
P(A)CV breath pattern 94
Safety volume settings 95
Non-invasive ventilation (NIV) 96
Mask NIV 96
Mouthpiece NIV 96
Mouthpiece ventilation 96
Safety considerations for mouthpiece ventilation 97

Alarms 98
Alarm priority 99
Viewing the active alarms 101
Muting alarms 101
Resetting alarms 102
Adjusting alarm settings 103
Setting the alarm volume 104
Testing the alarm sounders and indicators 105
Testing the Remote Alarm 105
Testing the alarms 106
Testing the power alarms 106
Testing the pressure alarms 107
Testing the ventilation monitoring alarms 107
Testing the oximetry alarms 108
Testing the oxygen alarms 108
Testing the breathing circuit alarms 108
Testing the disconnection alarm 108
Alarm settings and conditions 109
Tidal volume alarms 109
Minute volume alarms 109
Respiratory rate alarms 110
Pressure alarms/limits 110
High pressure 110
Obstruction 111
Low pressure 111
PEEP 112
Breathing circuit alarms 112
High leak 112
NV Mask/Rebreathing 112
Flow sensor not calibrated 113
Circuit configuration alarms 113
Disconnection alarm 113
Oxygen alarms 114
Oximetry alarms 114
SpO2 114
Pulse rate 114
Apnea alarm 115
Ventilation stopped alarm 115
Power alarms 115
System alarms 115
Detecting circuit disconnection and de-cannulation 116
Astral Disconnection Alarm 117
Adjusting the Disconnection Alarm 117
Setting and testing Disconnection Tolerance 117
Setting Activation Time 119
Disabling (or enabling) the Disconnection Alarm 120

Data management process 122
Data management summary 123
Deleting patient data 124
Cleaning and maintenance 125
Single patient use 125
Weekly 125
Monthly 125
Multi-patient use 126
Replacing components 127
Replacing the air filter 127
Replacing the expiratory flow sensor and antibacterial filter (Astral 150 only) 128
Replacing the double limb adapter (expiratory valve) 129
Replacing the Oxygen sensor 129
Replacing the internal battery 130
Servicing 131
Maintenance Timetable 131
Internal Battery 131
Device information 132
Upgrading software 132
Additional considerations for hospital or healthcare facilities 132
Technical specifications 133
Monitoring 138
Time parameters 138
Volume and flow parameters 138
Pressure parameters 139
Other parameters 139
Accuracy of controls 140
Measurement System and Accuracy 143
Functional variants 143
Guidance and Manufacturer's Declaration Electromagnetic Emissions & Immunity 144
Guidance and manufacturer's declaration—electromagnetic emissions 144
Guidance and manufacturer's declaration – electromagnetic immunity 145
Recommended separation distances between portable and mobile RF communications equipment and the life support device 147
Potential impact of electromagnetic disturbances 147
Symbols 148
Standards compliance 149
Training and support 149
Troubleshooting 150
Alarm troubleshooting 150
Learn Circuit troubleshooting 155
General troubleshooting 158
Recommendations for suctioning 159
Limited warranty 160

Appendix A: Definitions 161
Ventilation settings definitions 161
Measured and calculated parameter definitions 163
Appendix B: Ventilation parameters.....165
Ventilation Parameters summary table.....165
Ventilation displayed parameters.....169
Supplementary Features 169
Supplementary Features displayed parameters.....172
Appendix C: Alarm parameters 174

Introduction

The Astral device provides mechanical ventilation to both ventilation dependent and non-dependent patients. It delivers pressure and volume ventilation through either a valve or leak circuit, and is compatible with a range of accessories to support specific use cases.

The information in this guide applies to both the Astral 100 and the Astral 150 devices. Where information applies to only one of these devices, that device will be specified.

Note: Some features may not be available on your device.

⚠ WARNING

- **Read the entire manual before using the Astral device.**
- **Use the Astral device only as directed by a physician or healthcare provider.**
- **Use the Astral device only for the intended use as described in this manual. Advice contained in this manual does not supersede instructions given by the prescribing physician.**
- **Install and configure the Astral device in accordance with the instructions provided in this guide.**

⚠ CAUTION

In the US, Federal law restricts this device to sale by or on the order of a physician.

Indications for use

The Astral 100/150 provides continuous or intermittent ventilatory support for patients weighing more than 11 lb (5 kg) who require mechanical ventilation. The Astral device is intended to be used in home, institution/hospital and portable applications for both invasive and non-invasive ventilation.

Indications for use (USA only)

The Astral 100/150 provides continuous or intermittent ventilatory support for patients weighing more than 11 lb (5 kg) who require mechanical ventilation.

The iVAPS mode with optional AutoEPAP is intended for patients weighing more than 66 lb (30 kg).

The Astral device is intended to be used in home, institution/hospital and portable applications for both invasive and non-invasive ventilation.

⚠ CAUTION

The Astral device is not intended for use as an emergency transport ventilator.

Contraindications

The Astral device is contraindicated in patients with the following pre-existing conditions:

- pneumothorax or pneumomediastinum
- pathologically low blood pressure, particularly if associated with intravascular volume depletion
- cerebrospinal fluid leak, recent cranial surgery or trauma
- severe bullous lung disease
- dehydration.

⚠ WARNING

AutoEPAP is contraindicated when using an invasive interface.

Adverse effects

Report unusual chest pain, severe headache or increased breathlessness to your physician. The following side effects may arise during use of the device:

- drying of the nose, mouth or throat
- nosebleed
- bloating
- ear or sinus discomfort
- eye irritations
- skin rashes.

General warnings and cautions

The following are general warnings and cautions. Further specific warnings, cautions and notes appear next to the relevant instruction in the manual.

A **warning** alerts you to possible injury.

⚠ WARNING

- If you notice any unexplained changes in the performance of the device, if it is making unusual or harsh sounds, if the device or the power supply are dropped or mishandled discontinue use and contact your healthcare provider.
- For ventilator-dependent patients, always have alternate ventilation equipment available, such as a back-up ventilator, manual resuscitator or similar device. Failure to do so may result in patient injury or death.
- The Astral device is a restricted medical device intended for use by qualified, trained personnel under the direction of a physician. Clinical supervision is required in critical care/intensive care unit environments.
- Ventilator-dependent patients should be continuously monitored by qualified personnel or adequately trained carers. These personnel and carers must be capable of taking the necessary corrective action in the event of a ventilator alarm or malfunction.
- The internal battery is not intended to serve as a primary power source. It should only be used when other sources are not available or briefly when necessary; for example, when changing power sources.
- The Astral device is not intended to be operated by persons (including children) with reduced physical, sensory or mental capabilities without adequate supervision by a person responsible for the patient's safety.
- The Astral device is not intended to be operated by patients unless they have been given adequate instruction concerning the operation of the device by a person responsible for the patient's safety.
- The Astral device must not be used in the vicinity of an MRI or diathermy device.
- The effectiveness of ventilation and alarms should be verified including after any ventilation or alarm setting change, any change in circuit configuration, or after a change to co-therapy (eg, nebulisation, oxygen flow).
- The Astral device and AC Power Supply can get hot during operation. To prevent possible skin damage do not leave the Astral device or AC Power Supply in direct contact with the patient for extended periods of time.
- The device can provide therapies typically associated with both ventilator-dependent and non-dependent patients. The mode of ventilation, circuit type, and alarm strategies should be chosen after a clinical evaluation of each patient’s needs.
- The device must not be used at an altitude above 9842 ft (3000 m) or outside the temperature range of 32–104°F (0–40°C). Using the device outside these conditions can affect device performance which can result in patient injury or death.

A **caution** explains special measures for the safe and effective use of the device.

⚠ CAUTION

- Repairs and servicing of the device should only be performed by an authorized ResMed service representative.
- The temperature of the airflow for breathing produced by the device can be as much as 43°F (6°C) higher than the temperature of the room. Caution should be exercised if the room temperature is warmer than 95°F (35°C).
- Do not expose the device to excessive force, dropping or shaking.
- Dusty environments may affect device performance.
- The Astral device may be used in the vicinity of electronic article surveillance (EAS) systems during mobile situations when attached to the patient or patient's wheelchair. The Astral device may experience interference in the vicinity of EAS. Keep the Astral device at least 8" (20 cm) away from the EAS. Note that the EAS might be concealed. If you experience any type of electromagnetic interference, move away from the suspected source.

A **note** advises of special product features.

Notes:

- When using Astral for long term invasive ventilation in the home, due consideration should be given to relevant practice guidelines such as the AARC Clinical Practice Guideline for Long Term Invasive Mechanical Ventilation in the Home - 2007 Revision & Update (www.rcjournal.com/cpgs/pdf/08.07.1056.pdf)
- For assistance and reporting of issues associated with the Astral device, contact your Health Care Provider or authorized ResMed representative.

The Astral system

The Astral system comprises a number of components, including:

- Astral device with:
  - hypoallergenic air inlet filter
  - internal battery
- Power Supply Unit (PSU)
- AC Power cord
- Astral carry bag
- Single limb adapter
- Single limb leak adapter
- Double limb adapter (Astral 150)
- ResMed USB stick
- Astral User Guide
- Astral Clinical Guide CD.

Optional accessories are also available for use with the Astral device, and include:

- Remote Alarm II
- Astral External Battery
- ResMed Power Station II (RPS II)
- Astral Mobility Bag
- Astral SlimFit Mobility Bag
- ResMed Homecare Stand
- Astral Table Stand
- Pulse oximeter
- Aerogen® nebuliser
- ResMed Connectivity Module (RCM)
- ResMed Connectivity Module for Hospital (RCMH).

Note: Some accessories may not be available in all regions.

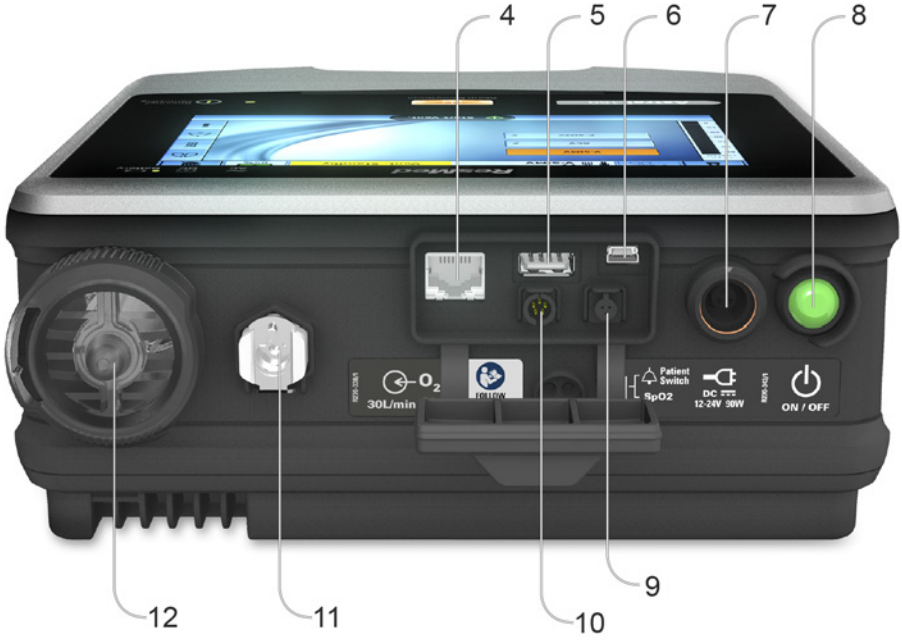
For a full list of accessories, see Ventilation accessories on www.resmed.com under the Products page. If you do not have internet access, please contact your ResMed representative.

⚠ WARNING

Before using any accessory, always read the accompanying User Guide.

The Astral device

The following images describe the components of the Astral device.



	Description
1	Adapter port Can be fitted with single limb adapter, single limb leak adapter or double limb adapter (Astral 150 only).
2	Handle
3	Inspiratory port (to patient) Provides an outlet for pressurised air to be delivered to the patient via the patient circuit. Includes FiO_2 sensor on the Astral 150. The FiO_2 sensor is an optional accessory on the Astral 100.
4	Ethernet connector (service use only)
5	USB connector (for download to ResScan and connection of approved accessories)
6	Mini USB connector (for connection to RCM or RCMH)

	Description
7	DC power inlet
8	Device on/off push button
9	SpO_2 Sensor connector
10	Remote alarm five pin connector
11	Low flow oxygen input (up to 30 L/min)
12	Air inlet (complete with hypoallergenic filter)

The Astral device interface

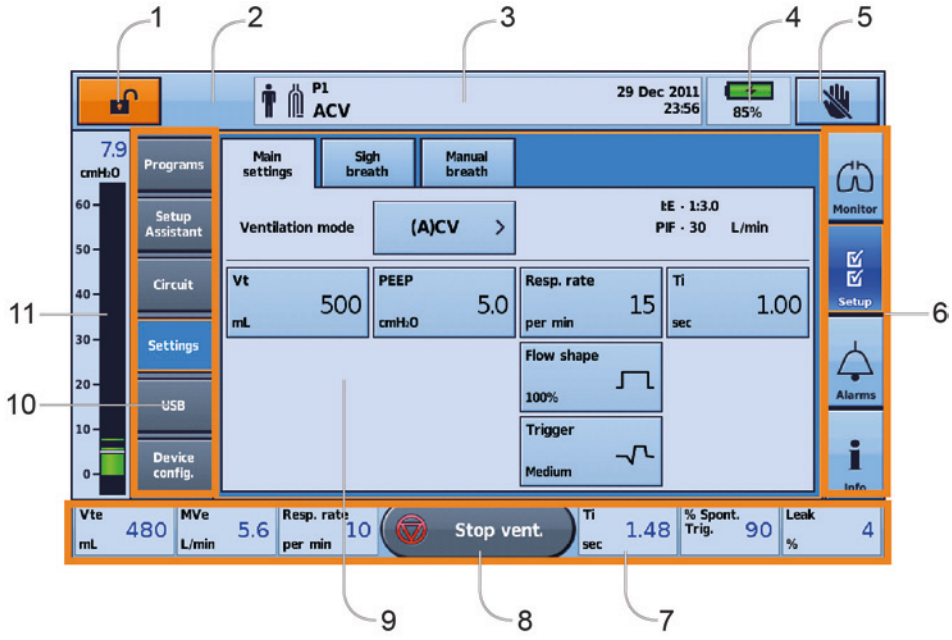
The interface of the Astral device comprises several different features described in the following image.

	Description
1	Touch screen
2	Power source indicators AC (mains power supply) DC (external battery or car accessory adapter or RPSII) Internal battery
3	Therapy on/off indicator **Device ready** Constant green display when the device is turned on but not ventilating. **Device ventilating** Flashes blue when the device is ventilating and the Ventilation LED setting is 'ON'. Otherwise is 'OFF'.
6	

	Description
4	Alarm mute/reset button Illuminates when an alarm is triggered and flashes when the sound is muted.
5	Alarm bar Flashing red — High priority alarm Flashing yellow — Medium priority alarm Constant yellow — Low priority alarm

Touch screen

The main method of interacting with the Astral device is via the touch screen. The display on the touch screen changes according to the function being performed.



	Description
1	Clinical mode access button Locked — Unlocked
2	Manual breath button only shown if enabled
3	Information bar
4	Internal battery indicator 100% — 8h00 — 70%
5	Lock touch screen button
6	Menu bar
7	Bottom bar

	Description
8	Start/Stop ventilation button
9	Main screen
10	Sub-menus
11	Pressure bar

Information bar

The Information bar is displayed at the top of the touch screen. The Information bar displays the operating status of the device, including patient type, current circuit configuration, programs, information messages, ventilation status, alarms and power status.

	Description
	Patient type – Adult
	Patient type – Pediatric
	Circuit type – Single limb with intentional leak
	Circuit type – Single limb with expiratory valve
	Circuit type – Double limb
	Circuit type – Mouthpiece
P1:DAY	Program number and program name
(A)CV	Ventilation mode
	Multiple alarms are active simultaneously. The highest priority active alarm is displayed first.
Message window	Will display alarms or information. Image above shows device in Standby. (Displayed when the device is powered on but not ventilating). Date and time will be displayed when the device is ventilating and there are no active alarms. Information messages are displayed in blue text. If the device Alert tone setting is 'On', you will be alerted to new information messages by a single beep.

Menu bar

The Menu bar provides access to the four main menus in the Astral device.

Monitors menu

View real-time patient data in either waveform or monitoring formats including pressure, flow, leak, tidal volume, synchronisation and oximetry.

Setup menu

Configure and view ventilation therapy or device settings; and import/export data.

Alarms menu

Configure and view alarms including alarm volume.

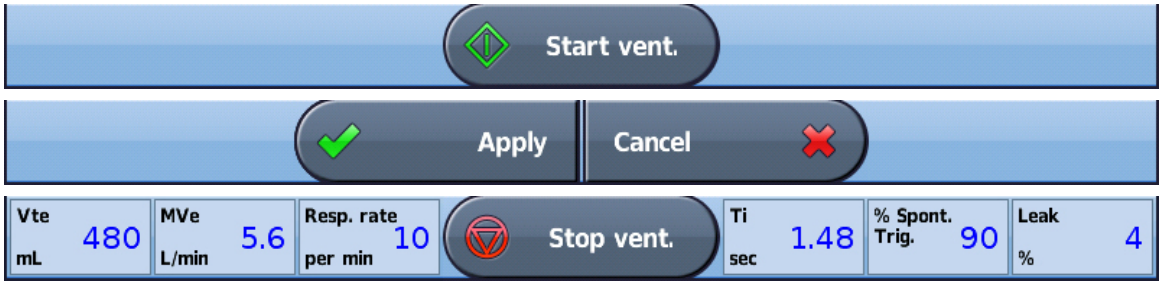
Information summary menu

View therapy statistics, used hours, events, reminder and device information.

Bottom bar

The Bottom bar changes with the function of the device.

It can display buttons to Stop or Start ventilation and Apply or Cancel functions. It can also display real-time readings.



Main screen

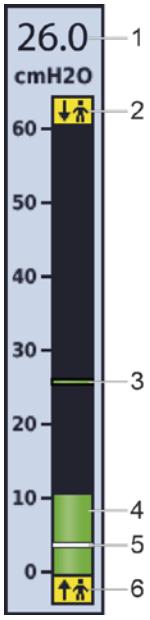
The Main screen displays the monitoring data, ventilation and device controls. Each function is accessed through the various menus and tabs.

Pressure bar

The Pressure bar displays real-time therapy data while the Astral device is ventilating.

Patient pressure is shown as a bar graph. Peak inspiratory pressure is shown as a numerical value and watermark. Spontaneously triggering and cycling is indicated by and .

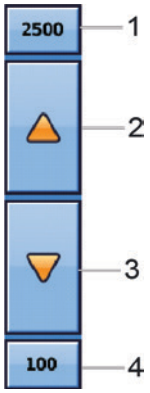
The example below displays the pressure bar when a patient is spontaneously breathing.



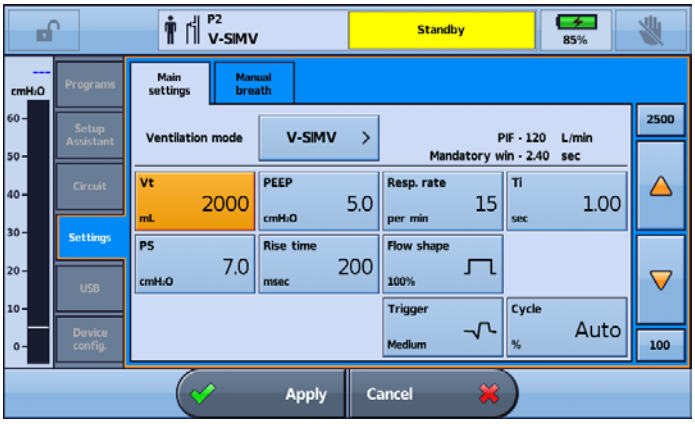
	Description
1	Peak inspiratory pressure (PIP) value
2	Spontaneous cycled breath marker—indicates patient-cycled breath
3	Peak inspiratory pressure marker
4	Current pressure
5	Positive end expiratory pressure (PEEP) setting
6	Spontaneous triggered breath marker—indicates patient-triggered breath

Settings bar

The settings bar appears on the right hand side of the touch screen when a therapy or alarm setting has been selected for adjustment. The settings bar allows the settings to be adjusted via the up and down scroll arrows or the minimum and maximum buttons. The example below displays the settings bar when a setting has been selected for adjustment.



	Description
1	Maximum button—adjusts setting to maximum limit
2	Up scroll arrow—increases setting by single increment
3	Down scroll arrow—decreases setting by single increment
4	Minimum button—adjusts setting to minimum limit



Circuits and patient interfaces

The following circuits are available for use with the Astral device.

- Single limb circuit with intentional leak (provides a leak compensated estimate of patient flow and exhaled tidal volume)
- Single limb circuit with expiratory valve
- Double limb circuit (exhaled gas returns to the device for monitoring) (Astral 150 only)
- Mouthpiece circuit (tube-only circuit for use with mouthpiece interfaces)

The Astral device is compatible with the following invasive and non-invasive patient interfaces:

Invasive

- endotracheal tubes
- tracheostomy tubes

Non-invasive

- vented and non-vented masks
- mouthpiece.

⚠ WARNING

The measurement of patient exhaled gas volume may be affected by leak.

Patient circuit accessories

The following patient circuit accessories are available for use with the Astral device:

- Humidifier
- Heat Moisture Exchange (HME)
- Antibacterial filter

For information on attaching and using patient circuit accessories, refer to Attaching patient circuit accessories (see page 46).

Power accessories

⚠ WARNING

- **The Astral device should only be used with accessories recommended by ResMed. Connection of other accessories could result in patient injury or damage to the device.**
- **Connecting the Astral device to the battery of a battery-powered wheelchair may affect the device performance and may result in patient harm.**

The Astral device can be connected to a range of accessories as follows:

- Astral External Battery
- ResMed Power Station II
- Astral DC adapter
- ResMed Remote Alarm II
- Pulse Oximeter.

Power supplies

In addition to the internal battery and mains power sources, the Astral device can be powered from the following sources:

- Astral External Battery
- ResMed Power Station II
- Astral DC adapter.

Astral External Battery

The Astral External Battery has been designed specifically for use with the Astral series of ventilators. It is intended to provide Astral ventilators with eight hours of power when mains power is unavailable during typical use.

ResMed Power Station II (RPSII)

The RPSII is an external lithium-ion battery that provides power when mains power is unavailable.

Remote Alarm II

The Remote Alarm II is self-powered (via battery) and connected to the Astral device via a cable. If required, a second Remote Alarm can be attached to the first Remote Alarm. This enables Remote Alarms to be placed in two separate locations. The Remote Alarm II can also be connected to a hospital alarm management system. For more information, see the Remote Alarm II user guide.

Pulse oximeter

Attaching a pulse oximeter to the Astral device enables real-time SpO_2 and pulse readings to be viewed from the Monitoring menu. For further information, refer to Attaching a pulse oximeter (see page 52).

Optional accessories

The Astral device can be used with a range of optional accessories as follows:

- Astral Mobility Bag
- Astral SlimFit Mobility Bag
- ResMed Homecare Stand
- Astral Table Stand
- Aerogen® nebuliser
- ResMed Connectivity Module (RCM)
- ResMed Connectivity Module for Hospital (RCMH).

Note: Some accessories may not be available in all regions.

Astral Mobility bag

The Astral Mobility Bag offers extra protection to the Astral device and enables patients to easily transport the device while ventilating. The bag may be carried by hand, worn as a backpack or attached to a wheelchair.

The bag holds the Astral device, optional battery pack and an Astral power supply unit.

Astral SlimFit Mobility bag

The Astral SlimFit Mobility Bag is a slim, light-weight bag that allows discrete, mobile use of the Astral device. The bag may be carried by hand, worn as a backpack or attached to a wheelchair.

The bag holds the Astral device, with an optional detachable pouch for storage of an external battery or power supply unit.

ResMed Homecare Stand

The ResMed Homecare Stand is designed to hold and move compatible ResMed ventilators and accessories between points of therapy in the hospital and limited care facilities. For further information, see the Homecare Stand user guide.

Astral Table Stand

The Astral Table Stand provides an ergonomic and convenient solution for placing the Astral device on a bedside table. The stand holds the Astral at an inclined angle for convenient operation by both the carer and the patient. The stand holds both the Astral device and its external power supply.

Aerogen® nebuliser

If required, a nebuliser can be used in conjunction with the Astral device. ResMed recommends Aerogen® nebuliser products. For more information, refer to Attaching a nebuliser (see page 51).

ResMed Connectivity Module (RCM)

The RCM provides cellular connection between a compatible ResMed ventilation device and the ResMed AirView™ system. For further information, see the RCM user guide.

ResMed Connectivity Module for Hospital (RCMH)

The RCMH provides connection between compatible ResMed ventilation devices and hospital Electronic Medical Record (EMR) systems. For further information, see the RCMH user guide.

Using the Astral device

⚠ WARNING

Make sure the area around the device is dry, clean and clear of bedding or clothes or other objects that could block the air inlet. Blocking the cooling vents could lead to overheating of the device. Blocking the air inlet could lead to patient injury.

⚠ CAUTION

- To prevent possible damage to the ventilator, always secure it to its stand or place it on a flat, stable surface. For mobile situations, ensure the Astral device is contained within its mobility bag.
- Ensure the device is protected against water if used outdoors.

Connecting to mains power

To connect to mains power:

1. Connect the DC plug of the supplied ResMed external power supply unit to the rear of the Astral device.
2. Connect the power cord to the ResMed power supply unit.
3. Plug the other end of the power cord into the power outlet.

For further information on powering the Astral device, refer to Power management (see page 55).

Powering on the device

To power on the Astral device, simply press the green power on/off button at the back of the device. The device will perform a system check as shown on the main screen.

On completion of the system check, the Patient Home screen and active program is displayed.

The Astral device is factory pre-set with one active program.

If more than one program displays on the Patient Home screen, the active program will be highlighted orange. For further information, refer to Programs (see page 24).

Note: Settings configured in the active program will be used when ventilation is started.

Powering off the device

The Astral device can only be powered off when ventilation is stopped.

Removing AC power does not power off the device. The device remains powered on internal battery.

Turning off the device must be done manually and must be performed before leaving the device disconnected from AC power for any extended period of time. Failure to do so may result in battery depletion and activation of alarms.

To power off the device, press the green on/off button at the back of the device and follow the on-screen prompts. To ensure the device is fully powered down, touch the screen.

Note: While the device remains connected to external mains power, the internal battery continues to charge.

Accessing Clinical mode

The closed padlock indicates the device is in Patient mode. To access clinical functions, such as the Setup Assistant and program configurations, you must enter Clinical mode.

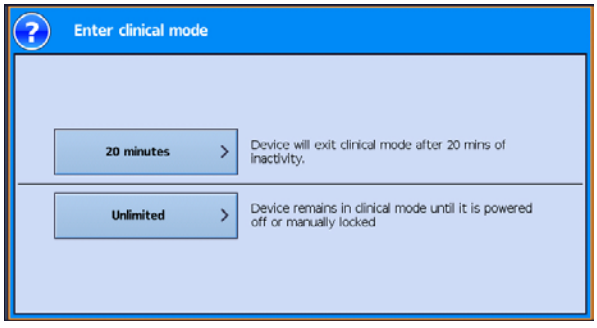
Clinical mode can be accessed from any screen, whether or not the Astral device is ventilating.

To access Clinical mode:

1. From the patient home screen, press and hold for 3 seconds, then release.
2. Select:

   20 minutes—the device will return to patient mode after 20 minutes of inactivity, or

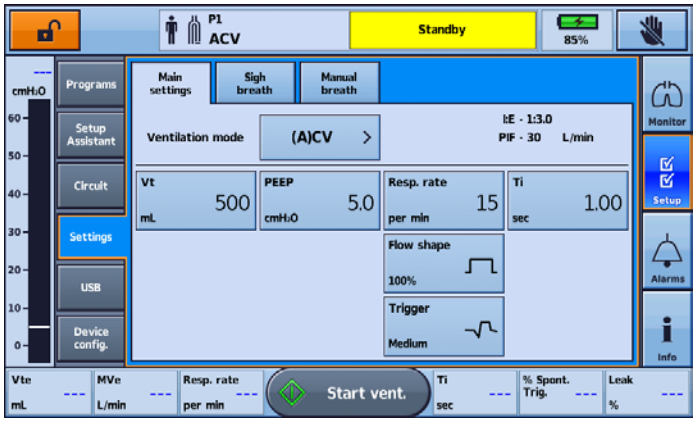
   Unlimited—the device will remain unlocked until powered off or manually locked.



CAUTION

Only select Unlimited if the device will remain under the continuous supervision of qualified trained personnel under the direction of a physician. When clinical access is no longer required, exit Clinical mode to return to Patient mode.

The padlock is unlocked and the Main Settings screen is displayed.



To exit Clinical mode:

1. Press . The Exit Clinical Mode screen is displayed.
2. Press **Confirm.** The padlock is locked and the Patient Home screen is displayed.

Note: If you do not make a selection within 7 seconds, the device returns to the previous screen.

Using the Setup Assistant

To quickly set up the Astral device and start ventilation, use the Setup Assistant.

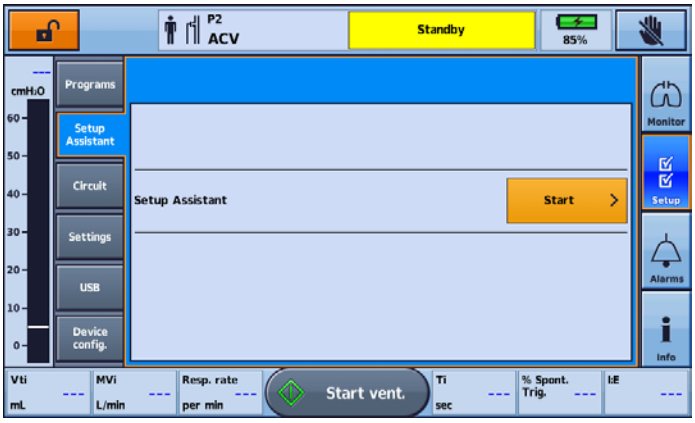
The Setup Assistant guides you through the process of setting up the device for use by a **new patient.** The Setup Assistant prompts you to assemble components and automates testing of the circuit. For detailed instructions on assembling patient circuits, and other components and accessories, refer to Assembling patient circuits (see page 35).

The Setup Assistant can only be accessed when the Astral device is in Clinical mode.

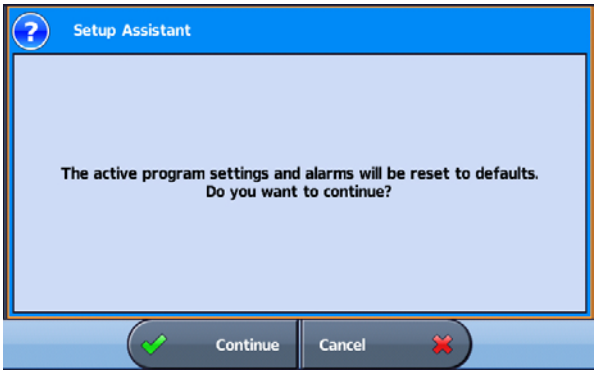
Note: Using the Setup Assistant will clear the current settings of the active program.

To use the Setup Assistant:

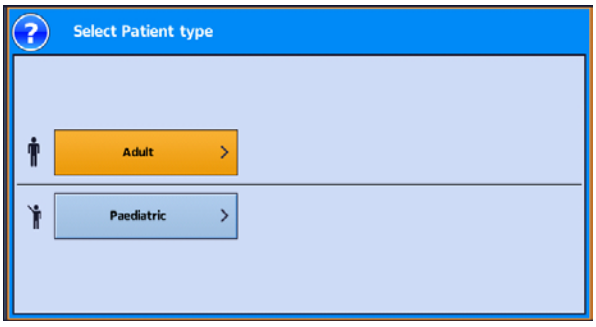
1. Access Clinical mode.
2. From the Main menu press Setup . The Setup menu is displayed.
3. Select **Setup Assistant** and press **Start**.



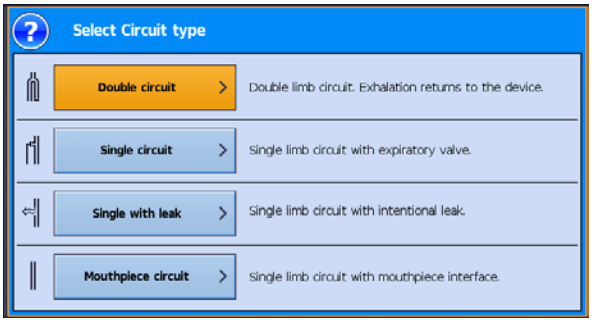
4. A warning message will display. Select **Continue**.



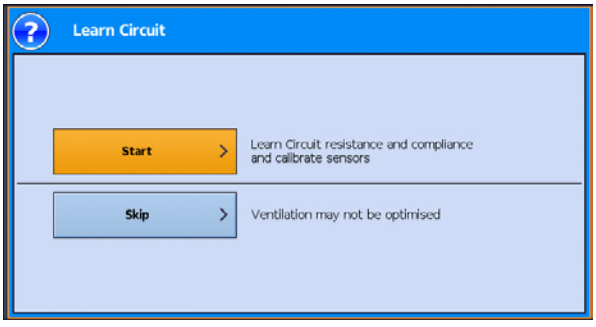
5. Select the Patient type. This will automatically configure default alarm and setting ranges.



6. The Select Circuit type screen is displayed. Select the circuit type to be connected to the device.



7. The Learn Circuit screen is displayed. Press **Start.**

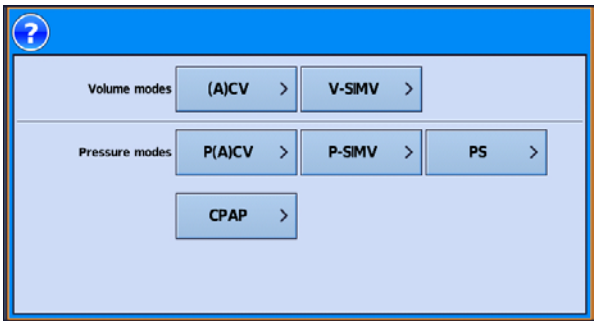


8. Follow the prompts to attach and test the circuit. For detailed instructions on how to attach the circuit, refer to Assembling patient circuits (see page 35).

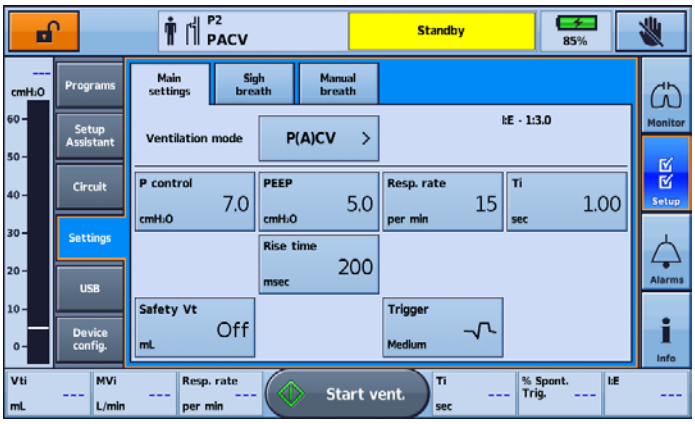
   When the Learn Circuit is complete, you will be prompted to select your required Interface type. The interface type selection is used to determine if the disconnection alarm can be turned off and also sets a suggested setting for the disconnection alarm.

Note: If the circuit is single with leak and Mask is selected as the Patient interface, the Select Mask Type screen will appear.

9. Select the required Ventilation mode.



The default settings for the mode are displayed.



10. Review and adjust the settings and alarms as required.

    For further information on adjusting setting parameters and alarm settings, refer to Adjusting patient settings (see page 28) and Adjusting alarm settings (see page 103).

11. Press

to start ventilation.

Enhanced access feature

The Astral device offers an enhanced access feature ('Big buttons' mode) to provide easier usability and accessibility for starting and stopping ventilation as well as Alarm mute.

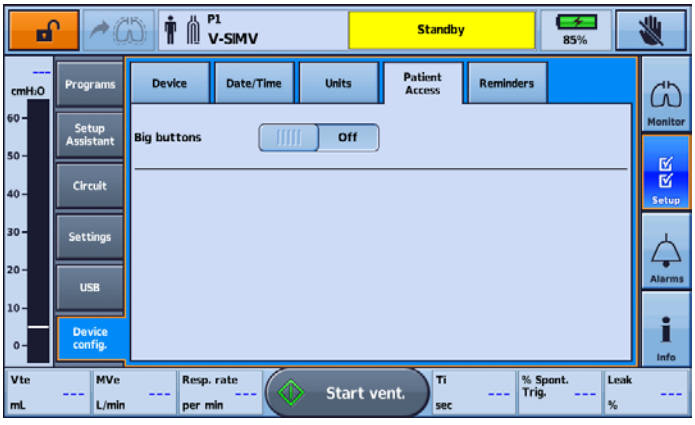
The 'Big buttons' mode can be switched on and off as required in either Clinical or Patient mode.

⚠ WARNING

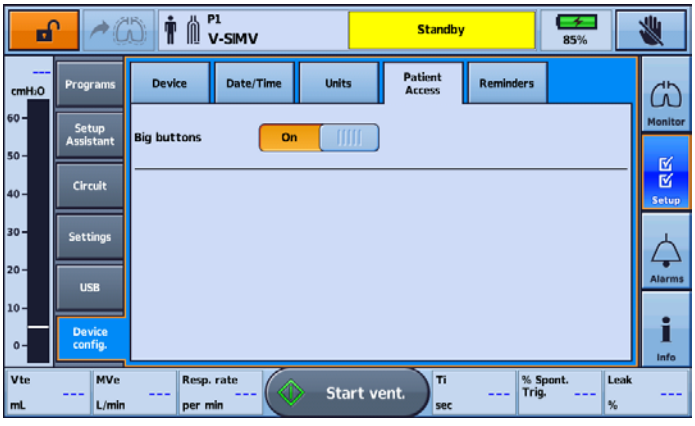
To prevent inadvertent alarm mute or reset, do not leave the patient in contact with the device screen.

To enable the 'Big buttons' mode:

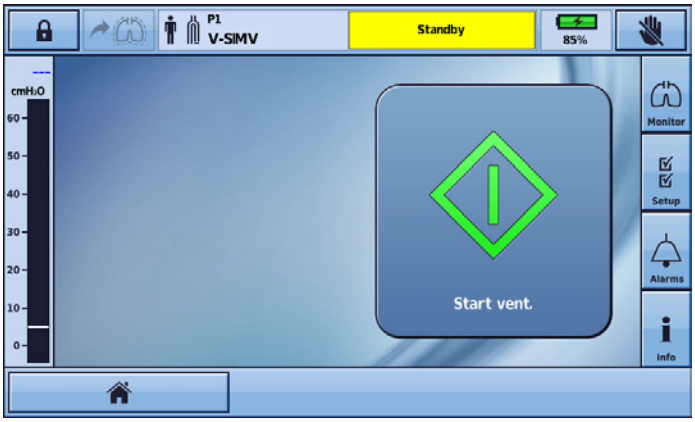
1. From the Main menu press Setup ☑. The Setup menu is displayed.
2. Select the **Patient Access** tab from the **Device Config.** menu.



3. Move the Big buttons slider to **On**.



Your enhanced access feature is now enabled.



With this feature enabled, it is possible to switch between 'Big buttons' mode and standard. Simply select the Home button from left hand corner of the Bottom bar.

Your screen will return to standard button size and the Home icon will be replaced by the Big buttons icon .

To return to 'Big buttons' mode, simply select the Big buttons icon from the bottom bar.

Note: With the enhanced access feature enabled, your screen will return to 'Big buttons' mode once the screen locks (after two minutes of inactivity).

Starting and stopping ventilation

⚠ WARNING

Always ensure that the values in the ventilation therapy and alarm settings are appropriate before starting therapy.

Note: If using the device for the first time, ResMed recommends performing a functional test before starting ventilation. Refer to Using the Astral device for the first time (see page 62).

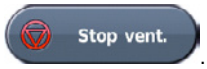
To start ventilation:

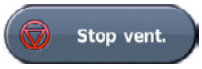
1. Press the green on/off button at the back of the device (if power is not already on).
2. Press

. Ventilation is started.
3. Add oxygen if required.

To stop ventilation:

Ventilation can be stopped at any time and from any screen.

1. If oxygen is connected, turn off the oxygen.
2. Press and hold 

.
3. Release 

when prompted.
4. Press **Confirm.** Ventilation is stopped.

Locking and unlocking the touch screen

The touch screen can be unlocked at any time in both Patient and Clinical modes.

To manually lock the touch screen, from the Information bar press . When the touch screen is locked the button is highlighted orange.

Unlocking the touch screen

Touch the screen anywhere and follow the on-screen prompts.

Navigating the menus

The Astral device has four menus accessible via the Menu bar. Each menu is further broken down into various sub-menus.

This chapter focuses on what the menus are and their structure. For information on adjusting and configuring features, refer to Using the Astral device (see page 14).

Monitors	Waveforms	
	Monitoring	
	Trends	
Setup	Programs*	
	Setup Assistant*	
	Circuit	
	Settings	Main Settings Manual Breath Sigh breath
	USB	Patient Data Settings Upgrade
	Device Config.	Device Date / Time Units Patient access

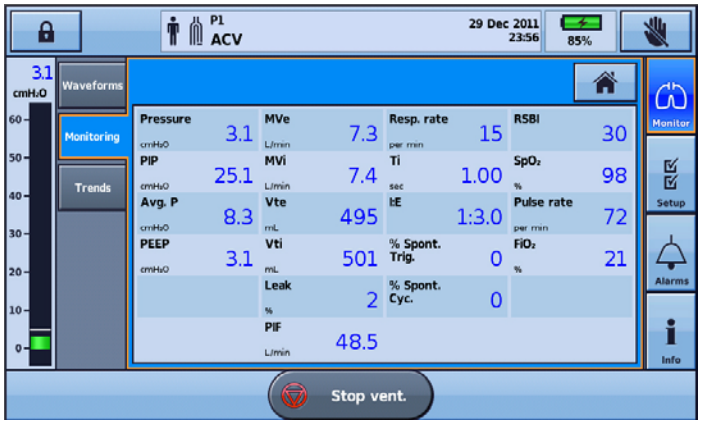
Alarms	Alarms 1 & 2	Tidal Volume (Vt) Minute Ventilation (Mv) Respiratory Rate Pressure Low PEEP Ventilation Stop Leak Non-vented Mask (NV Mask) / Rebreathing
	Alarm 3	FiO_2 SpO_2 Pulse
	Apnea Response	Apnea Response Apnea Detection
	Alarm Volume	Alarm Level Alarm Minimum Volume Alarm Test
	Disconnection Alarm	Disconnection Alarm
Information	Events	Alarms Settings System Delete
	Device	Basic Advanced
	Battery	Charge Maintenance

* Available in Clinical mode only.

Monitors menu

The Monitors menu allows you to view real-time ventilation data and is comprised of three sub-menus:

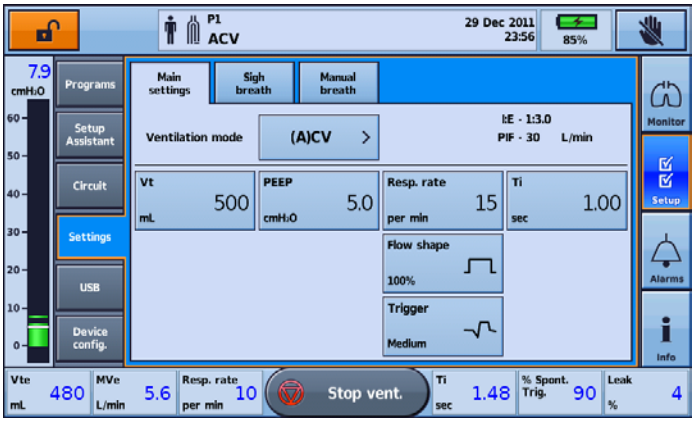
- Waveforms
- Monitoring
- Trends



Setup menu

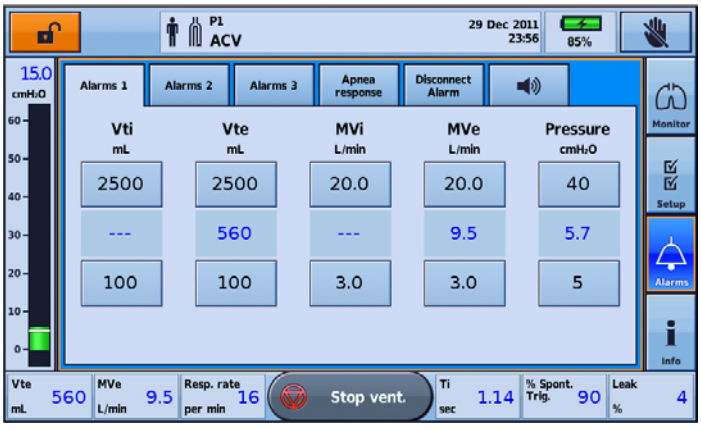
The Setup menu displays six different sub-menus:

- Programs—to configure therapy programs
- Setup Assistant—guides you through device setup
- Circuit—to set up the circuit
- Settings—to change the ventilation mode and related settings
- USB—to save patient data and import/export settings
- Device config.—to change the device configuration.



Alarms menu

Display the Alarms menu to view/update the individual thresholds for each alarm to trigger. Real-time values are displayed between the upper and lower thresholds. The options available for adjustment change depending on the circuit configuration.



Information menu

The Information menu is comprised of three sub-menus:

- Events—all logged event activity that has taken place is displayed. A breakdown of specific alarms, settings or system events can also be viewed.
- Device—information about the actual device is displayed, eg, Model and Serial numbers, Software version, and Next service due date.
- Battery—information about the state of charge of the internal and external batteries when connected including the combined total battery charge.

Programs

⚠ WARNING

The safety and effectiveness of ventilation therapy and alarms settings should be verified for each enabled Program.

Working with programs

The Astral device comes factory preset with one active program. Additional programs can be enabled. Astral 100 provides a maximum of two programs. Astral 150 provides for a maximum of four programs.

Programs allow for different circuit, ventilation and alarm settings. Programs provide convenient patient access to different device configurations to suit their needs such as sleeping, daytime use, and exercise or physiotherapy. A list of options is available to allow for each program to be named accordingly. Once configured, enabled programs can be selected from the Patient Home Screen.

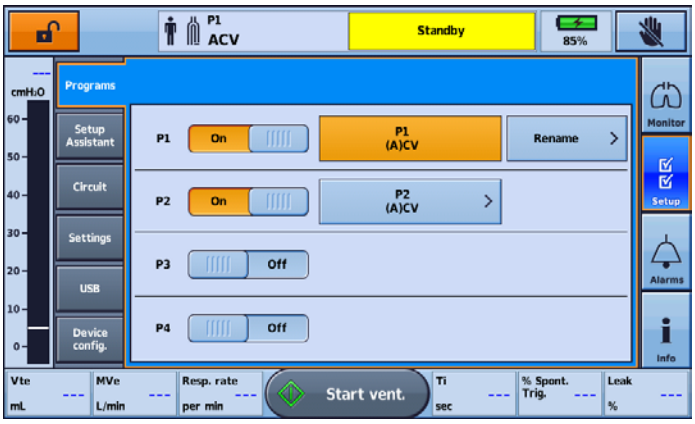
When configuring each new program, connect the appropriate circuit and perform a Learn Circuit.

To enable / disable additional programs:

1. Access Clinical mode.
2. From the Setup main menu, select **Programs.**
3. Enable additional programs by pressing the slider.

   Note: The current active program is highlighted in orange and cannot be disabled.

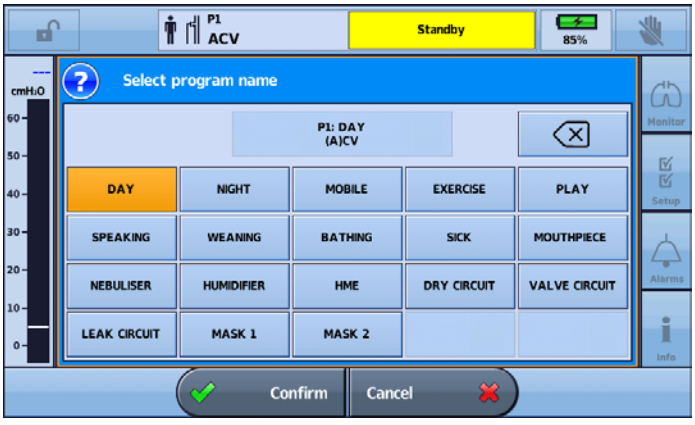
In the screen below, P1: (A)CV is the current active program. P2 has been enabled and is showing the factory preset mode.



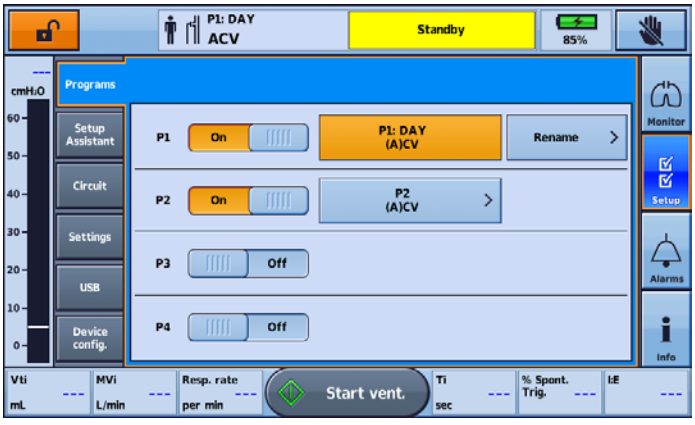
4. Rename the program by pressing the Rename button.

   Within the Rename window, a name for the current active program can be chosen from the list provided. In the screen below, the selected name DAY is highlighted.

   Note: A selected name can be removed by pressing the delete button .

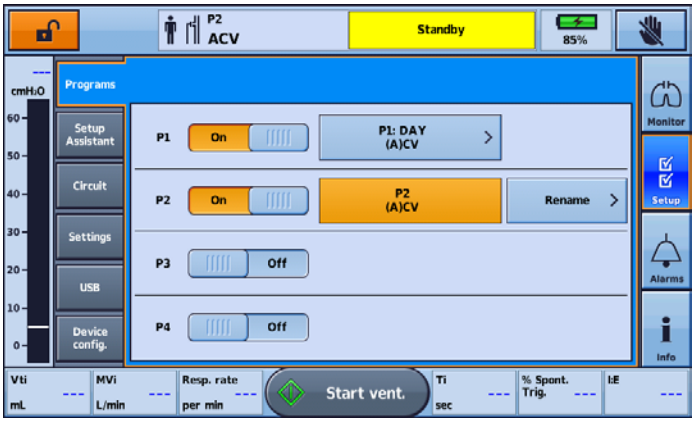


5. When selected, the program name is displayed on the program label and on the information bar when that program is active.



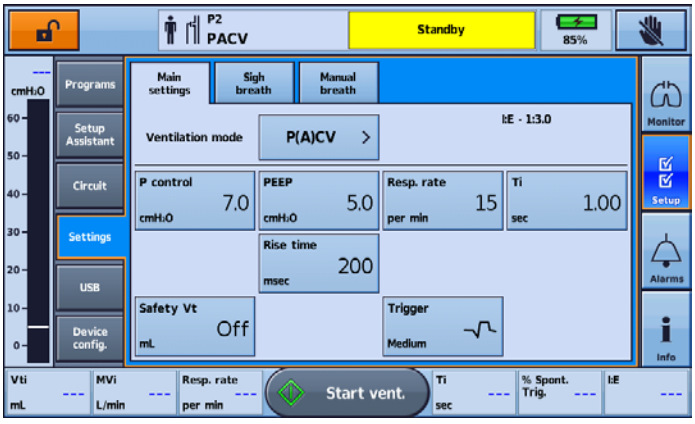
To change programs:

1. Select P2: (A)CV. P2 becomes the active program.



2. **Select** and start the **Setup** assistant. Refer to Using the Setup Assistant (see page 16).

   Once the Setup assistant is complete, P2 will now be configured to the settings you have chosen and is ready to Start ventilation. In the example below, P2 has been changed from (A)CV mode to P(A)CV.



Note: Each program retains its own circuit configuration. When switching between programs, ensure you use the correct circuit as 'learned' for that program.

Setting up a new program

Adjustments to program settings can only be made to the current active program. To make changes to settings of other programs, you must first activate that program.

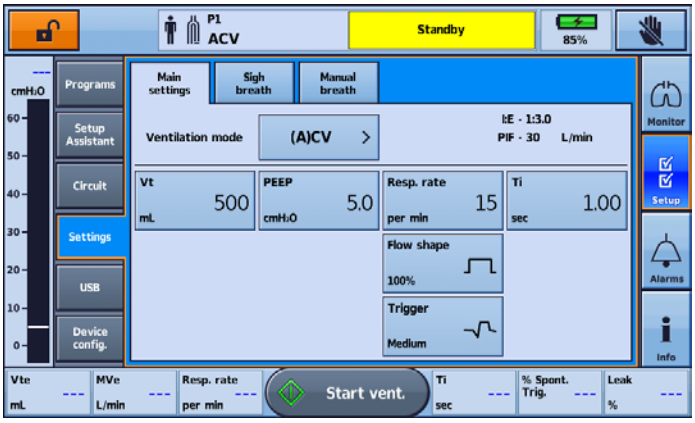
Adjustments to patient settings can be made while the device is Ventilating or in Standby mode.

⚠ WARNING

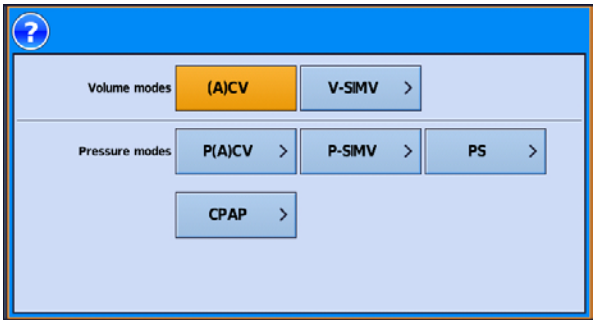
Always review and adjust alarm Settings when setting up a new program. For information, refer to Adjusting alarm settings (see page 103).

To adjust the Ventilation mode of the current active program:

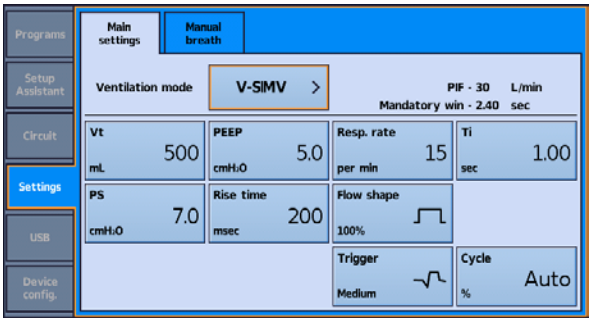
1. Access Clinical mode, the Main Settings screen will be displayed automatically.
2. The current active Ventilation mode and settings are displayed.



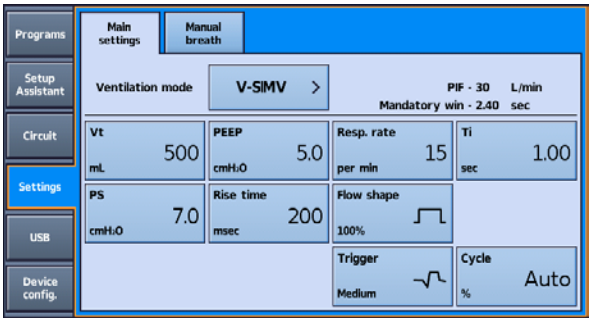
3. Press the **Ventilation mode** button. The **Select Ventilation Mode** screen will display, the current active Ventilation mode will be highlighted orange. Select your required Ventilation mode.



4. You will be returned to the Main Settings page. All changes you have made will be outlined in orange, indicating a pending status until you press **Apply.** If the mode change is cancelled you will be returned to the current active mode's primary settings page. Any modifications will be disregarded.



5. Once settings have been applied the program is updated with the new Mode selection. Perform a Learn Circuit.
6. To make changes to the patient settings within this mode, refer to Adjusting patient settings (see page 28).



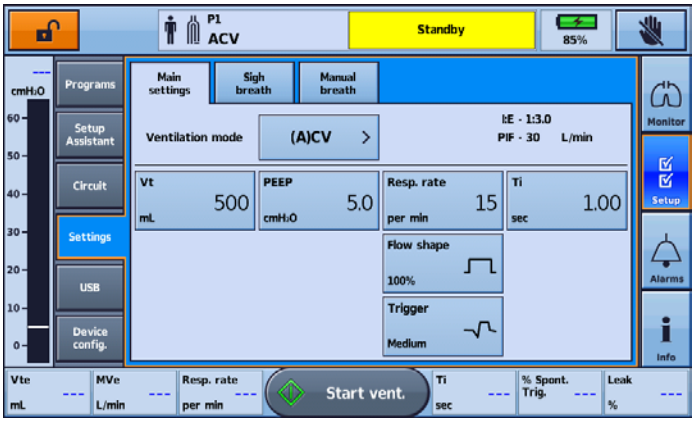
Note: If the mode change is cancelled you will be returned to the current active mode's primary settings page. All modifications will be disregarded.

Adjusting patient settings

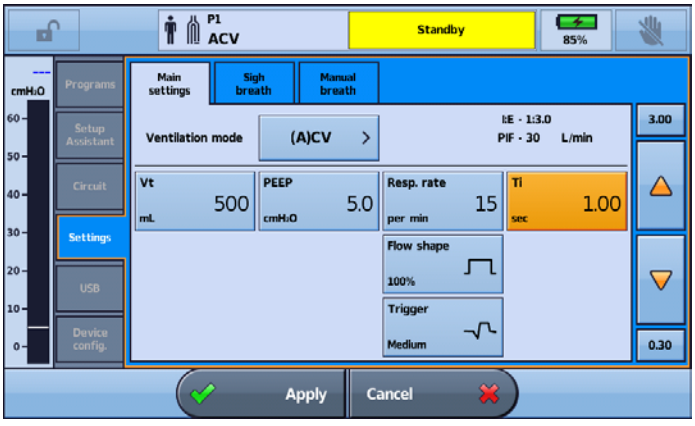
To adjust patient settings of the current active program:

1. Access Clinical mode.

   The Main settings screen will be displayed.



2. Select the setting that you want to adjust. The selected setting is highlighted in orange and the Settings bar appears on the right side of the screen.



3. Increase or decrease the selected setting as desired.
4. If adjustments to other selected settings are required, select the desired settings and repeat this process. All settings that have been adjusted are shown with an orange outline.
5. If no further adjustments are required, select **Apply.**

Review and adjust alarm settings as required. Refer to Adjusting alarm settings (see page 103) for more information.

Notes:

- The Apply button is disabled if one or more settings cannot be applied. Refer to Interdependence of controls (see page 83). A message is displayed indicating the reason.
- If the mode change is cancelled you will be returned to the current active mode's primary settings page. All modifications will be disregarded.

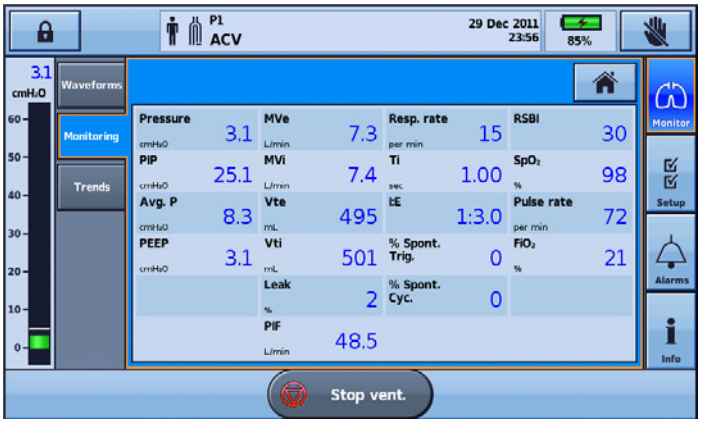
Monitoring ventilation

During ventilation, ventilation parameters are continuously monitored and displayed in real-time. The measures are displayed as follows:

- Numerical values on the Monitoring screen and a summary of critical values in the bottom bar.
- Graphically on the Waveforms, Trends screen and Pressure bar.

Monitoring screen

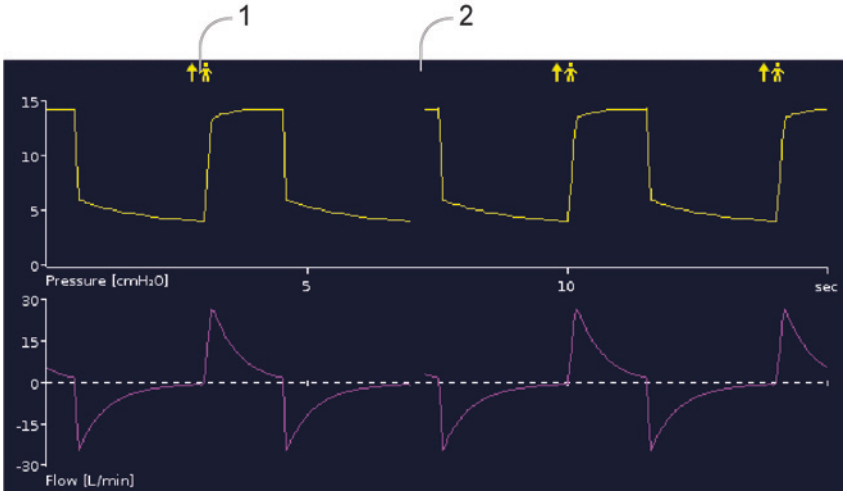
The Monitoring screen displays all measured parameters in numerical form.



For details on the available monitoring parameters refer to the Ventilation Parameters Summary Table (see page 165).

Waveforms

The Waveforms screen displays the last 15 seconds of patient airway pressure and flow in a graph. The graph updates in real-time and when necessary the vertical axis will auto scale to accommodate changes in amplitude.



	Description
1	Spontaneous trigger breath marker—indicates patient-triggered breath.
2	Break in graph—indicates the current position and moves from left to right.

Continuously displayed monitors

During ventilation, the Bottom bar displays the current measures for VT, MV, Resp.rate, Ti, % Spont Trig, and Leak. For a detailed description of the Bottom bar refer to Getting to know the Astral device (see page 6).

During ventilation, the Pressure bar displays real-time airway pressure, PEEP and PIP. For a detailed description of the Pressure bar refer to Getting to know the Astral device (see page 6).

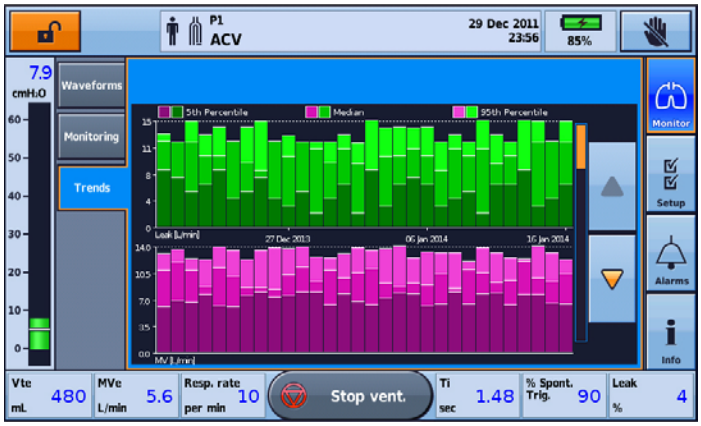
Both the Bottom bar and Pressure bar remain visible from other screens. This permits critical ventilation parameters to be continuously monitored while performing other tasks on the Astral device.

Note: The ventilation measures on the Bottom bar will be hidden while an action request is displayed. For example Apply/Cancel.

Trends screen

The Trends screen shows the 5th and 95th percentile values, as well as the median for the last 30 days for each of the following parameters:

- Leak
- Minute ventilation
- Peak inspiratory pressure
- Tidal volume
- Respiratory rate
- Inspiratory time
- SpO_2
- Pulse rate
- FiO_2
- Alveolar ventilation.



Information is displayed as bar graphs, with two graphs per screen.

Use the up and down scroll arrows to cycle through the graphs.

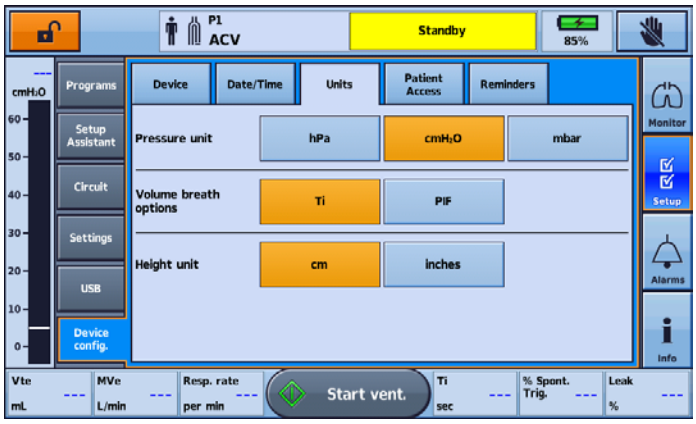
Device settings

All device configuration settings are stored independently of patient programs. The configurable settings are described in the following table.

Device setting	Adjustable by patient	Description
Inspiratory Phase Duration Options	N	Determines how to set-up the inspiratory phase for volume controlled breaths. Can be set to either Ti Option or PIF Option. Default: Ti Option
Alert tone	Y	Sets alert tones to on or off. Default: On Note: When 'On' you will be alerted to the display of new information messages by a single beep.
Minimum alarm volume	N	Allows a minimum volume level to be set for the device. Any setting less than the set minimum will be visible, but not able to be selected. Default: 3
Alarm volume	Y	Sets the volume level of the alarm system. Settings from 1, 2, 3, 4 or 5. Default: 3
Auto power off	Y	Automatically powers off the device after 15 minutes of inactivity. Conditions: The device is in Ventilation standby mode (not ventilating), is being powered by the Internal battery or an External battery Default: On
Display brightness	Y	Sets the brightness of the screen from Auto with a selection of five different brightness levels. Default: Auto
Backlight timeout	Y	Allows the screen backlight to turn off (go black) if the screen has not been touched for two minutes or more and there are no active alarms. Setting to 'Off' will mean the screen back-light will be permanently on. Default: On
Rotate display	Y	Flips the current orientation of the display.
Device Vent LED	Y	Sets the status of the Ventilation active LED to On or Off during ventilation. Default: On
Date	Y	Allows setting of the day, month and year of the current date.
Time	Y	Allows setting of the hours and minutes of the current time.
Language	Y	Sets the current language of the device selected from the list of available languages.
Pressure unit	N	Specifies displayed units for all pressure data and settings as cmH_2O, mBar or hPa. Note: The reference unit for all accuracy and monitoring claims is hPa. The conversion factor between units in accordance with industry practice is one.
Height unit	N	Specifies displayed units for the patient's height as inches or cm.
Big buttons	Y	Sets Big buttons feature to On or Off.

Adjusting device settings

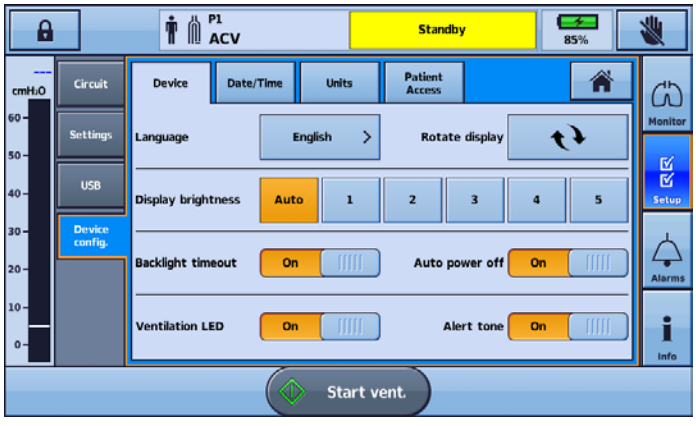
Access adjustable device settings from the **Setup** menu and select **Device config.**



The current active selections are highlighted in orange.

To change settings, simply select another of the available options. The revised setting is highlighted in orange.

Note: In Patient mode, only the settings that are able to be adjusted by the patient are enabled.



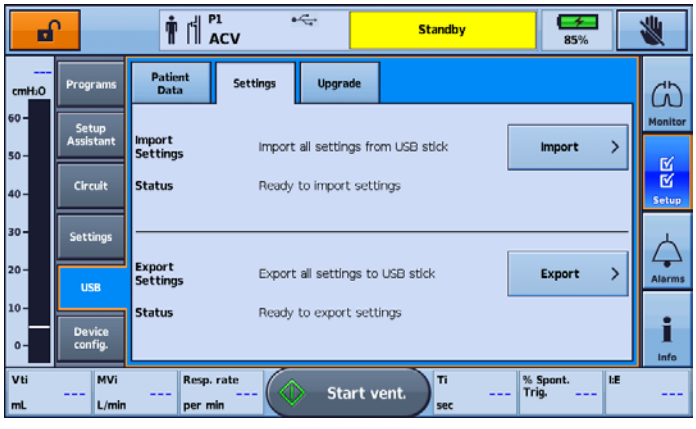
Copying device settings

The Astral device allows for all settings to be copied from one device to another via a USB stick. Ventilation settings for all available patient programs, and device configuration settings can be copied.

Settings can only be copied between compatible Astral devices. To be compatible, both devices must:

- be the same variant (eg, both Astral 150 or both Astral 100)
- have same product code
- have same software version*

*Subsequent releases will be backwards compatible.



Exporting device settings onto USB stick

Exporting of device settings can be performed at any time.

To export device settings:

1. Insert a USB stick into the USB connector at the rear of the device. Refer to Data Management process (see page 122).
2. From the Main menu, press Setup ☑. The Setup menu is displayed.
3. Select the **Settings** tab from the **USB** sub-menu.

   When the USB is ready, the **Export >** button will become active.
4. Press **Export >**.

   Any Astral settings currently on the USB stick will be deleted and replaced with the settings from the current device.
5. Press **Confirm** to proceed with the export.

   When the export is complete, a status message is displayed.

Importing device settings from the USB stick

Settings can only be imported when the device is in Clinical Mode and not ventilating.

Notes:

- All settings should be verified to be appropriate for the patient prior to commencing ventilation.
- Learn circuit must be performed for each enabled program prior to commencing ventilation.

To import device settings:

1. Insert a USB stick into the USB connector at the rear of the device. Refer to Data Management process (see page 122).
2. Enter **Clinical mode**.
3. From the Main menu, press Setup ☑. The Setup menu is displayed.
4. Select the **Settings** tab from the **USB** sub-menu.

   The **Import >** button will become active if there are settings from a compatible device available on the USB stick and the device is not ventilating.
5. Press **Import >**.

   A warning will be displayed to indicate that all device and patient program settings will be replaced.
6. Press **Confirm** to proceed with the import.

   A progress bar will be displayed while the settings are being imported and applied.

   When the import is complete, a status message is displayed as well as a reminder to check all settings have been applied correctly.

   Learn Circuit results will be reset to default parameters for each enabled program. Learn Circuit needs to be performed with the appropriate patient breathing circuit for each enabled program.

   All device configuration settings and all patient program settings should be verified to be appropriate for the patient prior to commencing ventilation.

Service reminders

The Service reminders provide information that device servicing is required in the near future.

There are two types of Service reminders:

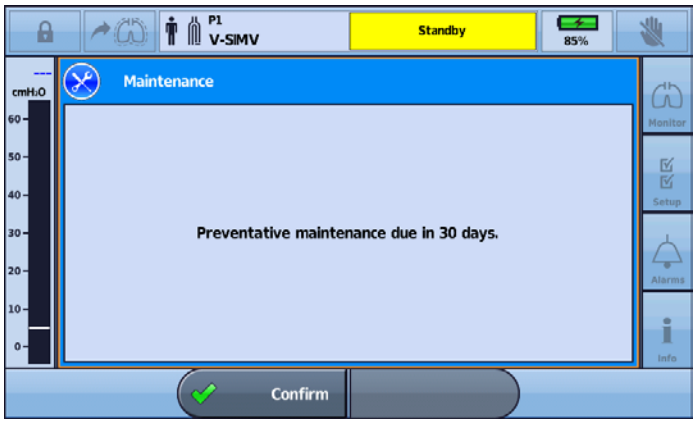
- Preventative maintenance reminder—the two year service interval is approaching.
  Note: This reminder is linked to the Next service due date as displayed on the Device information page.
- Battery replacement reminder—the internal battery is approaching the end of service life.

Using the Service reminders

When either a Preventative maintenance or Battery replacement reminder is present, a reminder button is displayed in the right corner of the bottom bar.

Note: Service reminders are only visible in Patient mode.

Select the reminder button to display the reminder prompt. Acknowledgment of the prompt will clear the reminder prompt and reminder button. The reminder button will remain if the user prompt has not been acknowledged or the **Next service due** date has passed.

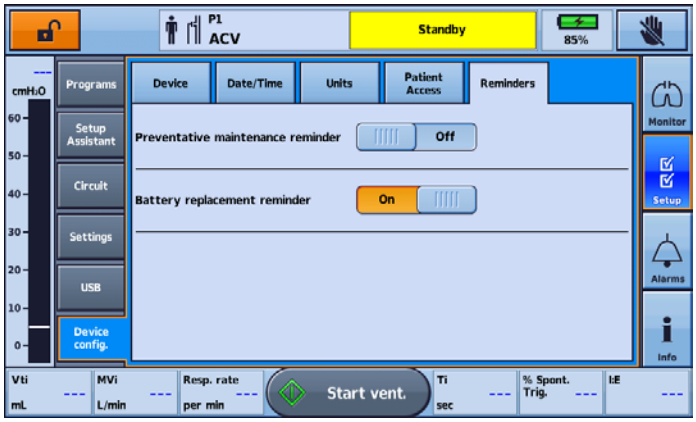


Note: More than one Service reminder can be present at a given time. In this case, the Service reminders will be displayed sequentially after each confirmation.

To enable a Service reminder:

The Service reminders can only be enabled or disabled in Clinical mode.

1. Access Clinical mode.
2. From the Main menu, press Setup ☑. The Setup menu is displayed.
3. Select the **Reminders** tab from the **Device Config.** sub-menu.



4. Move the Preventative maintenance or Battery replacement reminder to **ON**.
5. Access Patient mode.

   Your Service reminder is now enabled.

Circuit options

The Astral device supports a range of circuits (the device and accessories assembled together) to suit individual patient needs. The device uses interchangeable circuit adapters.

The following table may assist in selecting suitable circuits and settings for different patient types:

Tidal volume range	Recommended patient type setting	Suitable circuit diameters
50 mL to 300 mL	Pediatric	10 mm, 15 mm or 22 mm
> 300 mL	Adult	15 mm or 22 mm

Assembling patient circuits

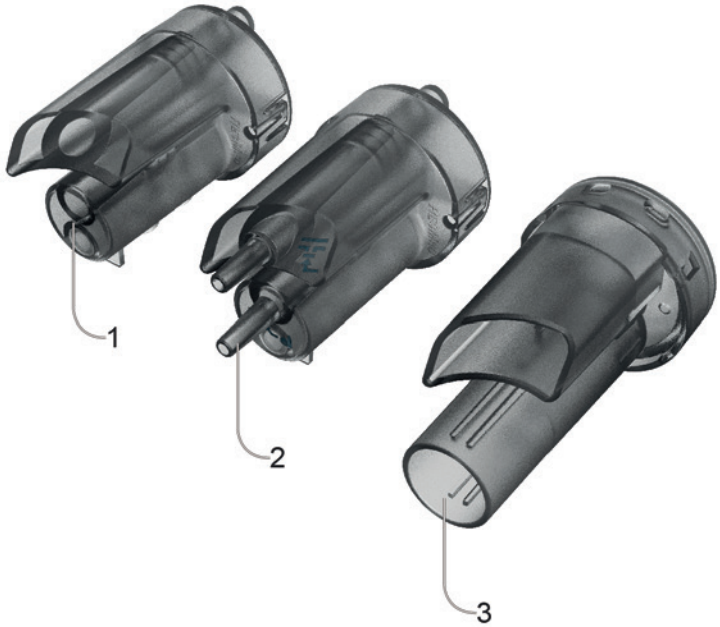
⚠ WARNING

- Use a double limb circuit for direct measurement of exhaled volumes. In this configuration, the expired volume is returned to the ventilator for independent measurement. (Astral 150 only)
- The Astral device does not support monitoring of exhaled volumes when used with a single limb circuit with expiratory valve.
- The patient circuit should be arranged so as not to restrict movement or pose a strangulation risk.
- Only use circuit components that comply with the relevant safety standards including ISO 5356-1 and ISO 5367.

⚠ CAUTION

For pediatric use, ensure that the patient circuit type fits and is suitable for use with a child. Use a pediatric patient type for patients that weigh less than 23 kg and normally require less than 300 mL tidal volume.

There are three circuit adapters:



	Adapter		For use with
1	Single limb leak		Single limb circuit with intentional leak or mouthpiece circuit
2	Single limb		Single limb circuit with expiratory valve (expiratory valve integrated into the circuit)
3	Double limb (Astral 150 only)		Double limb circuit (expiratory valve integrated into the adapter) OR single limb circuit with intentional leak or mouthpiece circuit

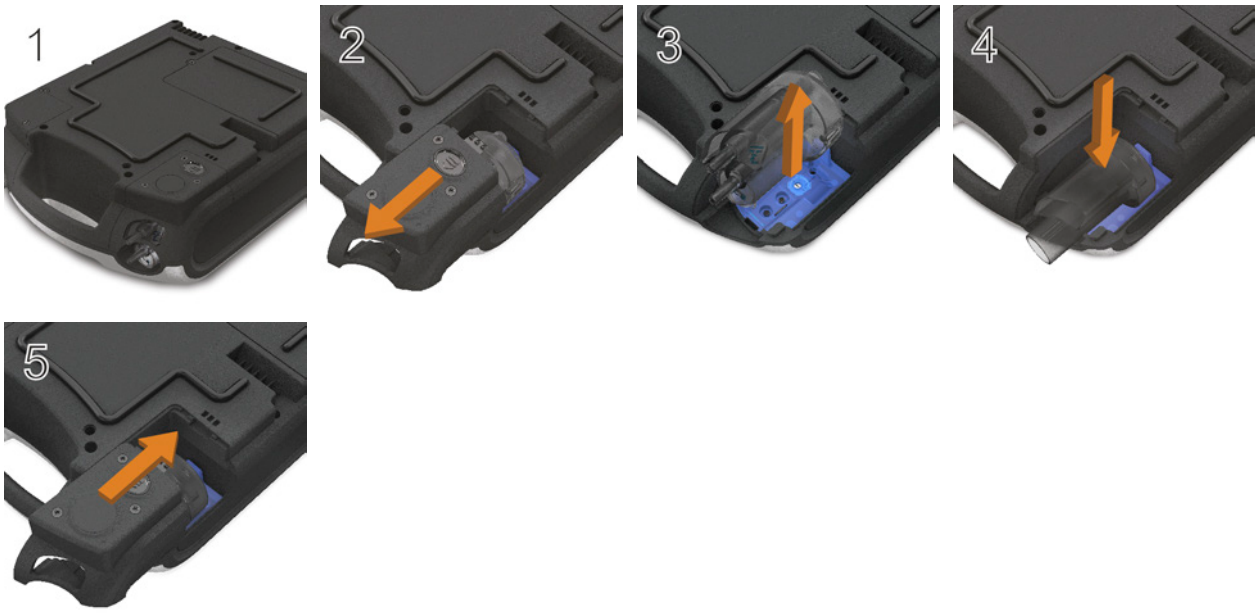
A Learn Circuit should be performed after any change of circuit. Astral will provide accurate therapy as long as the Learn Circuit is completed. Refer to Learn Circuit (see page 42) for further information.

Fitting the circuit adapter

Before connecting the patient circuit, the adapter specific to the required circuit type must be fitted.

To fit the adapter:

1. Turn over the device and place on a soft surface (to protect the LCD screen).
2. Press and hold the eject button. Pull the cover out towards you.
3. Lift the adapter out of the socket.
4. Replace with the new adapter, ensuring it sits firmly in the socket.
5. Place the cover over the enclosure, ensuring the runners on the device and the cover are aligned. Slide the cover back into place until the latch clicks.



Connecting a single limb circuit with intentional leak

An intentional leak may be provided in-line using the ResMed Leak Valve or via an integrated mask vent.

When using a circuit with intentional leak, estimation of the patient respiratory flow is enhanced by ResMed's automatic leak management feature —Vsync. Vsync technology allows the device to estimate the patient respiratory flow and tidal volume in the presence of unintentional leak.

⚠ WARNING

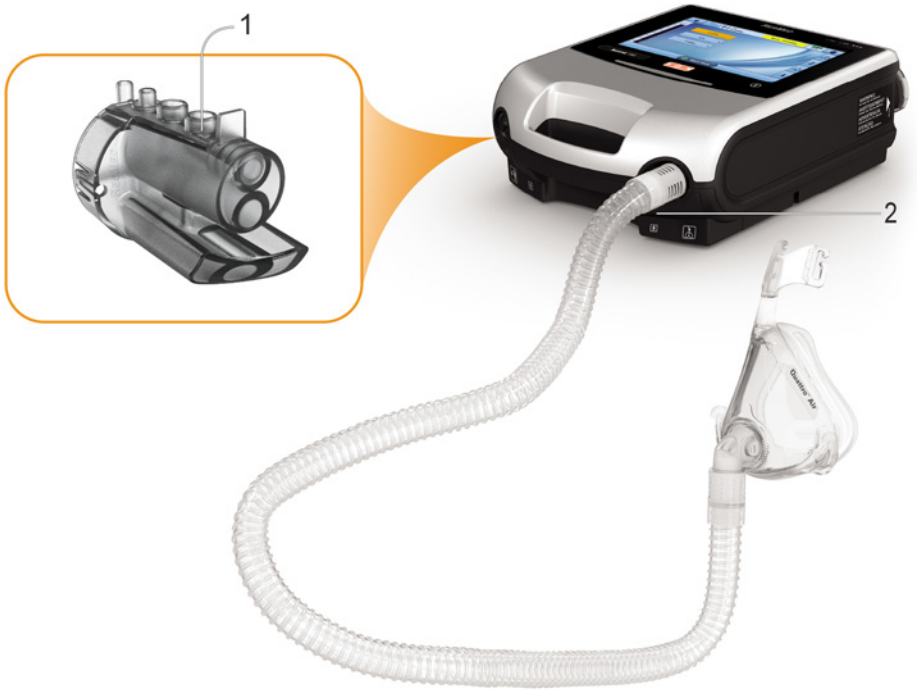
- **At low pressures, the flow through the mask vents may be inadequate to clear all exhaled gases, and some rebreathing may occur when using a single limb circuit with intentional leak.**
- **Ensure the vent holes at the mask or at the ResMed Leak Valve are unobstructed. Ensure the area around the vent holes is clear of bedding, clothes, or other objects and that the vents holes are not directed towards the patient.**

To connect a single limb circuit with intentional leak:

1. Check the device is fitted with the single limb leak adapter. Otherwise, change the adapter.
   Note: The Astral 150 can also support a single limb circuit with intentional leak using a double limb adapter.
2. Connect the inspiratory limb to the inspiratory port.
3. Attach any required circuit accessories (eg, humidifier or filter).
4. Select the circuit type and perform a Learn Circuit.
5. If using a non-vented mask or tracheostomy connector, attach a ResMed Leak Valve to the free end of the air tubing ensuring that the Leak Valve is as close as possible to the patient.

6. Attach the patient interface (eg, mask) to the Leak valve or the free end of the air tubing as appropriate and adjust the mask type setting on the Astral device.

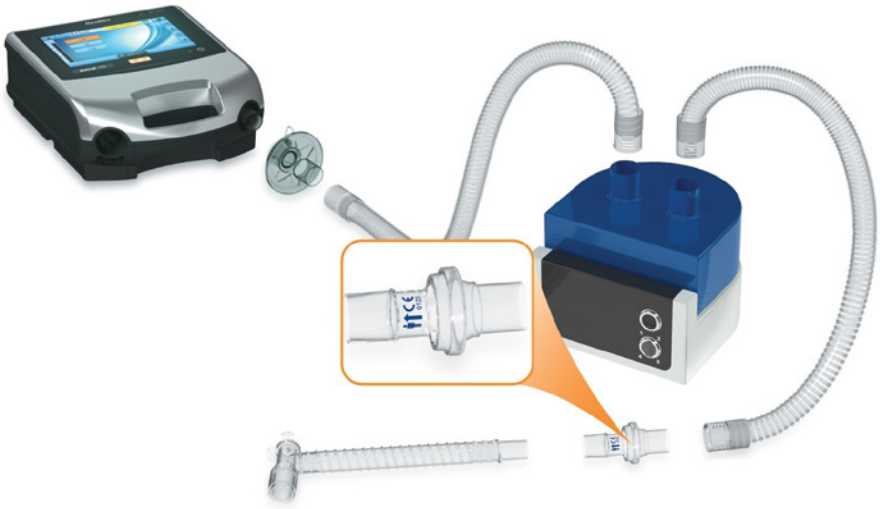
Note: If using the ResMed Leak Valve, select Leak Valve for the Mask type setting.



Connecting a single limb circuit for invasive use

⚠ CAUTION

Always set up the ResMed Leak Valve in the breathing circuit with the arrows and the symbol pointing in the direction of air flow from the Astral device to the patient.



For invasive ventilation, since the patient's upper respiratory system is bypassed by an artificial airway device (for example endotracheal or tracheostomy tube) humidification of the inspired gas is required to prevent lung injury.

Connecting a single limb circuit with expiratory valve

In a single limb circuit with expiratory valve, air pressure at the patient is monitored using the proximal pressure sensor line.

To enable fast and accurate connection, use an Astral Quick Connect Single Limb Circuit. This custom accessory with its integrated proximal pressure sensor and expiratory valve control line, is designed specifically for use with Astral ventilators.

To connect an Astral 'Quick Connect' Single Limb Circuit with expiratory valve:

1. Check the device is equipped with the single limb adapter (otherwise change the adapter).
2. Connect the air tubing to the inspiratory port on the device.
3. Attach the Astral Quick Connect circuit to the single limb adapter on the device (see diagram below).
4. Attach any required circuit accessories (eg, humidifier or filter).
5. Select the circuit type and perform a Learn Circuit.
6. Attach a patient interface (eg, mask) to the connector on the expiratory valve.

To connect a standard single limb valved circuit to the Astral:

1. Connect the Proximal pressure line to the upper connector of the Astral device single limb adapter.
2. Connect the PEEP control line to the lower connector of the Astral device single limb adapter.
3. Connect the air tubing to the inspiratory port of the device.
4. Attach any required circuit accessories (eg, humidifier or filter).
5. Select the circuit type and perform a Learn Circuit.
6. Attach a patient interface (eg, mask) to the connector on the expiratory valve.

Connecting a double limb circuit (Astral 150 only)

A flow sensor within the Astral device measures exhaled air flowing through the expiratory valve integrated into the double limb circuit adapter. (This arrangement enables patient-exhaled tidal volume to be accurately measured and monitored).

To connect a double limb circuit:

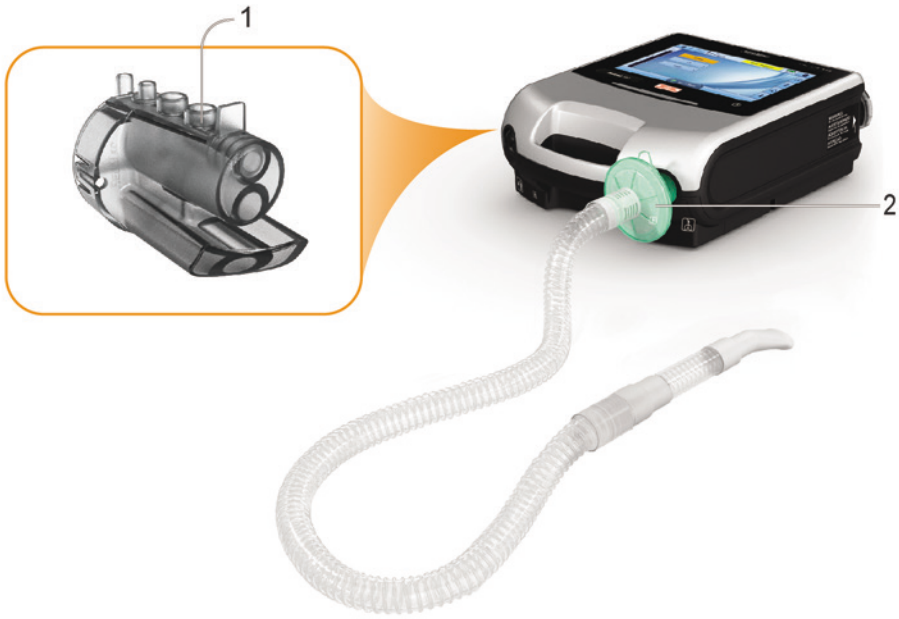
1. Ensure the device is fitted with the double limb adapter (otherwise change the adapter).
2. Connect the ends of the air tubing to the inspiratory and adapter ports on the device.
3. Attach any required circuit accessories (eg, humidifier or filter).
4. Select the circuit type and perform a Learn Circuit.
5. Attach a patient interface (eg, mask) to the end of the air tubing.

Connecting a mouthpiece circuit

The mouthpiece circuit is a single limb circuit with no expiratory valve or intentional leak. This circuit is not intended to support continuous exhalation into the circuit. For patients that may prefer continuous exhalation into the circuit, a circuit with expiratory valve or intentional leak should be considered.

To connect a mouthpiece circuit:

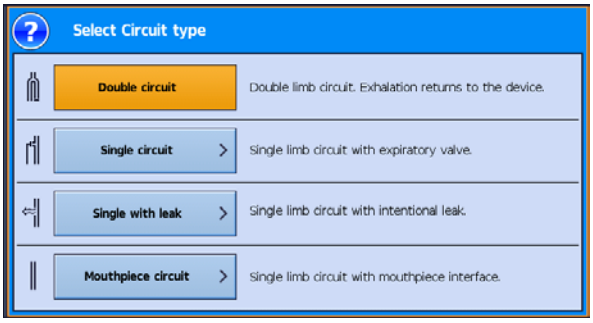
1. Check the device is fitted with a single limb leak adapter. Otherwise, change the adapter.
   Note: The Astral 150 can also support mouthpiece circuit using a double limb adapter.
2. Connect the inspiratory limb to the inspiratory port.
3. Attach any required circuit accessories (eg, filter).
4. Select the circuit type and perform a Learn Circuit.
5. Attach the patient interface (eg, mouthpiece) to the free end of the air tubing as appropriate.



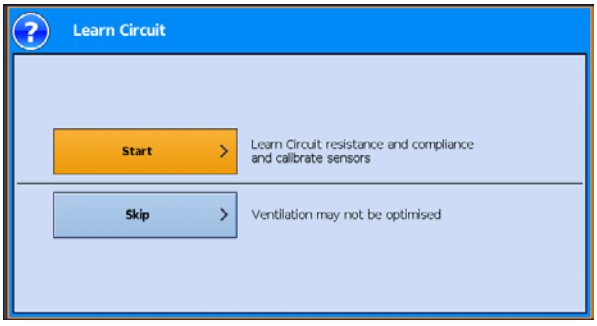
Changing the circuit selection

To change the circuit selection on the Astral device:

1. From the Setup main menu, select **Circuit**.
2. Select **Circuit Type**. (The current circuit type will be shown in orange).



3. Select the circuit you want to change to which will be highlighted orange. You will be taken to the Learn Circuit screen.
4. Press **Start** to run the Learn Circuit and follow the on-screen prompts.



Learn Circuit

In order to support a wide range of circuit configurations and accessories, the Astral device provides a Learn Circuit function to determine the characteristics of the circuit. As part of the Learn Circuit functionality the Astral performs a device self-test and a calibration of the FiO_2 sensor (if installed).

⚠ CAUTION

To ensure optimum and accurate performance, it is recommended that the Learn Circuit function be performed with every change of circuit configuration and at regular intervals not less than once every three months.

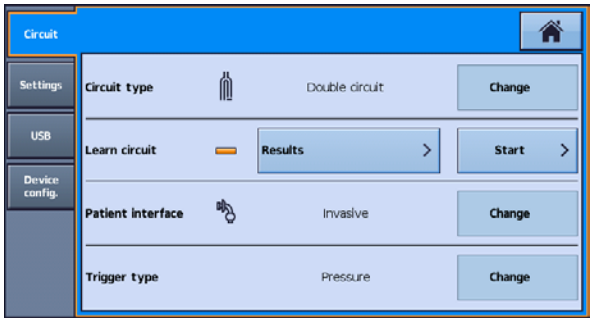
Do not connect patient interfaces prior to performing the Learn Circuit. Patient interfaces include any components placed after the single circuit's expiratory valve or exhalation port, or double limb circuit's 'Y' piece (eg, HMEF, catheter mount, mask, tracheostomy tube).

The following table may assist in selecting suitable circuits and settings for different patient types:

Tidal volume range	Recommended patient type setting	Suitable circuit diameters
50 mL to 300 mL	Pediatric	10 mm, 15 mm or 22 mm
> 300 mL	Adult	15 mm or 22 mm

To perform a Learn Circuit:

1. From the **Setup** main menu, select the **Circuit** sub-menu.
2. Press **Start** and follow the on-screen prompts.



Note: Trigger type sets whether a pressure-based or flow-based trigger threshold is used when a Double circuit is selected.

The prompts will guide you through a number of steps including:

- With the patient interface disconnected from the patient connection port, the Astral device will characterise the impedance of the inspiratory path.
- With the patient connection port sealed, the Astral device will characterise the total circuit compliance, and then the impedance of the expiratory path.

After completing these steps, a test result screen is displayed. You can access this Results screen later using the Results button in the Circuit setting up screen.

Circuit options

The following icons are used to report the Learn Circuit results:

Learn Circuit Results

Icon	Description
✔	Learn Circuit completed
▬	Learn Circuit not tested. Default circuit characteristics will be applied. Accuracy of control and monitoring may not be met. Ensure that ventilation and alarms are effective before proceeding further.
?	Learn Circuit completed. Circuit resistance is high.* The device will use the learned circuit characteristics. Accuracy of control and monitoring may not be met. Ensure that ventilation and alarms are effective before proceeding further. *The International Standards Organisation (ISO) has judged that patients ventilated with tidal volumes in excess of 300 mL (Adult range) should use breathing circuits with a resistance no more than 6 cmH_2O pressure drop at a flow rate of 30 L/min and 6 cmH_2O at 15 L/min for tidal volumes less than 300 mL (Pediatric range). **This circuit configuration may be appropriate for particular patients and hence clinical discretion is required.** Should ventilation cease for any reason, the patient must overcome this resistance in order to breath. **Note:** Patient/carer should be informed that this icon will appear each time Learn Circuit is performed using this configuration.
✖	Learn Circuit has failed. Default circuit characteristics will be applied. Below are general steps to resolve the Learn Circuit issue. Refer to Learn Circuit Troubleshooting (see page 155) for suggested actions on the error code. 1. Inspect the circuit and proximal lines for disconnection or excessive leak. 2. Check that the circuit is correctly connected and matches the selected circuit type. 3. Check that the correct circuit adapter is installed for the selected circuit type. 4. Check the module, the blue membrane and sensor are pressed all the way in and sit flush with the enclosure. Accuracy of control and monitoring will be degraded. Ensure that ventilation and alarms are effective before proceeding further.

Device Test Results

Icon	Description
✔	Device Test has passed.
▬	Device Test has not been run. This only occurs on setting up a new therapy program.
✖	Device Test has failed. Learn Circuit cannot be run. Below are general steps to resolve the Learn Circuit issue. Refer to Learn Circuit Troubleshooting (see page 155) for suggested actions on the error code. 1. Inspect the air inlet for foreign materials. 2. Inspect the air filter and replace it, if necessary. Refer to Cleaning and maintenance (see page 127) for further instructions. 3. Remove the expiratory module and inspect the module and blue membrane for any foreign materials. 4. Re-install the module, ensuring that it is securely in place. 5. Repeat Learn Circuit. If problem persists, refer to Learn Circuit Troubleshooting (see page 155) for suggested actions on the error code. If you choose to proceed with ventilation, accuracy of control and monitoring will be degraded. Ensure that ventilation and alarms are effective before proceeding further.

Oxygen (FiO_2) Sensor Results

Icon	Description
✔	Oxygen sensor calibration has passed.
▬	Oxygen sensor not tested or not installed. 1. If your device was supplied without an oxygen sensor, ignore this message and proceed with therapy. 2. If possible, check that the oxygen sensor is securely attached as described in Replacing the oxygen sensor (see page 129). 3. Repeat Learn Circuit. If the oxygen sensor is still not detected, return the device for servicing by an authorized ResMed Service Centre.
✖	Oxygen sensor calibration has failed. Below are general steps to resolve the oxygen sensor calibration issue. Refer to Learn Circuit Troubleshooting (see page 155) for suggested actions on the error code. 1. If possible, replace the oxygen sensor as described in Replacing the oxygen sensor (see page 129). 2. Repeat Learn Circuit. If problem persists, return the device for servicing by an authorized ResMed Service Centre. If you choose to proceed with ventilation, FiO_2 alarms will be disabled. An alternate method for monitoring FiO_2 is required.

Expiratory Flow Sensor Results

Icon	Description
✔	Expiratory flow sensor calibration has passed.
▬	Expiratory flow sensor not tested or not installed.
✖	Expiratory flow sensor calibration has failed. Below are general steps to resolve the expiratory flow sensor calibration issue. Refer to Learn Circuit Troubleshooting (see page 155) for suggested actions on the error code. 1. Remove the adapter, seal, and expiratory flow sensor. 2. Inspect the module, seal, and flow sensor for any foreign materials. 3. Re-install the module and flow sensor, ensuring that it is securely in place. 4. If possible, replace the expiratory flow sensor as described in Replacing the expiratory flow sensor (see page 128). 5. Repeat Learn Circuit. If problem persists, return the device for servicing by an authorized ResMed Service Centre. If you choose to proceed with ventilation, check Vte and MVe alarms are effective.

Accessories

For a full list of accessories, see Ventilation accessories on www.resmed.com under the Products page. If you do not have internet access, please contact your ResMed representative.

Attaching patient circuit accessories

⚠ WARNING

- Adding or removing circuit components can adversely affect ventilation performance. ResMed recommends performing a Learn circuit every time an accessory or component is added to or removed from the patient circuit. If the circuit configuration is changed, the Disconnection Alarm needs to be checked for correct operation.
- Do not use electrically conductive or anti-static air tubing.

Attaching a humidifier

A humidifier or HME is recommended for use with the Astral device.

⚠ WARNING

- For invasive ventilation, since the patient's upper respiratory system is bypassed by an artificial airway device (for example endotracheal or tracheostomy tube) humidification of the inspired gas is required to prevent lung injury.
- Always place the humidifier on a level surface below the level of the device and the patient to prevent the mask and tubing filling with water.
- Only use humidifiers that comply with the relevant safety standards, including ISO 8185 and set up the humidifier according to the manufacturer's instructions.
- Monitor the air tubing for water condensation and / or spillage from the humidifier. Use appropriate precautions to prevent water in the circuit transferring to the patient (eg, a water trap).

For non-invasive ventilation, for patient experiencing dryness of the nose, throat or mouth, humidification of the inspired gas will prevent subsequent irritation and discomfort.

⚠ CAUTION

Make sure that the water tub is empty and thoroughly dried before transporting the humidifier.

To attach a humidifier to a patient circuit:

1. Connect a length of air tubing to the inspiratory port on the device.
2. Connect the other end of the air tubing to the inlet port on the humidifier.
3. Connect the patient circuit to the outlet port on the humidifier.

The image below shows proper use of a humidifier in combination with a double limb circuit.

When using heated humidification with a double limb circuit, condensation may form in the expiratory flow sensor if the air is cooled to below its dew point. Condensation may also form in the patient circuit and is most likely to form at high humidity settings and low ambient temperatures.

Condensation forming in the expiratory flow sensor may cause a loss of expiratory flow measurement and compromised therapy (ie, auto-triggering, increased PEEP and activation of the leak alarm.

To prevent condensation at the Expiratory flow sensor, always follow the humidifier manufacturer's instructions on how to prevent condensation and regularly check the patient circuit for condensation.

To ensure accurate therapy, Astral's Learn Circuit function should be performed prior to filling the water tub.

Attaching a Heat Moisture Exchange (HME)

HME's are passive humidification systems that retain heat and moisture from the patient's exhaled gases via an internal membrane. An HME should not be used with active humidification. An HME can be used with the Astral device with a double limb circuit or single limb circuit with integrated valve.

⚠ WARNING

Only use HMEs that comply with the relevant safety standards, including ISO 9360-1 and ISO 9360-2.

Place the HME between the patient end of the circuit and the patient interface.

Do not connect patient interfaces prior to performing the Learn Circuit. Patient interfaces include any components placed after the single circuit's expiratory valve or exhalation port, or double limb circuit's 'Y' piece (eg, HMEF, catheter mount, mask, tracheostomy tube).

Attaching an antibacterial filter

⚠ WARNING

- Regularly check the antibacterial filter and expiratory valve for signs of moisture or other contaminants, particularly during nebulisation or humidification. Failure to do so could result in increased breathing system resistance and/or inaccuracies in expired gas measurement.
- Only use antibacterial filters that comply with the relevant safety standards, including ISO 23328-1 and ISO 23328-2.

⚠ CAUTION

The antibacterial filter must be used and replaced according to the manufacturer's specifications.

To attach an antibacterial filter:

1. Fit the antibacterial filter to the inspiratory port of the device.
2. Connect the air tubing to the other side of the filter.
3. Perform the Learn Circuit function.
4. Attach the patient interface to the free end of the air tubing.

⚠ WARNING

- To prevent the risk of cross-contamination, an antibacterial filter is mandatory if the device is to be used on multiple patients.
- The expiratory module, internal antibacterial filter, expiratory flow sensor and blue membrane come into contact with exhaled gases but do not form part of the inspiratory pathway.

Adding supplemental oxygen

The Astral device is designed to be compatible with levels of supplemental oxygen up to 30 L/min.

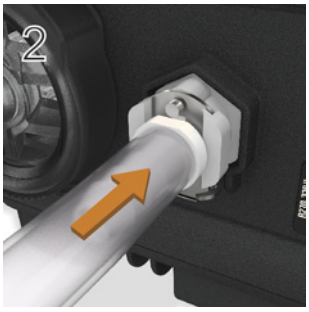
At a fixed rate of supplemental oxygen flow, the inhaled oxygen concentration will vary depending on the Ventilation mode and settings, patient breathing pattern, mask selection, and leak rate.

⚠ WARNING

- Use only medical grade oxygen sources.
- Always ensure that the device is ventilating before the oxygen supply is turned on.
- Oxygen flow must be turned off when the device is not ventilating so that oxygen does not accumulate within the device enclosure. Explanation: Accumulation of oxygen presents a risk of fire. This applies to most types of ventilators.
- Oxygen supports combustion. Oxygen must not be used while smoking or in the presence of an open flame. Only use oxygen in well-ventilated rooms.
- Supplemental oxygen must be added into Astral's oxygen inlet at the rear of the device. Adding oxygen elsewhere, ie, into the breathing system via a side port or at the mask, has potential to impair triggering and accuracy of therapy/monitoring and impair alarms (eg, High Leak alarm, Non-vented mask alarm)
- The patient circuit and the oxygen source must be kept at a minimum distance of 2 m away from any sources of ignition.
- Monitor supplemental oxygen using the integrated FiO_2 sensor and alarms or use an external O2 monitor compliant with ISO 80601-2-55.
- When operating Astral in its mobility bag do not add more than 6 L/min of supplemental oxygen.
- Astral is not designed for use with heliox, nitric oxide or anesthetic gases.
- Do not position the Astral device on its side as this may affect FiO_2 monitoring accuracy.

To add supplemental oxygen:

1. Unlock the low flow oxygen inlet at the rear of the device by pushing up on the locking clip.
2. Insert one end of the oxygen supply tubing into the oxygen port connector. The tubing will automatically lock into place.
3. Attach the other end of the oxygen supply tubing to the oxygen supply.
4. Start ventilation.
5. Turn on oxygen and adjust (at the oxygen supply) to the prescribed flow rate or FiO_2 level.

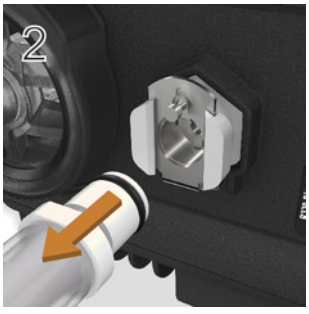


Supplemental oxygen can also be added from an oxygen bottle however, a flow regulator must be fitted to ensure the delivered oxygen remains at or below 30 L/min.

Before you remove supplemental oxygen from the device, ensure the Oxygen supply has been turned off.

To remove supplemental oxygen:

1. Unlock the low flow oxygen inlet at the rear of the device by pushing up on the locking clip.
2. Remove the oxygen port connector from the low flow oxygen inlet.



Monitoring delivered oxygen

The FiO_2 sensor is a standard inclusion on the Astral 150 and an optional accessory on the Astral 100. The sensor measures the average of percentage of oxygen delivered to the circuit through the inspiratory limb.

Prior to using the FiO_2 monitor, a Learn Circuit needs to be performed to calibrate the sensor. Repeat the calibration at regular intervals at least once every three months.

Note: It may take up to 30 minutes for the FiO_2 sensor readings to meet the specified accuracy after powering on the device from off state or when all power source indicators are off.

The FiO_2 sensor performance can be adversely affected by relative humidity, condensation on the sensor or unknown gas mixtures.

⚠ WARNING

Do not position the Astral device on its side as this may affect FiO_2 monitoring accuracy.

Attaching a nebuliser

If required, a nebuliser can be used in conjunction with the Astral device. ResMed recommends Aerogen® nebuliser products—designed to operate in-line with standard ventilator circuits and mechanical ventilators without changing ventilator parameters or interrupting ventilation.

⚠ WARNING

- **Always connect antibacterial filters to both the inspiratory port and the expiratory inlet of the Astral device to protect the device.**
- **Regularly check the antibacterial filter and expiratory valve for signs of moisture or other contaminants, particularly during nebulisation or humidification. Failure to do so could result in increased breathing system resistance and/or inaccuracies in expired gas measurement.**
- **Only operate the nebuliser when the device is ventilating. If ventilation is stopped, switch off the nebuliser.**
- **Use of a gas jet nebuliser may affect ventilator accuracy. Monitor the patient and compensate for the gas volume introduced by the gas jet nebuliser as appropriate.**
- **For full details on using a nebuliser, see the User Guide that comes with that device.**

Connect the nebuliser unit with a T-piece into the inspiratory limb of the breathing circuit before the patient. If one of the Aerogen nebuliser models is being used (ie, Aeroneb Solo and Aeroneb Pro), it can be powered via the USB connector at the rear of the Astral device, or the Aerogen USB AC/DC adapter.

Pictured above: Aeroneb® Solo in-line.

For full instructions for use, please consult the Aeroneb Solo System Instruction Manual.

Attaching other accessories

Attaching a pulse oximeter

⚠ WARNING

- Only use compatible NONIN™ finger pulse sensors*.
- Pulse oximeter sensors must not be used with excessive pressure for prolonged periods as this can cause patient pressure injury.
- The pulse oximeter sensor and cable needs to be verified for compatibility with Astral, otherwise patient injury can result.

⚠ CAUTION

Factors that may degrade pulse oximeter performance or affect the accuracy of the measurement include the following: excessive ambient light, excessive motion, electromagnetic interference, blood flow restrictors (arterial catheters, blood pressure cuffs, infusing lines, etc.), moisture in the sensor, improperly applied sensor, incorrect sensor type, poor pulse quality, venous pulsations, anemia or low hemoglobin concentrations, cardiogreen or other intravascular dyes, carboxyhemoglobin, methemoglobin, dysfunctional hemoglobin, artificial nails or fingernail polish, or a sensor not at heart level.

To connect the pulse oximeter:

1. Connect the plug of the finger pulse sensor to the plug of the pulse oximeter.
2. Connect the plug of the pulse oximeter to the SpO_2 (pulse oximeter) connector at the rear of the device.

*Please refer to the Ventilation accessories on www.resmed.com under the Products page for part numbers of oximeter accessories with confirmed compatibility. For information on how to use these accessories, refer to the user guide that comes with these accessories.

Once you have attached the pulse oximeter, a message will briefly display in the information bar. Real-time SpO_2 and Pulse readings can be viewed from the Monitoring menu.

Notes:

- Values from the SpO_2 sensor are averaged over 4 heartbeats.
- Included SpO_2 sensor is calibrated for the display of functional oxygen saturation.
- The No SpO_2 monitoring alarm will activate if the pulse oximeter has been disabled or has a degraded signal for more than 10 seconds or has been disconnected.

Attaching a remote alarm

The ResMed Remote Alarm II has been designed for use with Astral devices. The Remote Alarm II alerts you to an alarm that requires immediate attention. It triggers an audible and visual alarm when an alarm is triggered on the Astral device. For full instructions on using the Remote Alarm II, see the User Guide that comes with that device.

To connect the Remote Alarm II to the Astral device:

1. Connect one end of the alarm cable to the (3 pin) input connector on the remote alarm.
2. Connect the other end to the (5 pin) output connector located at the rear of the Astral device.

⚠ CAUTION

To remove the cable, pull firmly on the connector. Do not twist.

Astral Carry Bag

The Astral device should always be packed in its Carry Bag when not in use to prevent damage to the device.

⚠ WARNING

The Astral should not be operated while in the Carry Bag. To ventilate while travelling, use the Astral Mobility bag or SlimFit mobility bag.

To use the Carry Bag

1. Prior to placing the device in the Carry Bag, remove:
   - the power connection from the rear of the device
   - all patient circuit components
   - all accessories, including Remote Alarm and oximeter
   - the USB Stick.
2. Place the Astral device carefully into the Carry Bag, ensuring the handle is at the top and the screen faces the printed image on the bag.
3. Secure the Astral device in place by using the Velcro strap. (To ensure the most secure position, thread the Velcro strap through the handle and attach.)
4. Place the Power Supply unit and any heavy components in the side zippered pocket.
5. Ensure all zippers are completely closed and the device secure before lifting the Carry Bag.

⚠ CAUTION

Do not place any heavy or bulky objects in the zippered pocket on the inside front of the bag. This could result in damage to the LCD Touch screen.

Travelling with the Astral device

⚠ WARNING

The Astral device should not be operated while in the Carry Bag. To ventilate while travelling, use the Mobility Bag or SlimFit Mobility bag.

When travelling with the Astral device:

- The Astral device should always be packed in its carry bag when not in use to prevent damage to the device.
- The carry bag is for carry-on luggage only. The carry bag will not protect the Astral device if it is put through checked baggage.
- For your convenience at security stations, it may be helpful to keep a printed copy of the user guide in the Astral carry bag to help security personnel understand the device and refer them to the following statement.
- ResMed confirms that the Astral device meets the Federal Aviation Administration (FAA) requirements (RTCA/DO-160, section 21, category M) for all phases of air travel.
- For power management tips, refer to Power management (see page 55).

Power management

Helpful hints!

- Connect the ventilator to the mains power whenever possible. In the event of battery failure, connect to mains power immediately to resume ventilation.
- An external power source (Astral External Battery or RPSII) should always be available for ventilator-dependent patients.
- An external power source (Astral External Battery or RPSII) should be in use in mobile situations, including when mains power is unavailable or disrupted. Do not rely solely on the internal battery for mobile use.
- Ensure the external battery is sufficiently charged before using in mobile situations.

⚠ WARNING

- **Beware of electrocution. Do not immerse the device, power supply or power cord in water.**
- **Make sure the power cord and plug are in good condition and the equipment is not damaged.**
- **Keep the power cord away from hot surfaces.**
- **Explosion hazard—do not use in the vicinity of flammable anesthetics.**

The Astral device can be used with different power sources:

- Mains power
- Astral External Battery
- External DC power supply (eg, car 12V power outlet)
- ResMed Power Station II
- Internal battery

For information on power supplies and sources, refer to the Technical Specifications (see page 133).

Connecting to mains power

⚠ WARNING

Ensure that the power cord does not pose a tripping or choking hazard.

To connect to mains power:

1. Connect the DC plug of the supplied ResMed external power supply unit to the rear of the Astral device.
2. Before connecting the power cord to the ResMed power supply unit, ensure the end of the connector of the power cord is correctly aligned with the input socket on the power supply unit.
3. Plug the other end of the power cord into the power outlet.

Note: The power cord is equipped with a push-pull locking connector. To remove, grasp the power cord housing and gently pull the connector from the device. Do not twist its outer housing or pull on the cord.

Connecting the Astral External Battery

The Astral External Battery has been designed specifically for use with the Astral Series of ventilators. It is intended to provide Astral ventilators with eight hours of power during typical use.

For full details on using the Astral External Battery, refer to the External Battery user guide.

Using the External Battery

Connecting a fully charged External Battery to the Astral device can provide 8 hours of power during typical use. A second fully charged External Battery can be connected to the Astral device to provide a further 8 hours of power during typical use. A maximum of two external batteries can be connected to the Astral device.

Once the External Battery is connected to the Astral device, the DC mains indicator on the user interface will illuminate.

⚠ WARNING

- **Do not attempt to connect more than two external batteries. Battery specific messages and alarms on the Astral device will not operate for any additional units.**
- **In the unlikely event of an issue occurring with the external battery, Astral will sound an alarm and notify the user indicating that the device is operating on internal battery power. Ventilation will continue, however, users should connect to an alternative external power source (eg, AC power or another external battery) as soon as possible.**

Alarms and messages relating to the External Battery may occur from time to time. All message information will be displayed on the Astral user interface, and will be accompanied by an audible signal. Refer to the Alarms Troubleshooting (see page 150) for further information.

Connecting to a ResMed Power Station (RPSII)

The RPSII provides the Astral device with eight hours of power during typical use. To use, connect the power cord of the RPSII to the DC inlet port on the device.

⚠ CAUTION

- When using the Astral device with an RPSII, the internal battery will not be charged.
- Do not use the RPSII and external battery together.

Connecting to an external DC power source

⚠ CAUTION

- When using a car auxiliary adapter, start the car before plugging in the device's DC adapter.
- If the external DC power source drops to below 11V, the Astral will switch to internal battery.
- When the device is turned off while connected to the DC adapter, it will continue to draw power from the external DC power source.

To connect DC power:

1. Connect the DC plug of the external DC power supply unit to the rear of the device.
2. Plug the other end of the power cord into the power outlet.

Using the internal battery

An internal battery is included in the Astral device. It ensures a continuous power supply when mains power is disrupted and no external battery is connected to the device. When the Astral starts using the internal battery as its power source, you are notified by the **Using internal battery** alert and with the internal battery power source indicator.

The internal battery operates for approximately eight hours under typical conditions. During ventilation, alarms will alert the user to a low battery condition. During standby, no alarms will be announced. The user should regularly check the battery status.

⚠ WARNING

- When using the Astral device as a backup ventilator, ensure the internal battery level is checked on a regular basis.
- As the battery ages, the available capacity decreases. When the remaining battery capacity is low, do not rely on the internal battery as the primary power supply.
- The internal battery should be replaced every two years or sooner when there is a noticeable reduction in usage time when fully charged.
- The internal battery is not intended to serve as a primary power source. It should only be used when other sources are not available or briefly when necessary; for example, when changing power sources.

⚠ CAUTION

- Revert to AC mains power when the remaining capacity of the battery is low.
- The internal battery may stop charging when ambient temperatures of 95°F (35°C) or more are reached. This will be indicated with a Power fault/No charging alarm message.
- The internal battery will be depleted if the device is left in storage for an extended period of time. During storage, ensure the internal battery is recharged once every six months.
- Storing the Astral device at temperatures exceeding 122°F (50°C) for extended periods will accelerate battery ageing. This will not affect the safety of the battery or the device.

While connected to mains power, the internal battery continues to charge when the device is operating or in standby.

For more information on the expected operating time of the internal battery, see the Technical Specifications.

Battery run time

The internal battery powers the Astral device for eight hours under conditions typical to the chronic home ventilator-dependent patient.

Internal battery run time is determined by the:

- percent charge
- environmental conditions (such as temperature and altitude)
- condition and age of the battery
- device settings
- patient circuit setup and unintentional leak.

The internal battery should be replaced every two years or sooner when there is a noticeable reduction in usage time when fully charged.

Storing and recharging

If the internal battery is not used, it must be recharged every six months.

It takes approximately four hours to fully recharge the internal battery from depletion; however this can vary depending on environmental conditions and the device operating state.

To prepare the internal battery for long-term storage:

1. Check that the battery charge level is between 50 and 100%. If not, charge the device to at least 50% prior to storage.
2. Remove the power cord from the Astral.
3. Turn off the device.

To recharge the internal battery:

1. Connect the device to mains power.
2. Charging commences as indicated by a flashing battery charging indicator symbol in the Information bar.

Notes:

- When charging a completely depleted battery, it will normally take up to 30 minutes to increase battery capacity from 0% to 1%.
- If the device has been stored outside the operating temperature range, an alarm message (**Power fault / No charging**) may appear. You can still continue using the device, however, if the alarm persists for more than 2 hours the battery may need replacement.

Device power source indicators

Information on system and battery charge levels can be accessed in one of two ways:

1. Battery Indicator

   The capacity of all connected batteries will be added to the RunTime indicator on the Information bar of the Astral interface. (This may take a couple of minutes). The total will be the sum of the Astral internal battery plus either one or two external batteries.

   Under normal operating conditions, the ventilator will display:

   - Total system state of charge as a percentage when in ventilation standby mode or connected to mains power.
   - Estimated remaining run time while delivering therapy.

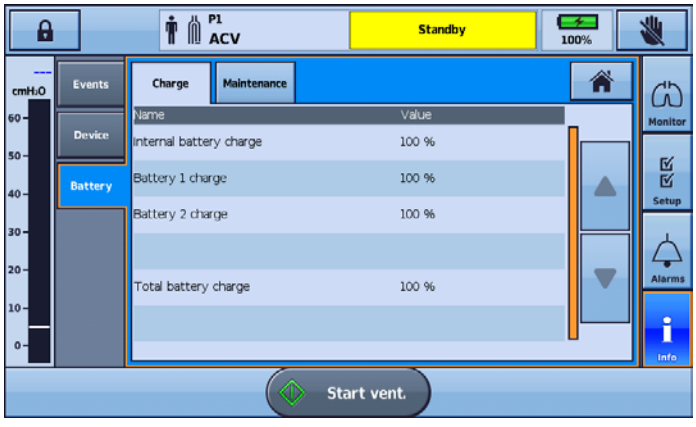
Display	Description
100%	When either the external or internal battery is in use, but the device is not ventilating, the battery charge level is displayed. The battery percentage is an average of all batteries connected to the system. Full details of individual battery capacities can be reviewed in the Battery information page.
8h00	When either the external or internal battery is in use during ventilation, the remaining usage is displayed as estimated by current operating conditions. The total will be the sum of all batteries connected to the system.
70%	When either the external or internal battery is charging, the charge battery symbol and percentage charged is displayed.

   Note: Only the Astral external and internal batteries are included in battery indicator calculations. RPSII battery levels are not displayed.

2. Battery information

   The battery information can be accessed from the Battery sub-menu in the Information menu. This menu has two tabs:

   - Charge—displays the current charge level (0-100%) for any batteries currently detected by the system, as well as the total system charge.
   - Maintenance—displays the full charge capacity and the charge cycle count for any batteries currently detected by the system.



Regularly check the charge level of the internal battery and any connected external batteries. It is recommended to replace any batteries at 400 charge cycles.

Using the Astral device for the first time

When using the Astral device for the first time, ResMed recommends you first perform a functional test. A functional test will ensure the device is in proper working order before starting therapy. Information to assist you in resolving any issues is available in the Troubleshooting (see page 150) section.

⚠ CAUTION

If any of the following checks fail, contact your Healthcare provider or ResMed for assistance.

To perform a functional test:

1. Turn off the device by pressing the power switch at the back of the device.
2. Check the condition of the device and accessories.
   Inspect the device and all accessories. Damaged components should not be used.
3. Check the patient circuit setup.
   Check the integrity of the patient circuit (device and provided accessories) and that all connections are secure.
4. Turn on the device and test alarms.

⚠ WARNING

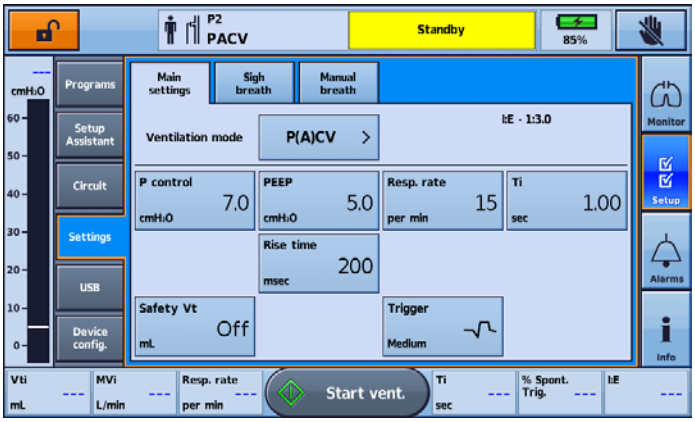
If no alarm sounds, do not use the ventilator.

   Press the power switch at the back of the device to turn on the device. Check that the alarm sounds two test beeps and the LEDs for the alarm signal and the alarm mute/reset button flash. The device is ready for use when the Patient Home screen is displayed.
5. Disconnect the device from the mains and external battery (if in use) so that the device is powered by the internal battery. Check that the Battery Use alarm is displayed and the battery LED is on.
   Note: If the charge state of the internal battery is too low an alarm occurs. Refer to Troubleshooting (see page 150).
6. Reconnect the external battery (if in use) and check that the LED for the DC power supply is lit. The External DC Power Use alarm will be displayed and the Alarm LED will light.
7. Reconnect the device to mains power.
8. Check the pulse oximeter sensor (if in use).
   Attach the accessories according to the set up descriptions. From the Monitoring menu, go to the Monitoring screen. Check that the values for SpO_2 and pulse are displayed.
9. Check the oxygen connection (if in use). Check for damage to hoses or leaks. Check remaining capacity of oxygen cylinders.
10. Perform a Learn Circuit.

Ventilation modes

Astral supports a variety of ventilation modes. Available modes will vary depending on the circuit type chosen. Mode settings can be accessed from **Main Settings** tab from the **Settings** menu.

Note: Some features may not be available on your device.



Mode	Circuit type			Supplementary feature			
	Leak circuits	Valve circuits	Mouthpiece circuits	Apnea ventilation	Safety Vt	Manual breath	Sigh breath
(A)CV		✓	✓	✓*		✓	✓*
P(A)CV		✓	✓	✓*	✓*	✓	✓*
P-SIMV		✓		✓		✓	
V-SIMV		✓		✓		✓	
PS	✓	✓	✓	✓*	✓*	✓*	
CPAP	✓	✓		✓*			
(S)T	✓				✓		
P(A)C	✓				✓		
iVAPS	✓						

* For valve circuits only

(A)CV mode - Assisted volume-controlled ventilation

(A)CV is a volume target ventilation mode delivering volume-controlled mandatory breaths:

- Inspiration can either be initiated by the ventilator at a set respiratory rate (time-triggered breath) or the patient (spontaneous-triggered breath). A spontaneous breath re-schedules the next time-triggered breath. Both Trigger and Resp. rate can be set to Off, but not at the same time. When Trigger is set to Off, the mode name will be shown on the Information bar as CV.
- End of inspiration (switch from inspiration to expiration) is controlled by the ventilator (time-cycled breath).

Parameter	Setting
Resp. rate (per min)	Adult: Off, 2 to 50 [15] Ped: Off, 5 to 80 [15]
PEEP (cmH_2O)	Off, 3.0 to 20.0 [5.0]
Vt (mL)	Adult: 100 to 2500 [500] Ped: 50 to 300 [100]*
PIF (L/min)	When Volume Breath option is set to PIF: Adult: 10 to 120 [50] Ped: 5 to 60 [10]
Ti (sec)	When Volume Breath option is set to Ti: Adult: 0.3 to 3.0 [1.0] Ped: 0.3 to 3.0 [0.6]
Flow shape (%)	100 (Constant), 75, 50, 25 [100]
Trigger Type	Flow / Pressure
Trigger	When Trigger Type is set to **Flow** (double limb circuit only) Adult: Off, 0.5 to 15 [1.0] (L/min) Ped: Off, 0.5 to 15 [0.5] (L/min)
	When Trigger Type is set to **Pressure** (double and single limb circuit) Off, Very low to Very high [Medium]

Note: Some default settings are different for Mouthpiece circuit.

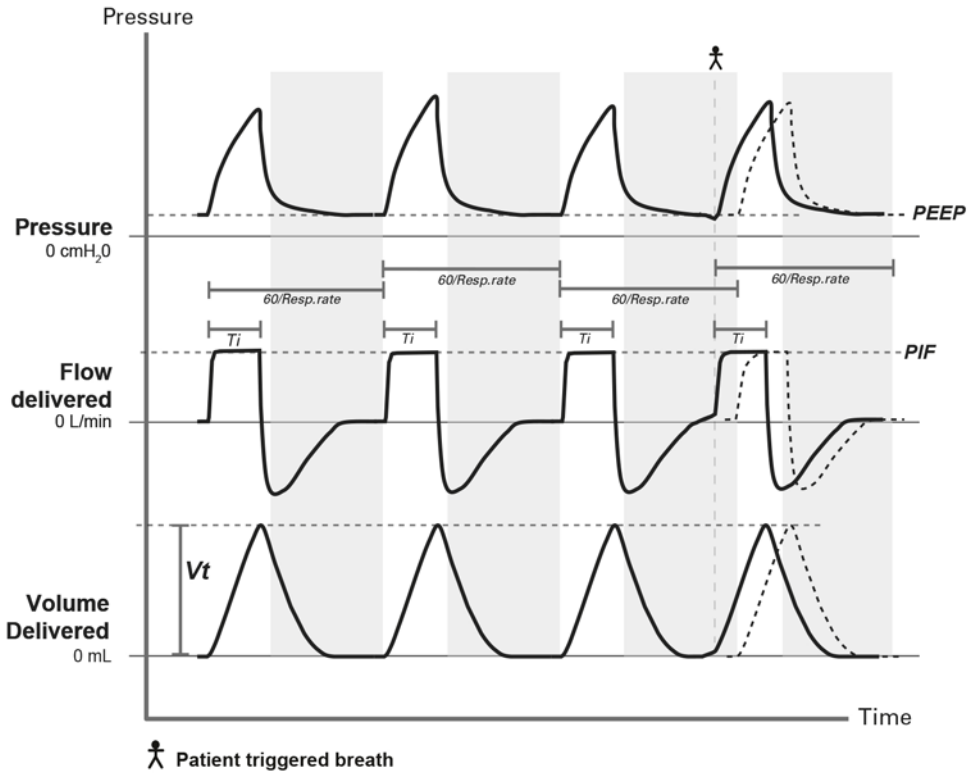
*The International ventilator standard indicates that Pediatric patient type is intended to be used for a patient receiving less than 300 mL, however Astral permits adjustment of 'Vt' setting parameter up to 500 mL for cases where 'Vt' is set such that it compensates for leak in the breathing circuit.

⚠ WARNING

ResMed does not recommend 500 mL as the upper limit for the pediatric tidal volume use; however, clinicians may choose this upper limit based on their clinical determination.

Supplementary features:

- Apnea response
- Sigh breath (Astral 150 only)
- Manual breath (Astral 150 only)



(A)CV breath pattern showing one patient triggered breath amongst time triggered breaths, with inspiratory duration defined by Ti. The patient-triggered breath re-schedules the next time-triggered breath.

P(A)CV mode - Assisted pressure-controlled ventilation

P(A)CV is a pressure target ventilation mode delivering pressure-controlled mandatory breaths:

- Inspiration can either be initiated by the ventilator at a set respiratory rate (time-triggered breath) or the patient (spontaneous-triggered breath). Spontaneous-triggered breaths re-schedule the next time-triggered breath. Both Trigger and Resp. rate can be set to Off, but not at the same time. When Trigger is set to Off, the mode name will be shown on the Information bar as PCV.
- End of inspiration (switch from inspiration to expiration) is controlled by the ventilator (time-cycled breath).

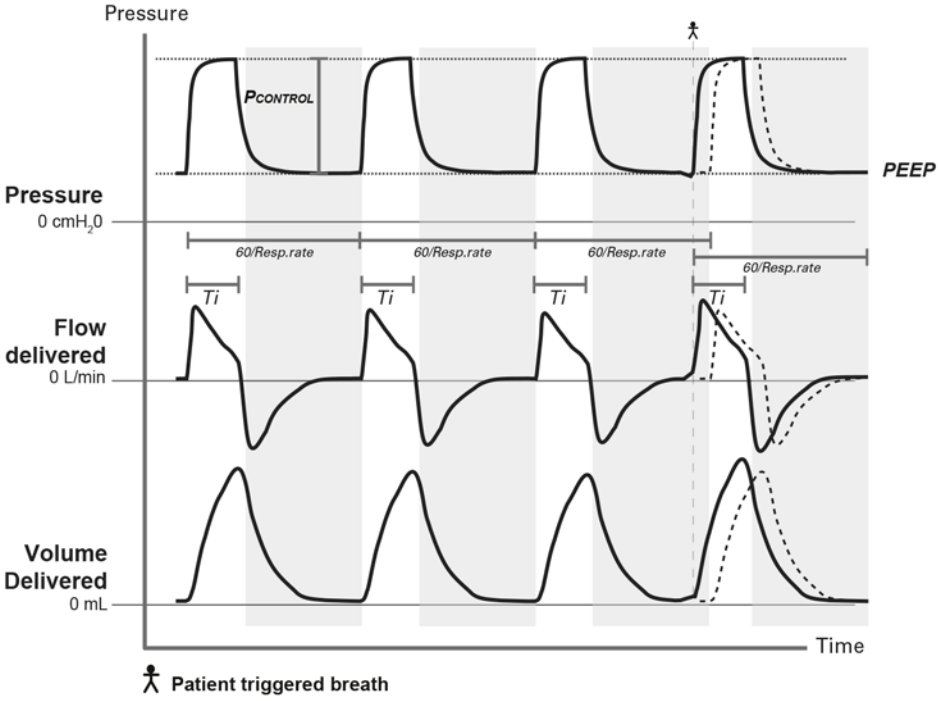
Parameter	Setting
Resp. rate (per min)	Adult: Off, 2 to 50 [15] Ped: Off, 5 to 80 [15]
PEEP (cmH_2O)	Off, 3.0 to 20.0 [5.0]
P control (cmH_2O)	Adult: 2 to 50 [7] Ped: 2 to 50 [7]
Ti (sec)	Adult: 0.2 to 5.0 [1.0] Ped: 0.2 to 5.0 [0.6]
Trigger type	Flow / Pressure Available with double limb circuits only.

Parameter	Setting
Trigger	When Trigger Type is set to **Flow**: Adult: Off, 0.5 to 15 [1.0] (L/min) Ped: Off, 0.5 to 15 [0.5] (L/min)
	When Trigger Type is set to **Pressure**: Off, Very Low to Very High [Medium]
Rise Time (msec)	Min, 150 to 900 [200]

Note: Some default settings are different for Mouthpiece circuit.

Supplementary features:

- Safety Vt (Tidal Volume)
- Apnea response
- Sigh breath (Astral 150 only)
- Manual breath (Astral 150 only)



The P(A)CV breath pattern showing one patient triggered breath amongst time-triggered breaths. The Safety Vt feature is turned off.

P-SIMV - Pressure Synchronised Intermittent Mandatory Ventilation

P-SIMV is a mixed ventilation mode delivering pressure-controlled mandatory breaths and pressure-supported spontaneous breaths.

Mandatory breaths are delivered at a set frequency and spontaneous breaths are permitted between mandatory breaths.

For mandatory breaths

The inspiratory pressure support is set using P control and is initiated by either:

- the ventilator at a set respiratory rate
- the patient - if the patient effort is close enough to the next scheduled mandatory breath. This time is 60% of the breath period or 10 seconds, whichever is less.

End of inspiration (switch from inspiration to expiration) is controlled by the ventilator (time-triggered breath)

For spontaneous breaths

The inspiratory pressure support is set using PS. Inspiration is either:

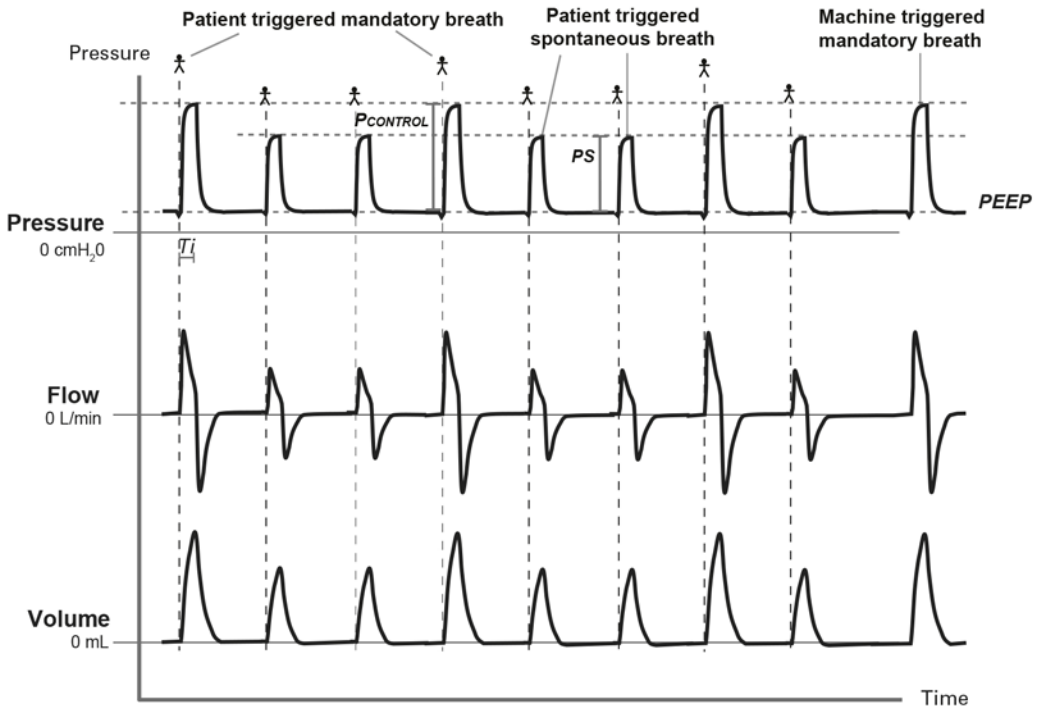
- Initiated by the patient (spontaneous-triggered breath)
- Ended by the patient (spontaneous-cycled breath)

The patient is free to take any number of spontaneous breaths between mandatory breaths.

Parameter	Setting
Resp.rate (per min)	Mandatory breaths: Adult: 2 to 50 [10] Ped: 5 to 80 [20]
PEEP (cmH_2O)	Off, 3.0 to 20.0 [5.0]
P control (cmH_2O)	Mandatory breaths: Adult: 2 to 50 [7] Ped: 2 to 50 [7]
PS (cmH_2O)	Spontaneous breaths: Adult: 2 to 50 [7] Ped: 2 to 50 [7]
Ti (sec)	Mandatory breaths Adult: 0.2 to 5.0 [1.0] Ped: 0.2 to 5.0 [0.6]
Cycle (%)	Spontaneous breaths: 5 to 90, Auto [Auto]
Trigger type	Flow / Pressure
Trigger	When Trigger Type is set to **Flow:** (double limb circuit only) Adult: 0.5 to 15 [1.0] (L/min) Ped: 0.5 to 15 [0.5] (L/min)
	When Trigger Type is set to **Pressure:** (double and single limb circuit) Very Low to Very High [Medium]
Rise Time (msec)	Min, 150 to 900 [200]

Supplementary features:

- Apnea response
- Manual breath



Spontaneous breaths are permitted between mandatory breaths as shown in the figure above. In order to promote synchrony with the patient's spontaneous efforts, mandatory breaths may be patient triggered. Such patient triggering will cause some variation in the mandatory ventilation respiratory rate.

V-SIMV - Volume Synchronised Intermittent Mandatory Ventilation

V-SIMV is a mixed ventilation mode delivering volume-controlled mandatory breaths and pressure-supported spontaneous breaths.

Mandatory breaths are delivered at a set frequency and spontaneous breaths are permitted between mandatory breaths.

For mandatory breaths

The inspiratory volume is set using Vt and is initiated by either:

- the ventilator at a set respiratory rate
- the patient - if the patient effort is close enough to the next scheduled mandatory breath. This time is 60% of the breath period or 10 seconds, whichever is less.

End of inspiration (switch from inspiration to expiration) is controlled by the ventilator (time-triggered breath)

For spontaneous breaths

The inspiratory pressure support is set using PS. Inspiration is:

- initiated by the patient (spontaneous-triggered breath) and
- ended by the patient (spontaneous-cycled breath)

The patient is free to take any number of spontaneous breaths between mandatory breaths.

Parameter	Setting
Resp.rate (per min)	Mandatory breaths: Adult: 2 to 50 [15] Ped: 5 to 80 [15]
PEEP (cmH_2O)	Off, 3.0 to 20.0 [5.0]

Parameter	Setting
PS (cmH_2O)	Spontaneous breaths: Adult: 2 to 50 [7] Ped: 2 to 50 [7]
Vt (Tidal Volume) (mL)	Mandatory breaths: Adult: 100 to 2,500 [500] Ped:50 to 300 [100]*
PIF (L/min)	When Volume Breath option is set to PIF Mandatory breaths: Adult: 10 to 120 [50] Ped: 5 to 60 [10]
Ti (Inspiratory time) (sec)	When Volume Breath option is set to Ti Mandatory breaths: Adult: 0.3 to 3.0 [1.0] Ped: 0.3 to 3.0 [0.6]
Flow shape (%)	Mandatory breaths: 100 (Constant), 75, 50, 25 [100]
Cycle (%)	Spontaneous breaths: 5 to 90, Auto [Auto]
Trigger type	Flow/Pressure
Trigger	When Trigger Type is set to **Flow:** (double limb circuit only) Adult: 0.5 to 15 [1.0] (L/min) Ped: 0.5 to 15 [0.5] (L/min)
	When Trigger Type is set to **Pressure:** (double and single limb circuit) Very Low to Very High [Medium]
Rise Time (msec)	Spontaneous breaths: Min, 150 to 900 [200]

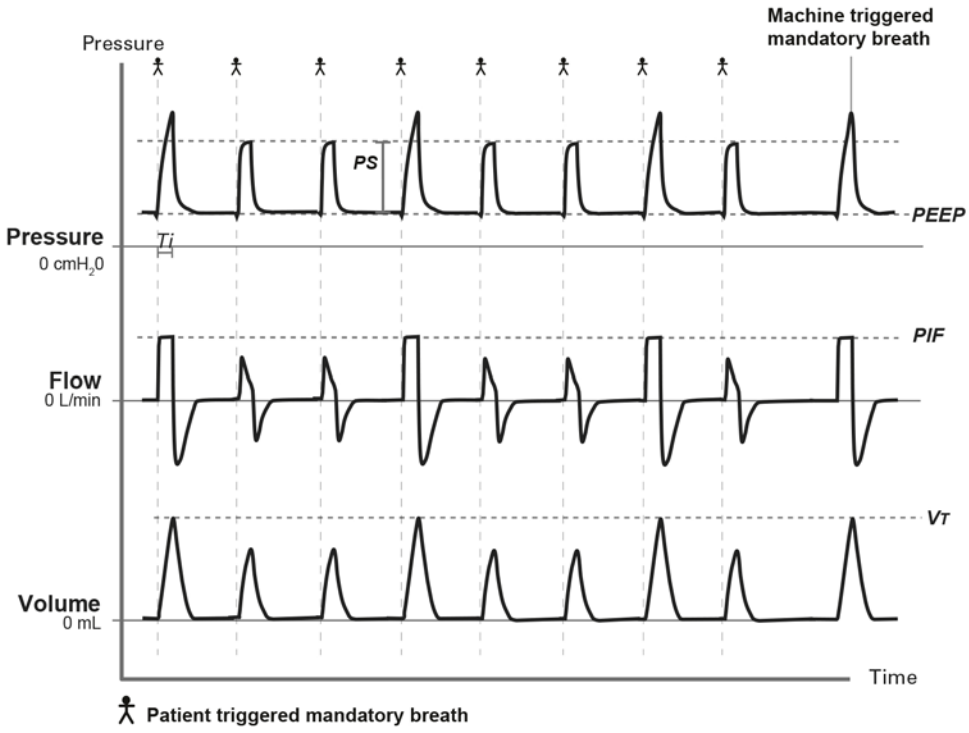
*The International ventilator standard indicates that Pediatric patient type is intended to be used for a patient receiving less than 300 mL, however Astral permits adjustment of 'Vt' setting parameter up to 500 mL for cases where 'Vt' is set such that it compensates for leak in the breathing circuit.

⚠ WARNING

ResMed does not recommend 500 mL as the upper limit for the pediatric tidal volume use; however, clinicians may choose this upper limit based on their clinical determination.

Supplementary features:

- Apnea response
- Manual breath (Astral 150 only)



Spontaneous breaths are permitted between mandatory breaths as shown in the figure above. In order to promote synchrony with the patient's spontaneous efforts, mandatory breaths may be patient triggered. Such patient triggering will cause some variation in the mandatory ventilation respiratory rate.

PS mode - Pressure support

PS is a pressure target ventilation mode delivering pressure-supported spontaneous breaths:

- Inspiration is either initiated by the ventilator at a set rate (time-triggered breath), or the patient (spontaneous-triggered breath). Spontaneous-triggered breaths re-schedule the next time-triggered breath. Set respiratory rate can be disabled.
- End of inspiration (switch from inspiration to expiration) is controlled by the patient (spontaneous-cycled breath).

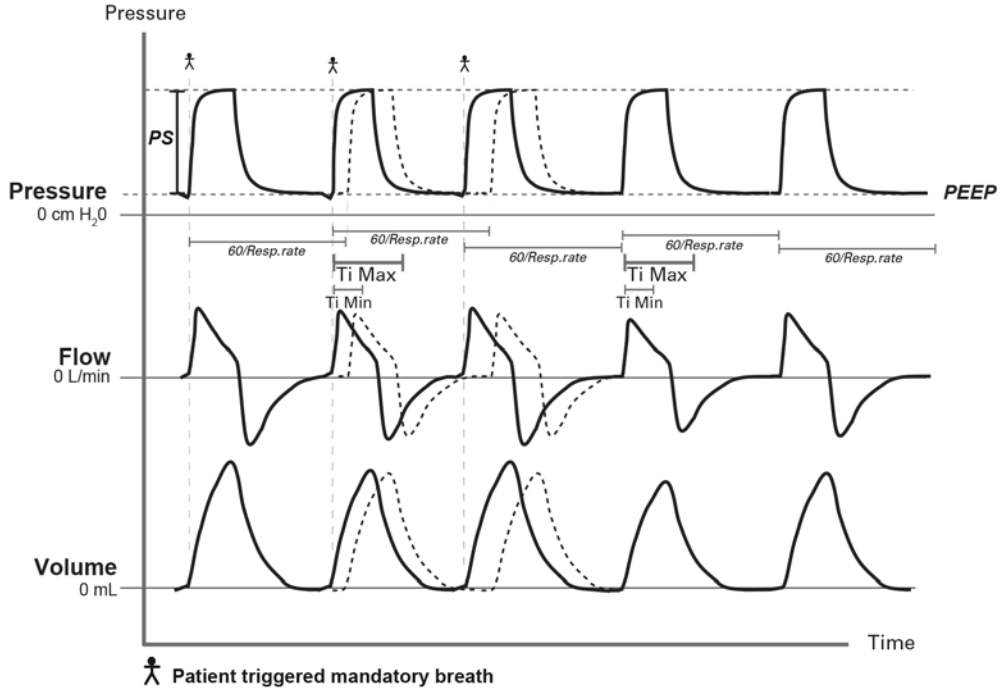
Parameter	Setting
Resp. rate (per min)	Adult: Off, 2 to 50 [15] Ped: Off, 5 to 80 [15]
PEEP (cmH_2O)	Off, 3 to 20.0 [5.0] (valve circuits) 2 to 25.0 [5.0] (vented circuits)
PS (cmH_2O)	Valve circuits: Adult: 2 to 50 [7] Ped: 2 to 50 [7]
	Vented circuits: Adult: 2 to 48 [7] Ped: 2 to 48 [7]
Cycle (%)	5 to 90, Auto [Auto] (valve circuits) 5 to 90 [25] (vented circuits)

Parameter	Setting
Trigger type	Double limb: Flow/Pressure Single limb: Pressure
Trigger	Double limb circuit: When Trigger Type is set to **Flow:** Adult: 0.5 to 15 [1.0] (L/min) Ped: 0.5 to 15 [0.5] (L/min) When Trigger Type is set to **Pressure:** Very Low to Very High [Medium]
	Single limb circuit: Very Low to Very High [Medium]
	Single with intentional leak: Off, Very Low to Very High [Medium]
Rise Time (msec)	Min, 150 to 900 [200]
Ti Min (sec)	0.2 to 4.0 [0.2]
Ti Max (sec)	Adult: 0.3 to 4.0 [1.5] Ped: 0.3 to 4.0 [0.8]

Note: Some default settings are different for Mouthpiece circuit.

Supplementary features:

- Apnea response (valve circuits only)
- Safety Vt (Tidal Volume)
- Manual breath (Astral 150 only) (valve circuits only)



- This graph shows PS mode with Resp. rate enabled with a transition from spontaneous-triggered to time-triggered breaths. Cycling is constrained within the limits of Ti Min and Ti Max.

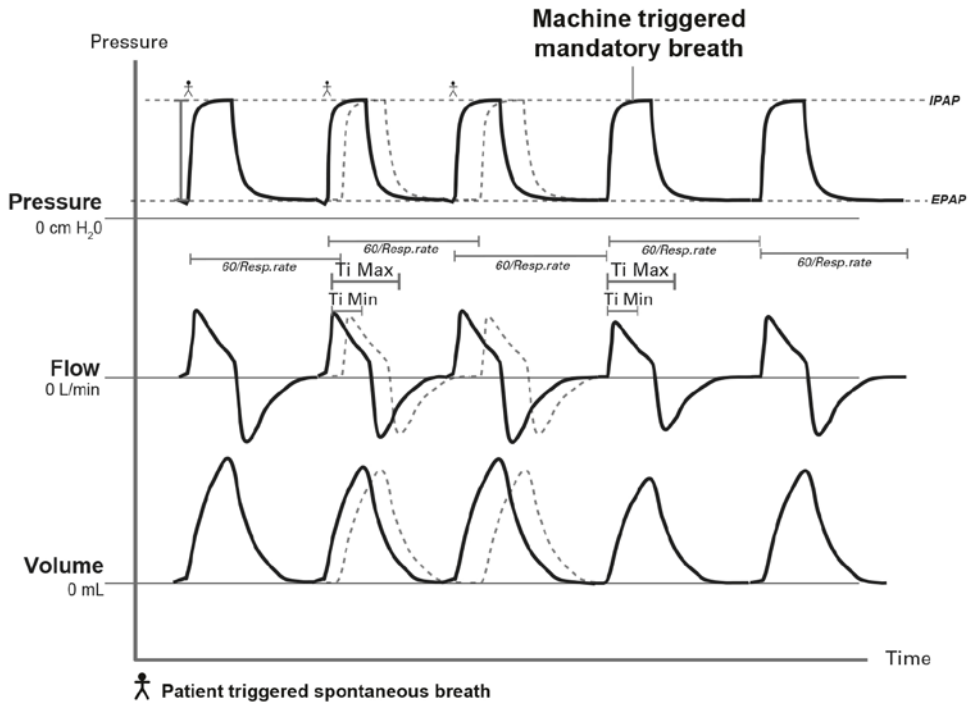
- To allow the patient sufficient time to exhale, Ti cannot exceed two-thirds of the breath period. (Breath period is equal to 60/Resp. rate).
- To allow sufficient time to reach the targeted inspiratory pressure, Rise time cannot exceed two-thirds of Ti Max.

(S)T mode - Spontaneous Ventilation with backup rate

(S)T is a bilevel ventilation mode delivering pressure-supported spontaneous breaths:

- Inspiration is either initiated by the ventilator at a set rate (time-triggered breath) or the patient (spontaneous-triggered breath). Spontaneous-triggered breaths re-schedule the next time-triggered breath. Resp. rate and Trigger can be set to Off, but not at the same time. When Trigger is set to Off, the mode name will be shown on the Information bar as T. When Trigger is active, and Resp.rate is set to Off, the mode name will be shown on the information bar as S.
- End of inspiration (switch from inspiration to expiration) is controlled by the patient (spontaneous-cycled breath) between Ti Min and Ti Max.

Parameter	Setting
Resp. rate (per min)	Adult: Off, 2 to 50 [15] Ped: Off, 5 to 80 [15]
EPAP (cmH_2O)	2 to 25 [5]
IPAP (cmH_2O)	Adult: 4 to 50 [12] Ped: 4 to 50 [12]
Trigger	Off, Very Low to Very High [Medium]
Rise Time (msec)	Min, 150 to 900 [200]
Ti Min (sec)	0.1 to 4.0 [0.2]
Ti Max (sec)	Adult: 0.3 to 4.0 [1.5] Ped: 0.3 to 4.0 [0.8]
Cycle (%)	5 to 90 [25]

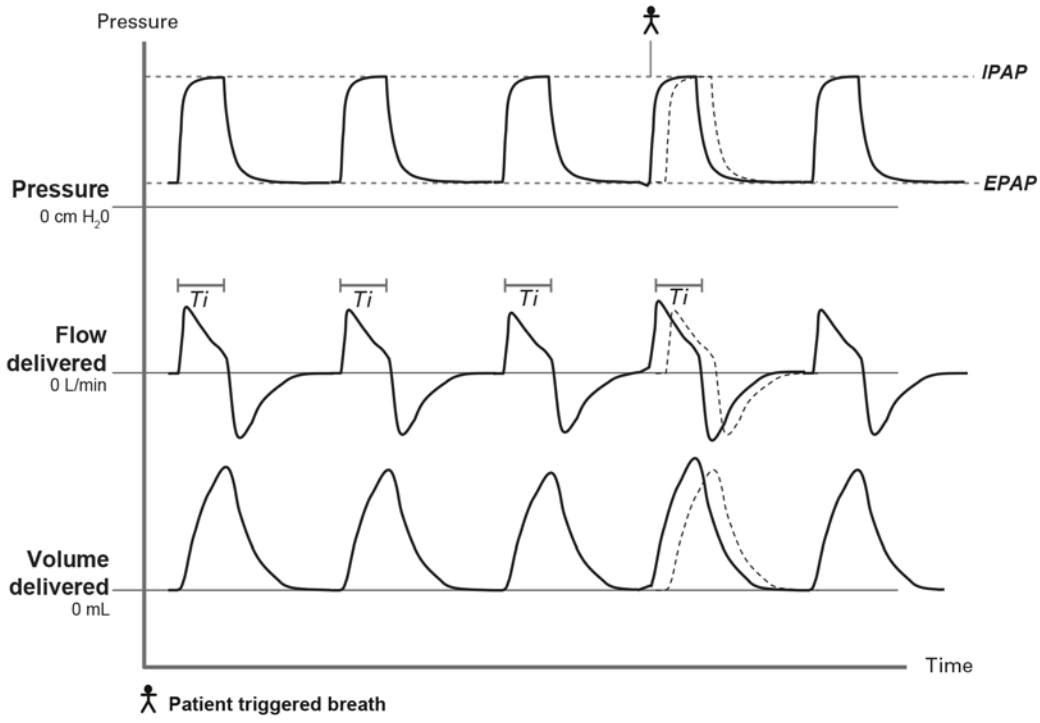


P(A)C mode

P(A)C is a bilevel ventilation mode delivering pressure-controlled mandatory breaths:

- Inspiration is either initiated by the ventilator at a set rate (time-triggered breath) or the patient (spontaneous-triggered breath). Spontaneous-triggered breaths re-schedule the next time-triggered breath. Resp. rate and Trigger can be set to Off, but not at the same time. When Trigger is set to Off, the mode name will be shown on the Information bar as PC.
- End of inspiration is controlled by the ventilator (time-cycled breath).

Parameter	Setting
Resp. rate (per min)	Adult: Off, 2 to 50 [15] Ped: Off, 5 to 80 [15]
EPAP (cmH_2O)	2 to 25 [5]
IPAP (cmH_2O)	Adult: 4 to 50 [12] Ped: 4 to 50 [12]
Ti (sec)	Adult: 0.3 to 4.0 [1.0] Ped: 0.3 to 4.0 [0.6]
Trigger	Off, Very Low to Very High [Medium]
Rise Time (msec)	Min, 150 to 900 [200]



- To allow the patient sufficient time to exhale, Ti cannot exceed two-thirds of 60/Resp. rate.
- To allow sufficient time to reach the targeted inspiratory pressure, Rise time cannot exceed two-thirds of Ti.

CPAP mode

CPAP mode delivers a constant level of pressure during inspiration and expiration.

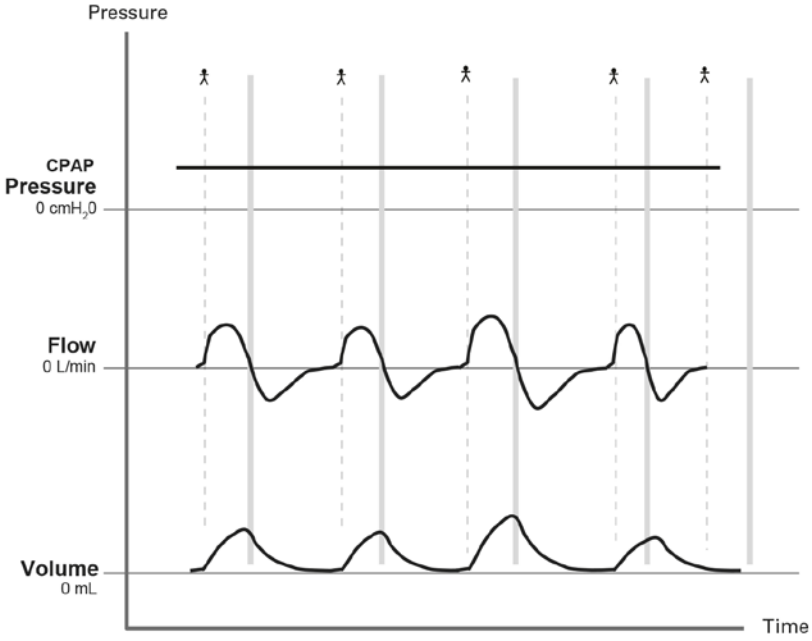
With CPAP administered via a valved breathing system, the inspiratory triggering level is settable to optimise the control of the exhalation valve and minimise the patient's work of breathing. Adjust trigger sensitivity to accurately report patient respiratory rate.

In a vented system, the inspiratory triggering level is settable to optimise monitoring and alarm performance.

Parameter	Setting
CPAP (cmH_2O)	All circuits: 3.0 to 20.0 [5.0]
Trigger type	Double limb circuit: Flow/Pressure
Trigger	Double limb circuit: When Trigger Type is set to **Flow:** Adult: 0.5 to 15 [1.0] (L/min) Ped: 0.5 to 15 [0.5] (L/min) When Trigger Type is set to **Pressure:** Very Low to Very High [Medium]
	Single limb circuit: Very Low to Very High [Medium]
	Single with intentional leak: Very Low to Very High [Medium]

Supplementary features:

- Apnea response (Valve circuits only)



CPAP operation with a single limb circuit with intentional leak is displayed.

iVAPS (intelligent Volume Assured Pressure Support) mode

Note: This feature may not be available on your device.

iVAPS is designed to maintain a preset target alveolar minute ventilation by monitoring delivered ventilation, adjusting the pressure support automatically and providing intelligent backup breaths. The iVAPS therapy mode is indicated for patients weighing 30 kg (66 lb) and above.

iVAPS offers the comfort and synchrony of pressure support, but with the assurance offered by a volume target.

Pressure support is adjusted continuously, breath to breath, aiming to maintain target alveolar ventilation. If ventilation falls, pressure support is increased until the target is reached. Conversely, if alveolar ventilation rises above target, pressure support falls. The range of pressure support adjustment is constrained within Min PS and Max PS.

The actual mask pressure achieved during iVAPS or iVAPS-AutoEPAP therapy is the sum of the EPAP and pressure support, limited to 2 cmH_2O below the set High Pressure limit. As a result, High Pressure limit can be a useful way to constrain overall therapy pressure, eg, during Mask NIV on page 96.

The rate of increase in pressure support can reach up to 0.7 cmH_2O/sec. The breath to breath changes in pressure support depend on the breath rate and how far the patient is from the target alveolar ventilation. Typically, the change in pressure support does not exceed 3 cmH_2O per breath.

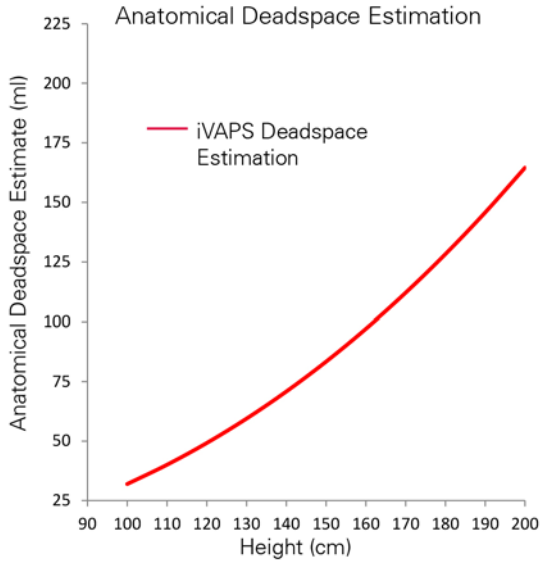
Parameter	Setting
Target Va (L/min)	1.0 to 30.0 [5.2]
Target Pt rate (per min)	Adult: 8 to 30 [15]
Pt Height	cm: 110 to 250 [175] inches: 44 to 100 [70]
EPAP (cmH_2O)	2.0 to 25.0 [5.0]
Min EPAP (cmH_2O)	2.0 to 25.0 [5.0] when AutoEPAP is ON
Max EPAP (cmH_2O)	2.0 to 25.0 [15.0] when AutoEPAP is ON
Min PS (cmH_2O)	0.0 to 50.0 [2.0]
Max PS (cmH_2O)	0.0 to 50.0 [20.0] when AutoEPAP is OFF 8.0 to 50.0 [20.0] when AutoEPAP is ON
Rise Time (msec)	Min, 150 to 900 [200]
Ti Min (sec)	0.1 to 4.0 [0.5]
Ti Max (sec)	0.3 to 4.0 [1.5]
Trigger	Very Low to Very High [Medium]
Cycle (%)	5 to 90 [25]

Target alveolar ventilation

iVAPS targets alveolar ventilation. Alveolar ventilation was chosen because gas exchange occurs at the alveoli level. Total ventilation includes the ventilation devoted to the conducting airways, whereas alveolar ventilation best represents the useful portion of ventilation that reaches the alveoli.

Alveolar ventilation cannot be measured directly, so iVAPS estimates it using a height approximated value of anatomical deadspace as shown in the graph below. Anatomic deadspace is the amount of breath that remains in the conducting airways, that does not reach alveoli and does not contribute to gas exchange. Its contribution is proportional to breath rate. By using alveolar ventilation as a servo-ventilation target, as opposed to tidal volume or minute ventilation, the effect of respiratory rate change on effective ventilation is compensated for.

Note: When ventilating in iVAPS mode, the current Va value is displayed on the Monitoring screen.



Adapted from Hart MC et al. Journal Applied Physiology.18(3), p519-522. 1963

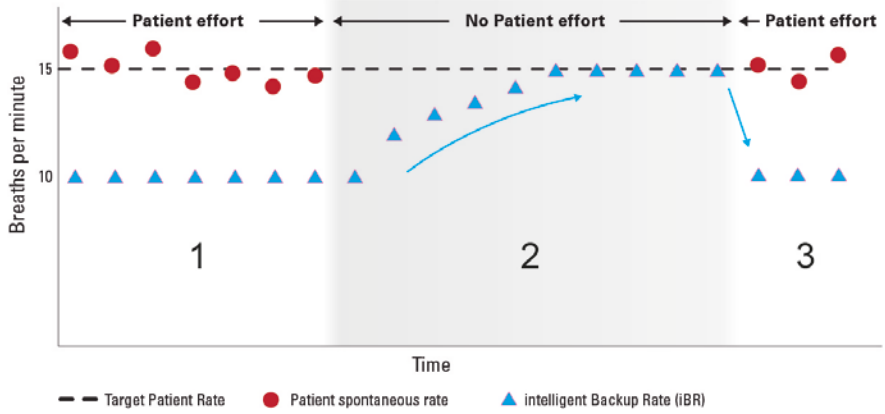
intelligent Backup Rate (iBR)

Instead of mandating a fixed backup rate, the intelligent Backup Rate (iBR) will shift automatically between two limits.

During sustained apnea, the iBR will adopt a pre-configured Target Patient Rate. This Target Patient Rate defines the upper boundary for iBR. Set the Target Patient Rate to match the patient's average spontaneous rate (unlike a traditional backup rate).

1. During spontaneous ventilation, the iBR adjusts to remain in the background, at two-thirds of the Target Patient Rate. This 'background' backup rate is lower than a traditional (S)T rate, so gives the patient maximum opportunity to spontaneously trigger.
2. When spontaneous triggering ceases (eg, at the onset of an apnea/hypopnea), the iBR adjusts from its background frequency to its Target Patient Rate in iVAPS mode and adjusts quickest (typically within 4 to 5 breaths) when ventilation is below the target ventilation.
3. A single spontaneous triggered breath resets the iBR to its background rate (two-thirds of Target Patient Rate).

iBR brings the patient back to target when backup breaths are required



Configuring iVAPS

There are two ways in which you can configure iVAPS mode:

- Adopting the recently learnt targets, from any vented mode (CPAP, (S)T or PAC)—learns the patient's breathing pattern and calculates the target values automatically, or
- Entering the target values manually.

Adopting recently learnt targets

While ventilating the patient on the Vented mode of your choice (CPAP, (S)T or PAC), the patient's resting ventilation is monitored, with the goal of learning the patient's Target Alveolar Ventilation (Target Va) and Target Patient Rate (Target Pt Rate) in preparation for iVAPS mode.

After the final circuit configuration (includes patient's height, EPAP, appropriate mask settings and any supplemental oxygen added) is achieved, follow the procedure below.

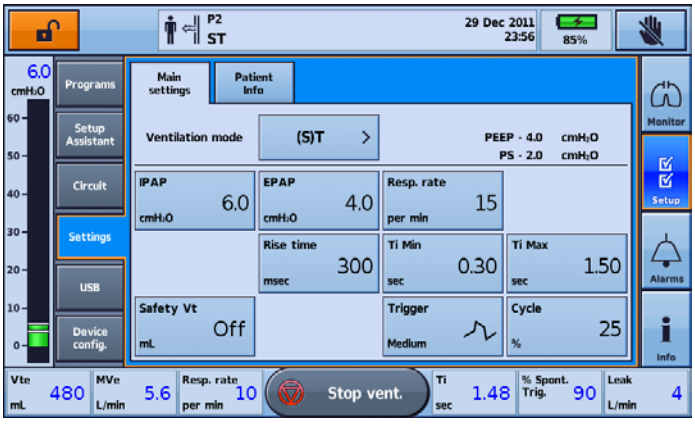
Over the last five minutes of ventilation, Tidal Volume and Respiratory Rate are recorded for each breath. Target Va and Target Pt Rate are then calculated over those last five minutes. Ensure the patient remains comfortable, breathing is stable and leak is minimised.

Note: iVAPS and AutoEPAP will only be initiated once Learn Target values are accepted.

Adopting recently learnt targets

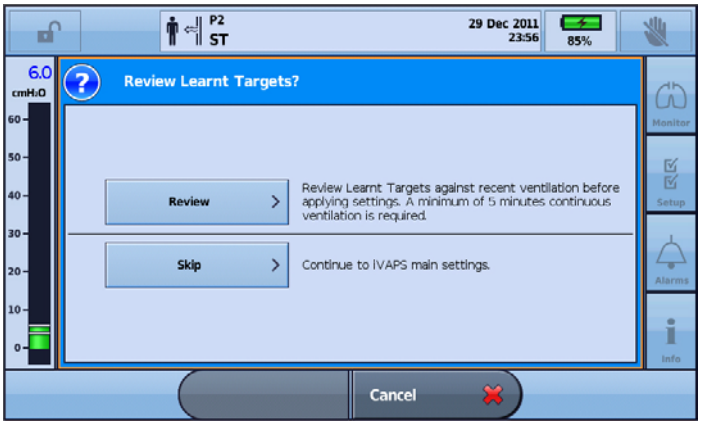
To adopt recently learnt targets

1. From the **Setup** main menu, select **Settings**.
2. From the **Settings** menu, select the **Main settings** tab



3. From the on-screen selections, press **Ventilation Mode**, then select **iVAPS**.

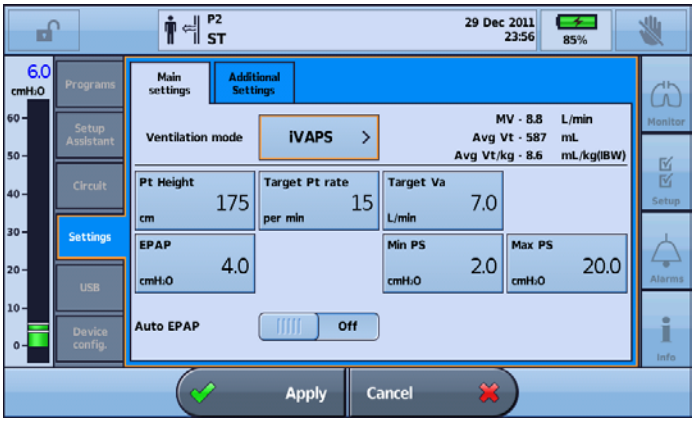
4. From the on-screen selections, press **Review**.



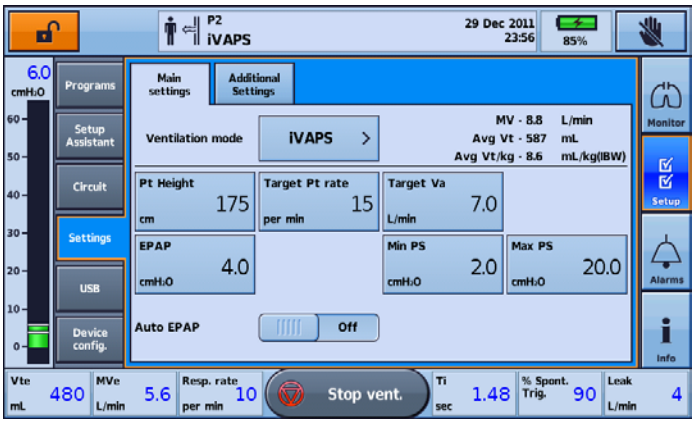
Note: The Review option will only be available for selection if there is at least five minutes worth of patient data available.

5. Review the **Learnt Targets** and make adjustment to **Pt Height** if required. Select **Confirm**.

6. Select **Apply**.



You have now successfully configured iVAPS.



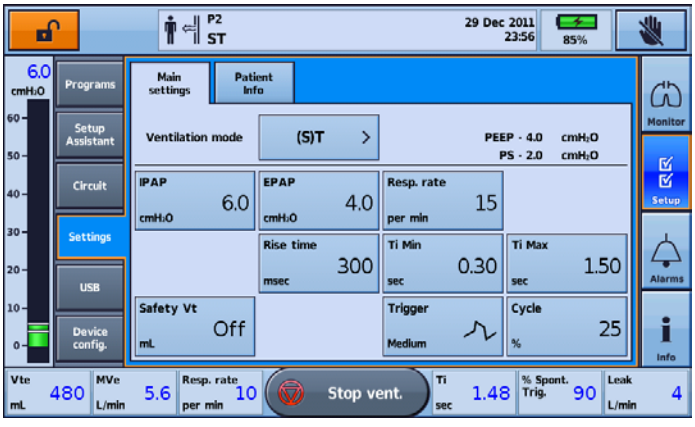
Note: With AutoEPAP switched on, the information window name is updated to iVAPS.AutoEPAP.

Entering the target values manually

The Target Va can also be determined to adopt a Target Patient Rate using a settable Target Va parameter and patient height. Target Pt Rate should match the patient's normal breathing rate.

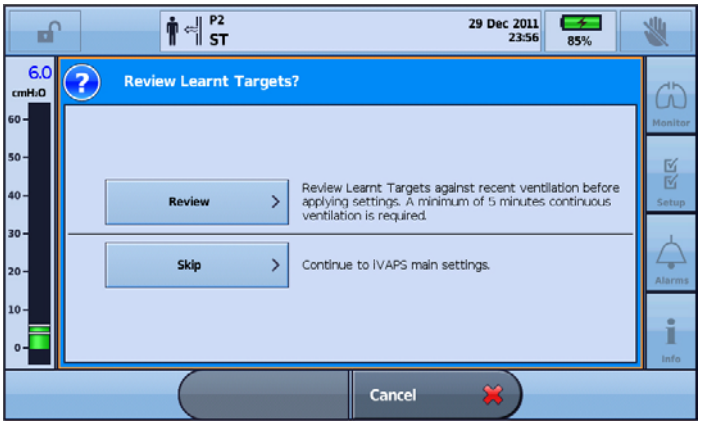
To enter the target values manually

1. From the **Setup** main menu, select **Settings**.
2. From the **Settings** menu, select the **Main Settings** tab.

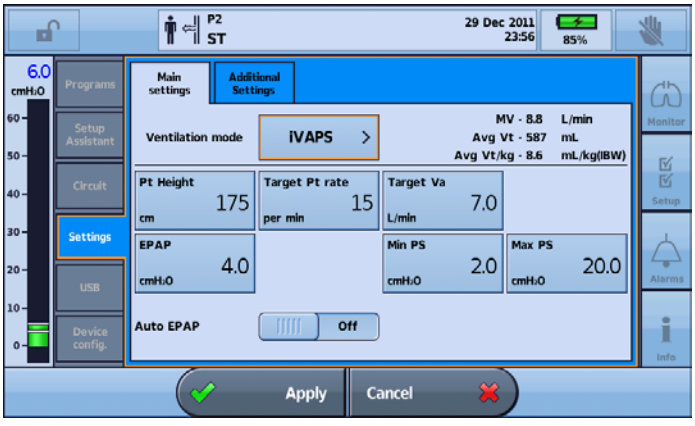


3. From the on-screen selections, press **Ventilation Mode**, then select **iVAPS**.

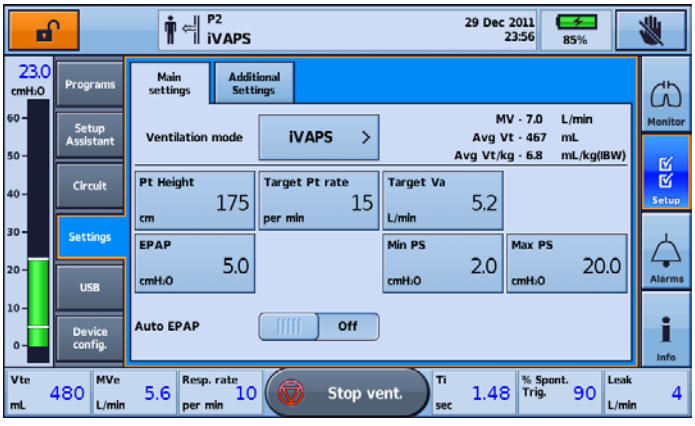
4. Select **Skip**.



5. From the iVAPS main settings screen select **Apply**.



iVAPS has been successfully applied.



AutoEPAP

iVAPS mode only.

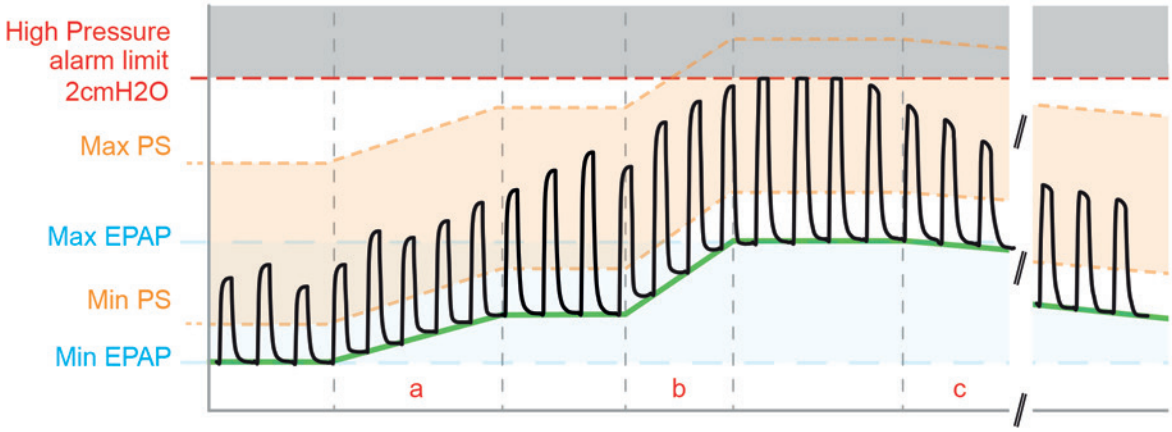
Note: This feature may not be available on your device.

The purpose of EPAP is to maintain upper airway patency. AutoEPAP automatically adjusts pressure in response to flow limitation or obstruction of the upper airway. EPAP is adjusted within Min EPAP and Max EPAP settings with the response depending on the degree of the upper airway obstruction.

⚠ WARNING

AutoEPAP is contraindicated when using an invasive interface.

Pressure support is adjusted on top of the EPAP. The maximum delivered pressure, EPAP plus pressure support, is limited to 2 cmH_2O below the set High Pressure limit. If the sum of EPAP plus pressure support exceeds the maximum pressure limit, pressure support is sacrificed to maintain airway patency (ie, EPAP). However, pressure support will not drop below the set minimum pressure (Min PS).



(a) For flow limitation, EPAP will increase at a maximum rate of 0.5 cmH_2O (0.5 hPa) per breath.

(b) For obstructive apnea, EPAP will increase at a rate of approximately 1 cmH_2O (1 hPa) per second spent in inspiration on termination of the apnea.

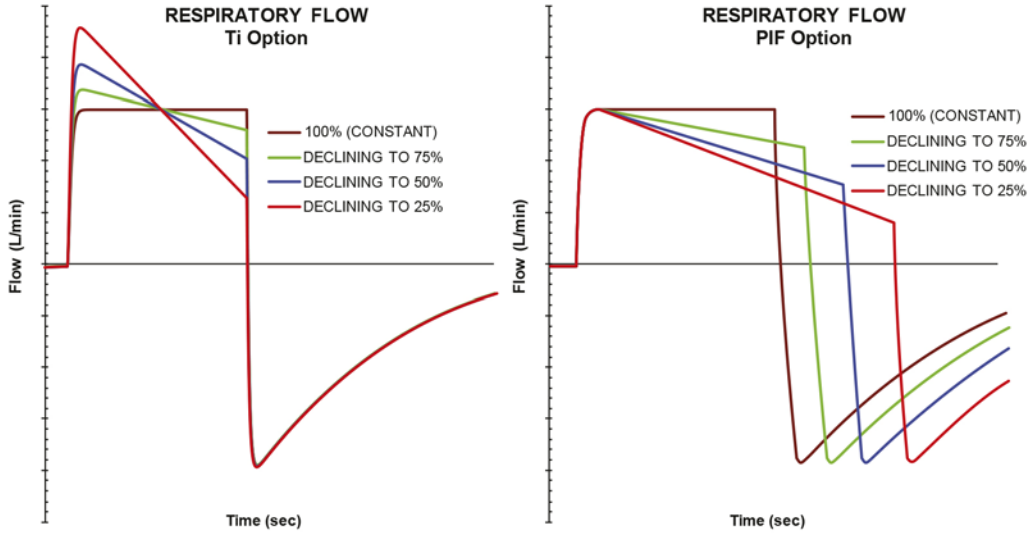
(c) EPAP will start to decrease from the first breath after upper airway obstruction has resolved and will continue to decrease slowly until either another upper airway flow limitation/obstruction occurs or Min EPAP is reached.

The AutoEPAP algorithm does not address any other titration target such as lung recruitment to improve oxygenation or offset intrinsic PEEP. Min EPAP should be set to treat lower airway conditions. AutoEPAP will increase airway pressure to treat upper airway conditions.

Flow shape settings

The Astral device supports four flow shape settings:

1. 100% (Constant)
2. 75%
3. 50%
4. 25%



Effective flow shape setting with Volume breath option set to Ti and PIF for a fixed volume

The figure illustrates how Flow Shape affects breath delivery for a fixed volume. With volume breath option set to PIF (Peak Inspiratory Flow), adjusting the flow shape alters the inspiratory duration, whereas with volume breath option set to Ti (Inspiratory time), adjusting the flow shape alters the Peak Inspiratory Flow.

When the flow shape is set to 100%, the flow is generally constant during inspiration. For decreasing percentages, the flow starts at the peak flow and declines to approximately the percentage setting of this value at the end of inspiration.

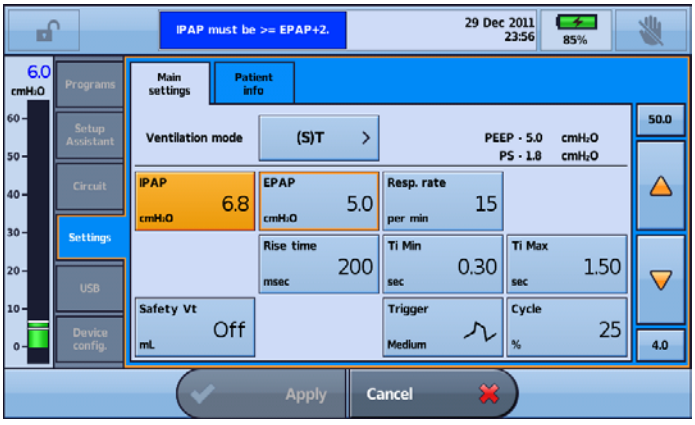
To select between Ti and PIF options:

1. From the Setup menu select Device config.
2. Select Units
3. Select Ti or PIF.

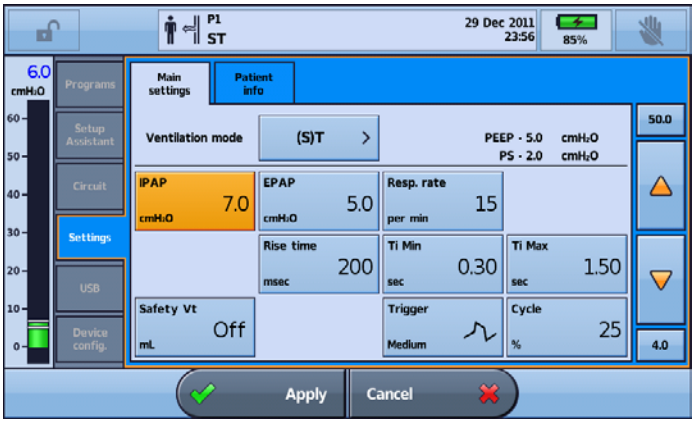
Interdependence of controls

Dynamic settings limits

The adjustable range of one setting may be restricted by the value of another. When a dynamic limit of this kind is reached, a message describing the limitation (interdependence) is displayed on the Information bar and the Apply button is disabled.



To enable the Apply button, modify one of the conflicting settings. For example in this case, to continue IPAP must be increased or EPAP decreased.



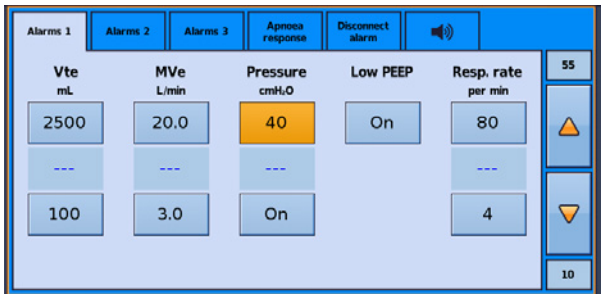
Making use of Astral's High Pressure limit

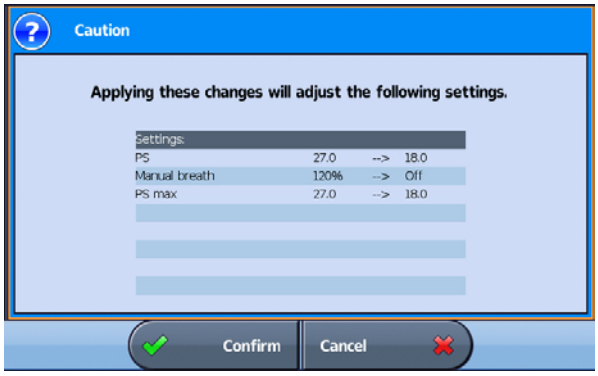
Astral's High Pressure limit acts as a traditional High Pressure alarm for volume target therapies and fault situations. For pressure modes and volume-assured pressure modes, the High Pressure setting acts as an overall pressure limit, keeping the maximum delivered pressure to 2 cmH_2O less than the High Pressure setting, regardless of the individual control settings.

For example, reducing the High Pressure limit may constrain the following parameters:

- P control
- PS
- P control max
- Max PS
- PEEP
- IPAP
- EPAP
- CPAP
- Apnea breath settings
- Sigh breath Magnitude
- Manual breath Magnitude

When making adjustments to the high pressure alarm limit, you are prompted to confirm the changes to any affected settings. If these setting changes are not accepted, the change to the high pressure alarm limit is not applied.





Triggering and cycling

- The Astral device has adjustable trigger and cycle sensitivities to provide optimal synchrony between the patient and the device and to minimise work of breathing.
- Triggering is the device response to an increase in patient effort. Once the set inspiratory trigger threshold is reached, the device starts the inspiratory phase.
- Cycling (also called expiratory triggering) is the response to a decrease in patient inspiratory flow. Once the set cycling threshold is reached the device cycles from the inspiratory to expiratory phase.

The higher the sensitivity selected, the smaller the patient effort required to trigger inspiration, and the smaller the reduction in patient inspiratory flow to initiate expiration.

The triggering method depends on the circuit type.

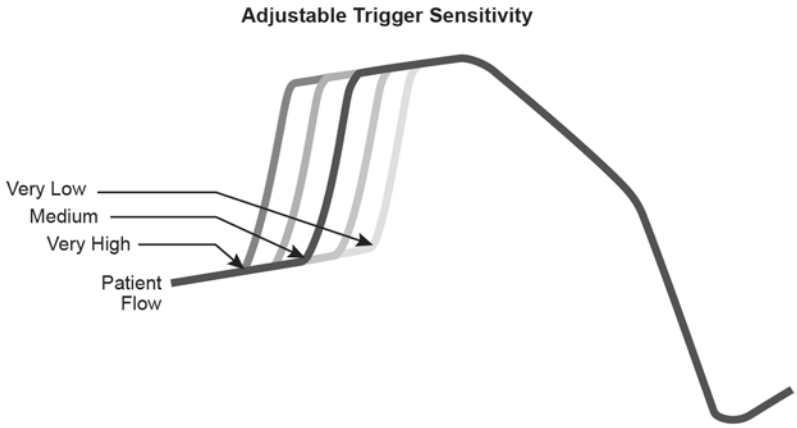
Circuit type	Trigger type	Trigger detection
Single limb circuit with intentional leak	Flow Very Low to Very High	Vsync
Single limb circuit with integrated valve	Pressure Very Low to Very High	NIV+
Double limb circuit	Choice between Pressure: Very Low to Very High Flow: 0.5 - 15 L/min	 NIV+ Flow
Mouthpiece circuit	Flow Touch, Low to High	Touch

Triggering with intentional leak circuits

When using a circuit with intentional leak, estimation of the patient respiratory flow is enhanced by ResMed's automatic leak management feature—Vsync.

Vsync technology allows the device to estimate the patient respiratory flow in the presence of unintentional leak. Using the respiratory flow signal, the device is able to trigger and cycle closely with the patient's effort.

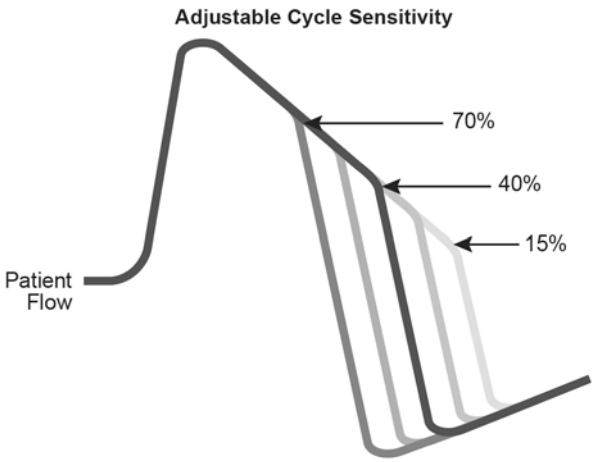
The Astral device has five trigger sensitivity levels (Very Low to Very High). The higher the sensitivity selected the smaller the patient effort required to trigger inspiration.



Cycling with intentional leak circuits

The Astral device is able to detect a decrease in patient respiratory flow during inspiration, indicating the optimum point to commence exhalation.

The Astral device provides an adjustable cycle sensitivity set point expressed as a percentage of the maximum flow. The higher the sensitivity selected, the smaller the reduction in inspiratory flow to cycle to expiration.



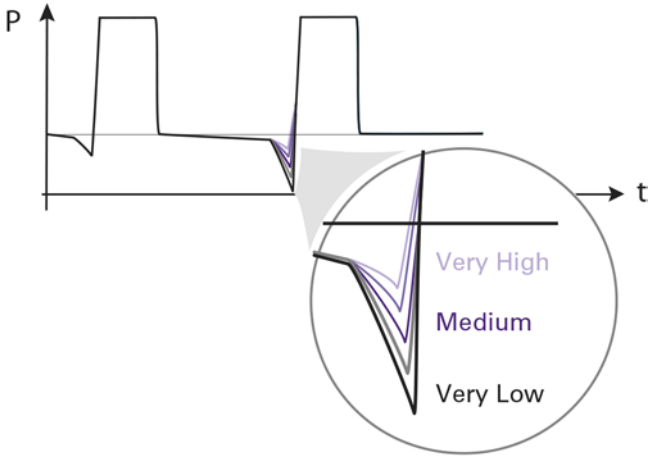
Note: Cycling is constrained within the limits of TiMin and TiMax. This means that the inspiratory period cannot be less that TiMin or longer than TiMax.

Triggering with valve circuits

When using single or double limb valve circuits, the Astral device uses ResMed's NIV+ trigger sensitivity technology. Unlike simple conventional triggering which only considers the magnitude of the pressure change, NIV+ also considers the shape of the pressure waveform to significantly improve trigger sensitivity.

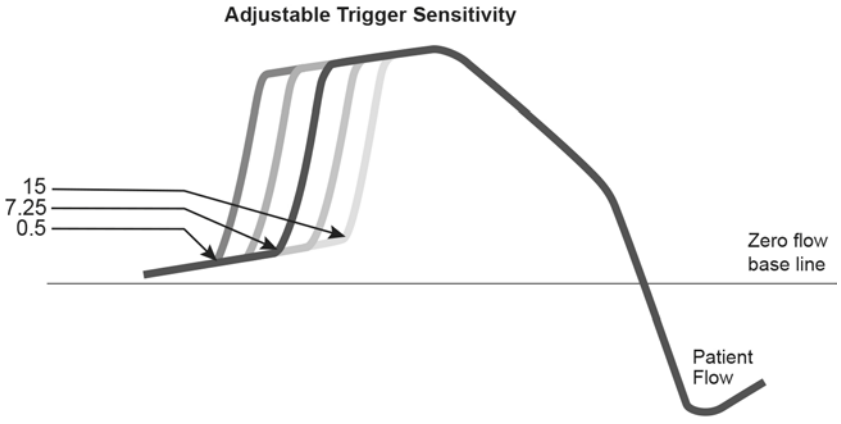
Pressure trigger with single and double limb circuits

The Astral device is able to detect a negative change of pressure, relative to the pressure base line at the end of expiration, indicating the start of a patient spontaneous breath. There are five sensitivity levels of trigger sensitivity from Very Low to Very High.



Flow trigger with double limb circuits

Flow triggering is suitable for use with double limb circuits for invasive applications with no expected leak eg, cuffed tracheostomy. By monitoring the exhaled gas, the Astral device is able to detect an increase in patient respiratory flow at the end of expiration, indicating the start of a spontaneous breath. The flow trigger threshold represents the increase in patient respiratory flow at the end of expiration. When that threshold is reached the device starts the inspiratory phase.



Flow trigger range	L/min
Adult:	0.5-15 [Default = 1.0]
Pediatric:	0.5-15 [Default = 0.5]

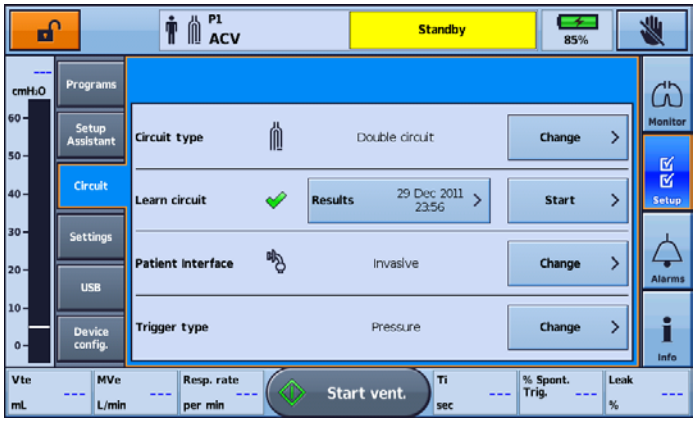
The lower the setting number, the higher the sensitivity.

Changing the Trigger Type

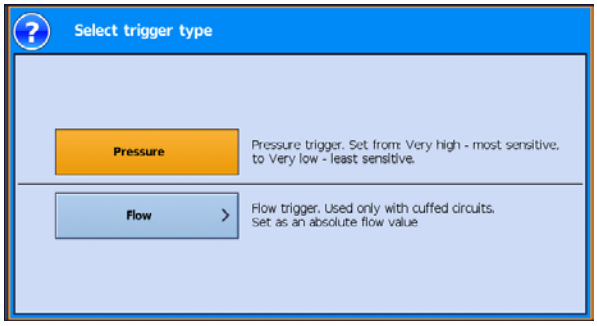
For double limb circuits, changing Trigger type can be done while the device is ventilating or in Standby.

To change between pressure and flow trigger types on double circuits:

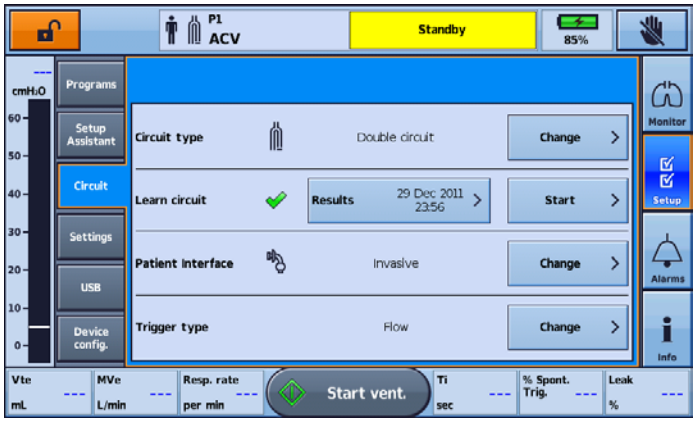
1. From the Setup menu, select **Circuit**.



2. From the Trigger type option, press **Change**. The current Trigger Type is highlighted.



3. Select Flow. You will be returned to the Circuit screen where the changed Trigger type will be displayed.



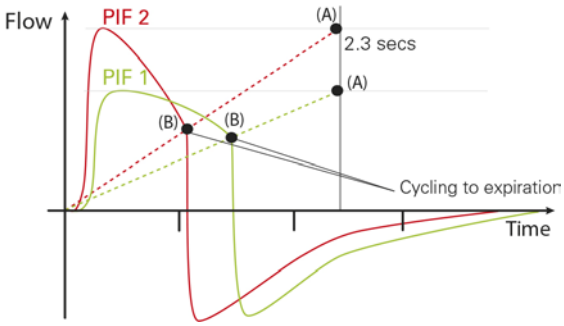
Cycling with valve circuits

Cycling in the Astral device is based on flow and can be set to automatic or manual.

Automatic cycling adjustment

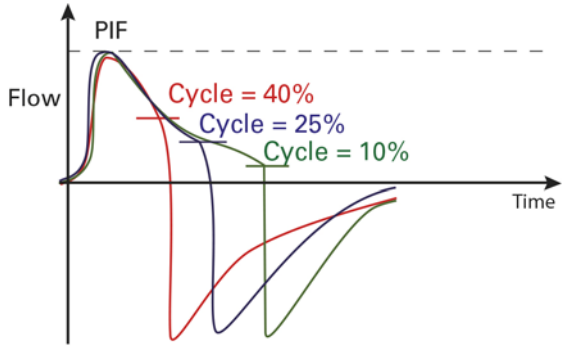
Allows for the duration of the inspiratory phase (Ti) to vary from one breath to another, according to the characteristics of the patient's spontaneous breathing. Therefore, Ti varies according to the shape of the flow curve and the maximum flow value.

In the figure below, a dotted line is drawn between the start of inspiration and point (A) marked at the peak inspiratory flow (PIF) at 2.3 seconds. Cycling occurs when the decelerating flow curve intersects with this dotted line (B). The two breaths in the figure have different PIF values and therefore different Ti times.



Manual cycling adjustment

The manual cycling set point is expressed as a percentage of the maximum flow. Cycling to expiration occurs when the decreasing patient respiratory flow reaches the set cycling threshold. The higher the percentage, the more sensitive the cycling.



Note: Cycling is constrained within the limits of TiMin and TiMax. This means that the inspiratory period cannot be less that TiMin or longer than TiMax.

To change between automatic and manual cycling features

1. From the Setup main menu, select Settings.
2. From the Settings menu, select the **Main settings** tab.
3. From the on-screen selections, press Cycle.

Triggering with mouthpiece circuits

When using a mouthpiece circuit, the Astral device monitors the flow during the expiration phase for changes in the magnitude and shape of the flow measurement to improve trigger sensitivity.

There are four sensitivity levels: Low, Medium, High and Touch.

Low, Medium and High trigger sensitivity levels are based on the detection of a change in flow during expiration indicating the start of a spontaneous breath. The higher the sensitivity selected, the smaller the patient effort required to trigger inspiration.

The Touch trigger setting combines the standard trigger with ResMed's Touch trigger technology to detect the patient engaging or blocking the mouthpiece to trigger inspiration.

Supplementary features

Manual breath settings

Manual breath feature allows the user to manually insert a breath within the currently delivered breathing pattern.

The Manual breath feature is used to trigger manual breath(s) and can be pressed at any time.

- If pressed during **expiration**, the manual breath will be delivered immediately.
- If pressed during **inspiration**, the manual breath will be delivered 300 ms after the end of the current inspiration.

The manual breath can be configured as a magnified version of the primary breath (magnification factor set from 100 to 250%).

For pressure-target breaths, the inspiratory duration and pressure are magnified proportionally.

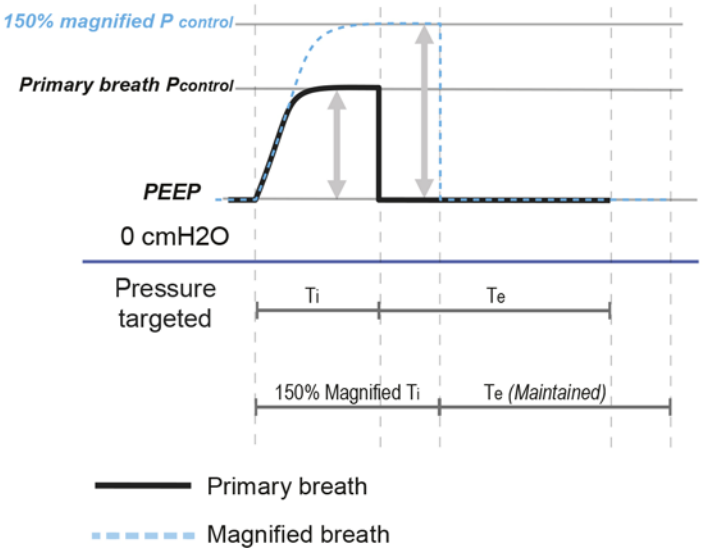
For volume-target breaths, the delivered volume is magnified proportionately.

Adjustable parameters:

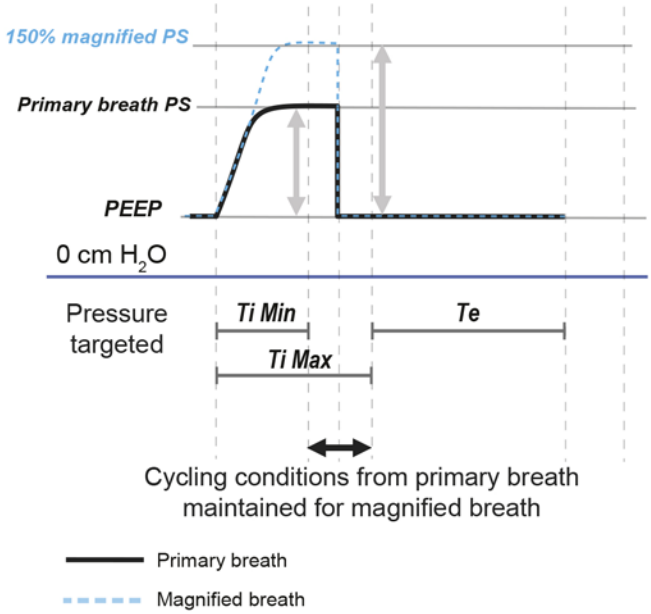
Parameter	Setting
Manual Breath	Off, On [Off]
Magnitude (%)	100 to 250 [150]

Note: The Magnitude (%) value is clipped at 2500 mL and 500 mL for Adult and Pediatric patient types respectively.

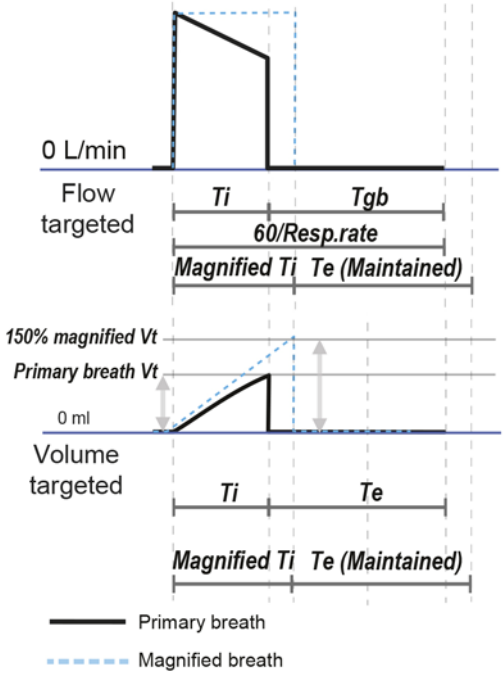
For pressure-controlled mandatory breaths, the P control and breath duration are magnified by the magnification factor. This applies to mandatory breaths in P(A)CV mode and in P-SIMV and V-SIMV modes.



For pressure-assisted spontaneous breaths only the PS is magnified.



For volume-controlled mandatory breaths, the volume is magnified by firstly flattening the flow shape, then by extending the Ti and finally by increasing the PIF. This applies to mandatory breaths in (A)CV and V-SIMV modes.



Sigh settings

The Sigh breath feature allows the user to program the delivery of a 'sigh breath' at a regular interval (sigh interval) within the currently delivered breathing pattern.

The sigh breath is a magnified version of the primary breath (Magnification factor set from 120 to 250%).

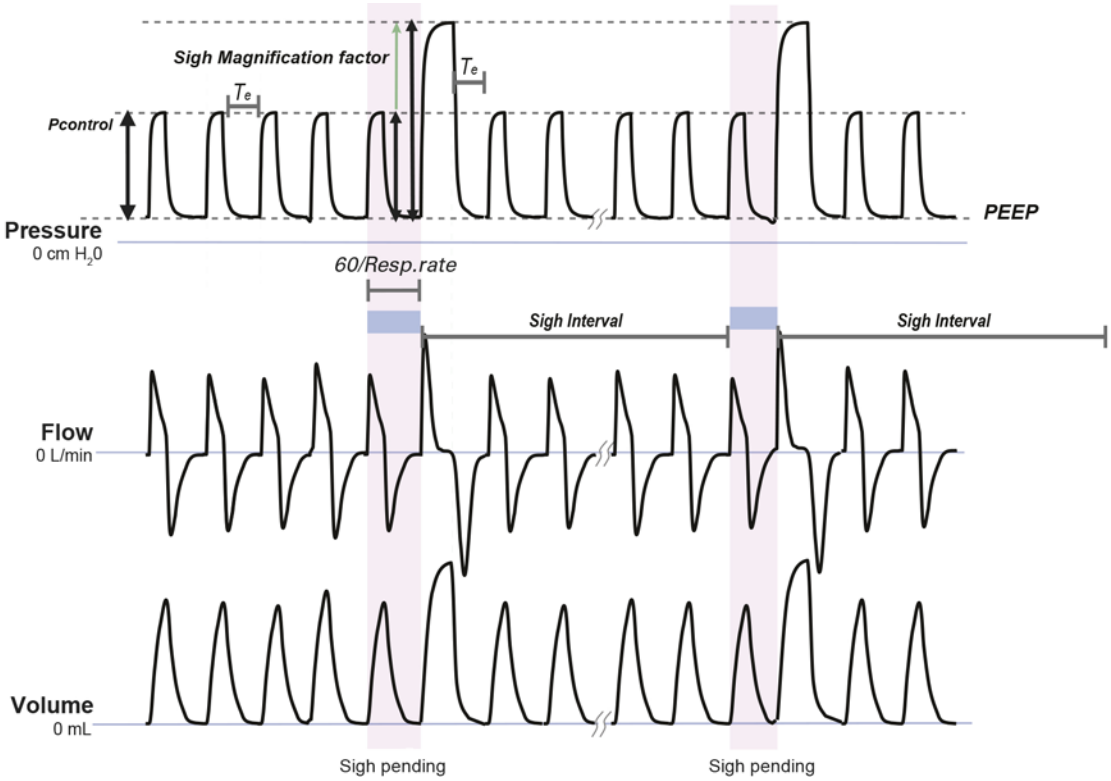
For pressure-target breaths, the inspiratory duration and P control are magnified proportionally.

For volume-target breaths, volume is magnified.

Adjustable parameters – (A)CV & P(A)CV Modes only:

Parameter	Setting
Sigh Breath	Off, On [Off]
Sigh Alert	Off, On [Off]
Interval (min)	3 to 60 [10]
Magnitude (%)	120 to 250 [150]

Note: The Magnitude (%) value is clipped at 2500 mL and 500 mL for Adult and Pediatric patient types respectively.



Apnea Settings

The Astral device allows the clinician to define what should happen when the device detects an apnea.

An apnea refers to the absence of breath within a configurable period: T apnea (Apnea Interval).

Apnea can be defined as an absence of patient-triggered breaths (No Spont Breath), or an absence of any breaths (No Breath), whether they are patient, time, or manually-triggered breaths.

Three types of Apnea response settings can be selected on the Astral device:

1. Alarm only
2. Alarm + apnea ventilation ((A)CV breath pattern)
3. Alarm + apnea ventilation (P(A)CV breath pattern)
4. Off

When Alarm + apnea ventilation ((A)CV or P(A)CV) is selected, apnea ventilation is automatically triggered following the detection of an apnea event. Apnea ventilation is displayed on the Information bar.

The Apnea response will deactivate when the patient triggers three consecutive breaths.

ResMed recommends that Apnea ventilation is enabled whenever the Resp. rate is set to Off.

Control settings for Apnea ventilation

Parameter	Setting
Apnea response	
All modes	Alarm only
Valve ventilation modes only	(A)CV + Alarm (for (A)CV breath pattern)
Valve ventilation modes only	P(A)CV + Alarm (for P(A)CV breath pattern)
All modes (Adult)	Off
Apnea Detection	No breath, No Spont. breath [No breath]* *Adult: [Off] when the mouthpiece interface is selected.
T apnea (min:sec)	Adult: 15s to 60s [20s]* Ped: 5s to 30s [10s] *Adult T apnea can be extended to 15min when the mouthpiece interface is selected.

⚠ WARNING

Setting Apnea Detection to No breath and T apnea to a value greater than 60s will make the Apnea Alarm and Response ineffective.

(A)CV Breath pattern

Parameter	Setting
Vt (mL)	Adult: 100 to 2,500 [500] Ped: 50 to 300 [100]*
Ti (sec)	When Volume Breath option is set to Ti: Adult: 0.3 to 3.0 [1.0] Ped: 0.3 to 3.0 [0.6]
PIF (L/min)	When Volume Breath option is set to PIF: Adult: 10 to 120 [50] Ped: 5 to 60 [10]
Resp. rate (per min)	Adult: 4 to 50 [15] Ped: 12 to 80 [15]

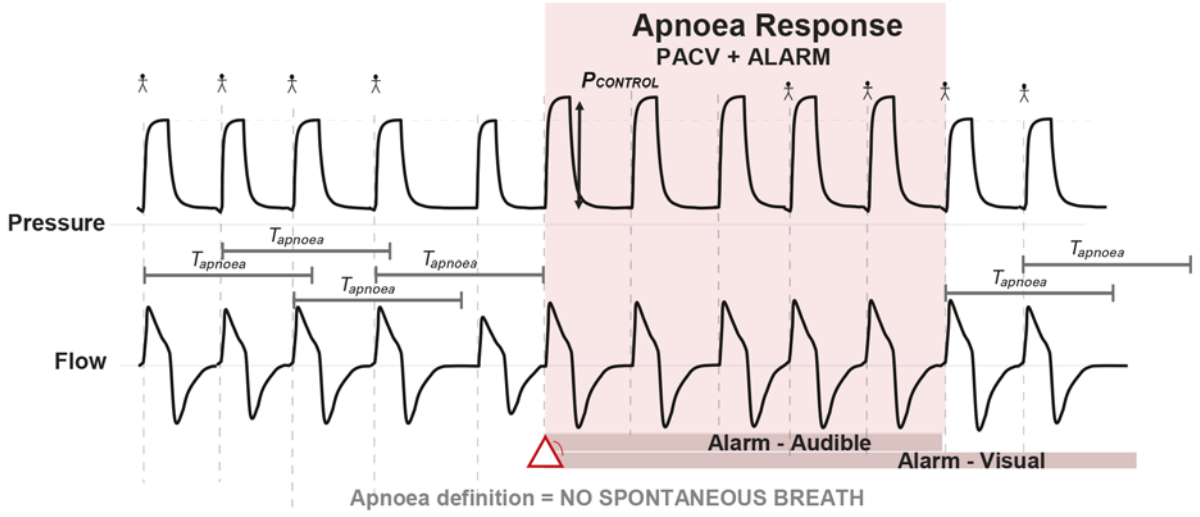
*The International ventilator standard indicates that Pediatric patient type is intended to be used for a patient receiving less than 300 mL, however Astral permits adjustment of 'Vt' setting parameter up to 500 mL for cases where 'Vt' is set such that it compensates for leak in the breathing circuit.

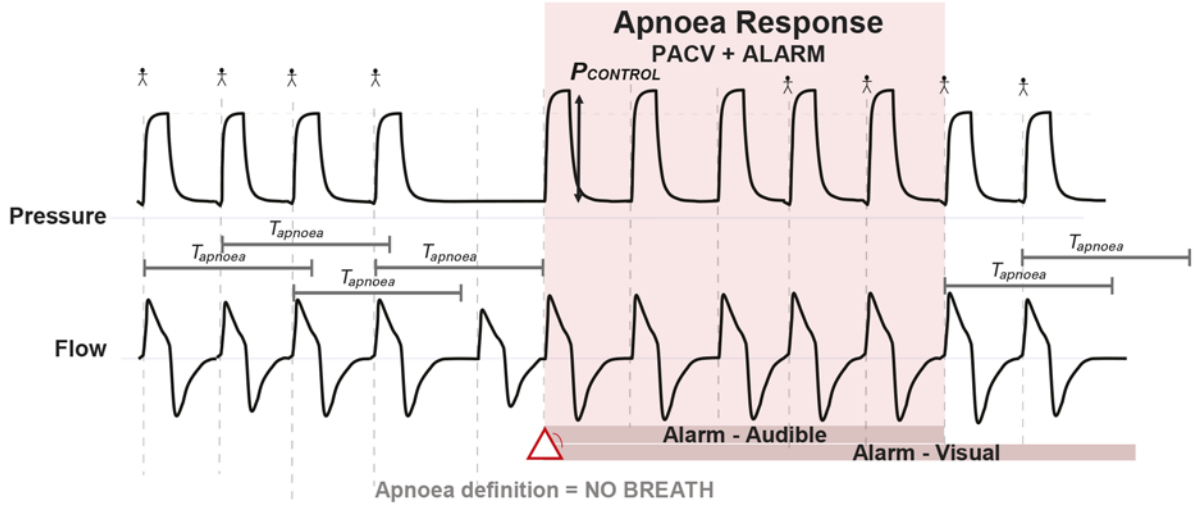
⚠ WARNING

ResMed does not recommend 500 mL as the upper limit for the pediatric tidal volume use; however, clinicians may choose this upper limit based on their clinical determination.

P(A)CV breath pattern

Parameter	Setting
P control (cmH_2O)	Adult: 2 to 50 [7] Ped: 2 to 50 [7]
Ti (sec)	Adult: 0.2 to 5.0 [1.0] Ped: 0.2 to 5.0 [0.6]
Resp. rate (per min)	Adult: 4 to 50 [15] Ped: 12 to 80 [15]





Safety volume settings

Astral's Safety Volume feature is an optional adaptive control mechanism that provides volume assurance to pressure modes (P(A)CV, PS, S(T) and PAC only). It combines the benefits of pressure-targeted ventilation with the assurance of a volume target.

A target Safety Volume (Safety Vt) can be set and the respective pressure value (PS, P Control or IPAP) is automatically adjusted to achieve the target.

The maximum inspiratory assistance is constrained by PS Max, P control max or IPAP Max.

The maximum breath-to-breath change in pressure assistance is limited to +/- 2 cmH_2O.

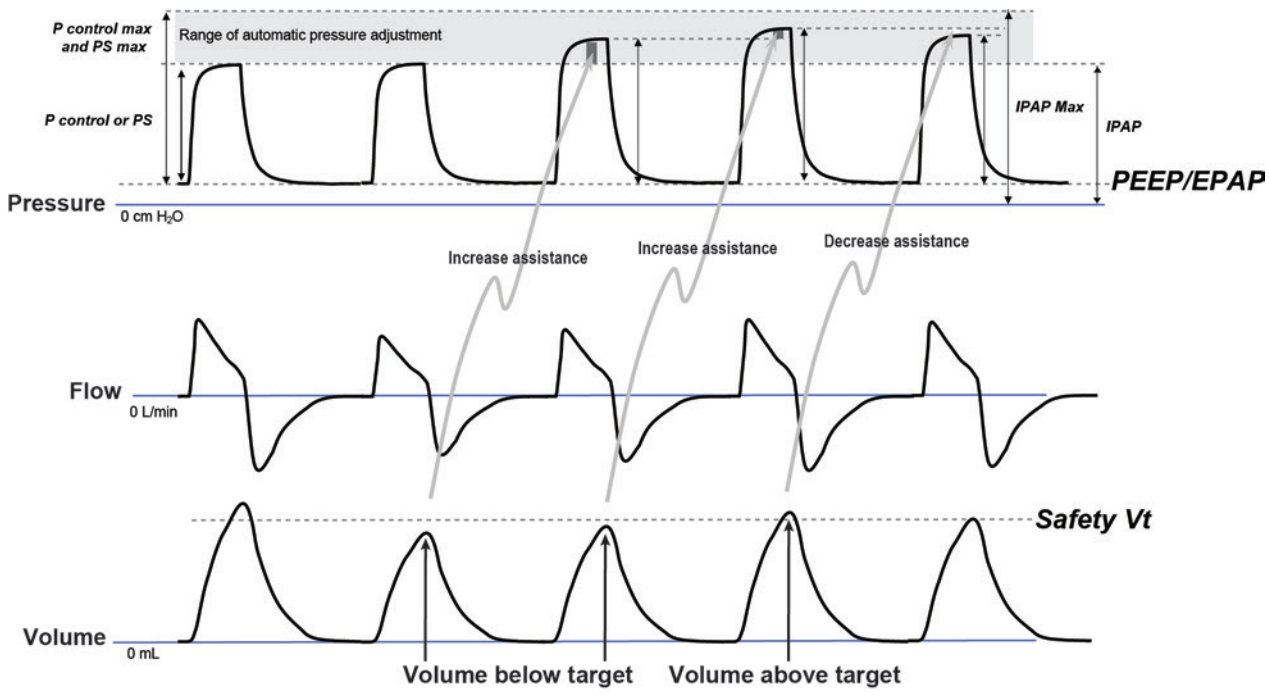
Adjustable parameters:

Parameter	Setting
Safety Vt (mL)	Adult: Off, 100 to 2500 [Off] Ped: Off, 50 to 300 [Off]*
PS Max (PS mode)	PS to 50 [PS + 5]
P control max (P(A)CV)	P control to 50 [P control + 5]
IPAP Max (S(T), PAC modes)	IPAP to 50 [IPAP + 5]

*The International ventilator standard indicates that Pediatric patient type is intended to be used for a patient receiving less than 300 mL, however Astral permits adjustment of 'Vt' setting parameter up to 500 mL for cases where 'Vt' is set such that it compensates for leak in the breathing circuit.

⚠ WARNING

ResMed does not recommend 500 mL as the upper limit for the pediatric tidal volume use; however, clinicians may choose this upper limit based on their clinical determination.



Non-invasive ventilation (NIV)

Mask NIV

Mask ventilation is supported by Astral on all circuit types and modes. NIV is commonly associated with leak, and minimising leak will promote optimal therapy. Astral's vented (intentional leak) circuit therapies (CPAP, S, ST, iVAPS, and T modes) possess advanced leak management methods optimised for mask ventilation. Note however that in situations of highly variable leak, pressure-target therapies (CPAP, S, ST, T modes) may offer advantage over volume-target or volume-assured pressure modes.

During NIV therapy, peak applied pressures are chosen to address the ventilation needs as well as patient tolerance, mask leak, and the potential for gastric distention (an adult's lower oesophageal sphincter pressure is 25-30 cmH_2O). Various guidelines suggest a typical maximum pressure for mask NIV of 20-30 cmH_2O.

Astral features an adjustable High Pressure limit which can be a convenient means of imposing a maximum pressure during Astral's pressure-target modes (including those with volume-assurance), regardless of the prevailing PEEP and PS. This is further discussed in Pressure alarms/limits.

Mouthpiece NIV

The decision to use mouthpiece ventilation is generally a consultative process between clinician and patient after considering the risks and advantages of this form of therapy. For example, the patient must possess adequate cognition, head/neck/mouth control, and oropharyngeal function, and significant individualized training may be required compared to other forms of ventilation.

To independently assess the patient condition during mouthpiece ventilation, SpO_2 can be monitored using a pulse oximeter. Should the oximeter sensor become disconnected from the patient's finger, the **No SpO_2 monitoring** alarm will activate.

⚠ CAUTION

Mouthpiece ventilation may not be appropriate for particular patients and hence clinical discretion is essential.

Mouthpiece ventilation

The settings below are suggested for 'open' or 'sip' mouthpiece ventilation where the patient exhales to atmosphere frequently or continuously, eg, for on-demand daytime ventilation via a 15 mm non-vented mouthpiece. Other circuit types, modes and settings are also available if required.

Ventilation setting	Selection	Detail/ explanation
Patient type	Adult	
Circuit	Mouthpiece circuit (Tube only)	15mm or 22mm circuit without intentional leak or expiratory valve Note: Not designed to support continuous exhalation into the circuit.
Interface	Mouthpiece	
Ventilation mode	(A)CV	(A)CV mode allows the patient to stack breaths as a set volume is delivered with each breath.
Patient settings	Vt, Trigger, Flow shape	Set based on patient comfort and preference.
Resp. Rate	As appropriate	Resp. Rate shall be set appropriately for patients who may rely on the backup rate. Otherwise, it can be turned Off.

Ventilation setting	Selection	Detail/ explanation
Trigger	Low, Medium, High, Touch	The Touch trigger setting will allow a breath to be delivered upon engagement of the mouthpiece. If the patient experiences false triggering then the trigger sensitivity should be reduced.

Vented (intentional leak) therapies are not recommended for highly discontinuous ventilation such as 'sip' mouthpiece ventilation.

Safety considerations for mouthpiece ventilation

The Disconnect Alarm allows detection of circuit disconnection (for example, when the mouthpiece has fallen out of reach of the patient), and whether the patient is able to reliably trigger ventilation or not.

Regardless of whether the Disconnection Alarm is active or not, other mitigations may need to be put in place to ensure that patient safety is not compromised, such as the Apnea alarm, external monitoring, an SpO_2 alarm, or full-time supervision.

Alarm setting	Selection	Detail/ explanation
Disconnection Alarm	On	Enables Disconnection Alarm.
Disconnection Tolerance (%)	As appropriate	Sets a higher or lower tolerance to the degree of circuit disconnection required to activate the Disconnection Alarm. Refer to Setting and testing Disconnection Tolerance (see page 117).
Alarm Activation Time	As appropriate	The time it takes for the alarm to activate once the disconnection threshold is satisfied. It can be adjusted from 5 seconds to 15 minutes for mouthpiece interface, as appropriate for the patient's ventilator dependency. Refer to Setting Activation Time (see page 119).
Apnea Response	Off	It may be appropriate to configure Apnea Response to OFF if the Disconnection Alarm is appropriately configured.

Low pressure alarms are sometimes used to imply circuit disconnection and are quick to activate. Should this be an annoyance, for example when the patient is receiving a partial breath or missing a breath, or if a false triggered breath occurs, it is at the discretion of the Clinician to turn OFF. Other mitigations may need to be put in place to ensure that patient safety is not compromised. This may include external monitoring, SpO_2 alarm, or full-time supervision.

Mouthpiece Ventilation with Astral 100/150 mouthpiece circuit is not intended to support continuous exhalation into the circuit. The non-user adjustable NV Mask/Rebreathing alarm will activate if the device detects continuous exhalation into the circuit. For patients that may prefer continuous exhalation into the circuit, a circuit with an expiratory valve or intentional leak should be considered.

Alarms

The Astral device activates alarms to alert you to conditions that require attention to ensure patient safety. When an alarm is activated, the Astral device provides both audible and visual alerts, and displays an alarm message in the Alarm display on the Information bar.

As part of the alarm system (eg, the overpressure protection and system alarms), Astral may perform an automatic restart. An automatic restart checks systems and ensures correct operation of the alarm.

	Indicator	Description
1	Alarm display	Displays either the alarm message for the highest priority active alarm, or the last alarm not yet reset. Press the Alarm display for further alarm information. Certain conditions may result in multiple alarms. indicates that there are multiple active alarms. Press when displayed to view all alarms and respond appropriately. Alarms are displayed in order of priority.
2	Active Alarms screen	Displays the full set of active alarms. Will automatically display upon activation of an alarm in Patient mode.
3	Information menu	Some alarms clear automatically. To view a history of alarms, view the alarm log through the Information menu.

	Indicator	Description
4	Alarm mute/reset button	State: • no light – no active alarms • steady light – active alarm/s • flashing light – alarm mute on. This button also allows you to: • mute the audible alert • reset the currently displayed alarm (if permitted).
5	Alarm bar	Indicates the priority of the alarm in the Alarm display.

Alarm priority

Alarms are classified into relative priority (high, medium and low) according to the severity and urgency of the alarm condition. Respond to all alarms. An immediate response is required for high priority alarms.

Alarm priority		Alarm bar	Audible alert
High		Red flashing light	10 beeps every 5 seconds
Medium		Yellow flashing light	3 beeps every 15 seconds
Low		Yellow steady	2 beeps every 25 seconds

Alarms

The following list of alarms is ordered by relative importance within priority. Adjustable alarms can be changed to suit therapy and care requirements.

High priority alarms	Medium priority alarms	Low priority alarms
Total power failure**	High Pressure*	Using internal battery
High pressure protection	Low PEEP*	Battery 1 fault
Circuit disconnection*	High PEEP	Battery 2 fault
Low Pressure*	Low pulse rate*	Power fault/No charging
Obstruction*	High pulse rate*	PEEP blower failure
High Pressure*	Device overheating	
Apnea*	Pressure line disconnected	
Low MVe*	Last self-test failed	
Low MVi*	Flow sensor not calibrated	
High MVi*	No SpO_2 monitoring	
High MVe*	No FiO_2 monitoring	
Low Vte*	Internal battery degraded	
High Vte*	Low internal battery	
Low Vti*	Circuit fault	
High Vti*		
Low Resp rate*		
High Resp rate*		
High leak*		
Ventilation stopped*		
Low SpO_2*		
High SpO_2*		
Low FiO_2*		
High FiO_2*		
NV mask/Rebreathing		
Incorrect circuit adapter		
Critically low battery		
Incorrect circuit attached		
Safety reset complete		
Battery inoperable		

*Alarm is adjustable.
**No LED will flash during a Total power failure alarm.

Viewing the active alarms

in the Alarm display indicates that there are multiple active alarms. Although multiple alarms can be active simultaneously, the Alarm display only shows the highest priority alarm. The full set of active alarms is displayed in the Active alarms screen.

When the highest priority alarm is cleared, the next highest priority alarm displays in the Alarm display.

To view the active alarms:

1. From any screen, press the Alarm display on the Information bar. The Active alarms screen is displayed. This screen contains a full list of currently active alarms, displayed in order of their relative priority.
2. Press **OK** to close the Active alarms screen and return to the previous screen.

Muting alarms

You can temporarily mute the audible alert on the Astral device for a two minute period. The Alarm display and Alarm bar continue to display the alarm as usual. If after two minutes the alarm condition is still present, the audible alert will sound again.

You can also use the Alarm Mute in advance, to 'pre-silence' alarms that you expect to occur. This can be helpful during suctioning procedures or when intending to disconnect the patient from the ventilator for a short period.

If any of the following high priority alarms are triggered, the Alarm mute is automatically cancelled:

- Total power failure
- Critically low battery
- Incorrect circuit.

To mute the audible alert on an active alarm:

Press .

The alarm is silenced for two minutes. During that period, is displayed on the Information bar and flashes.

Note: Pressing the Alarm mute/reset button again during the Alarm Mute period will reset the displayed alarm. Refer to Resetting alarms (see page 102).

To silence alarms before they activate:

1. Press . Alarm mute is active for two minutes. During that period, is displayed on the Information bar and flashes.
2. To cancel Alarm mute, press the flashing again.

Resetting alarms

The following alarms cannot be manually reset. For these alarms you must correct the cause of the alarm. Resolving the alarm will automatically clear the display.

- Total power failure
- Critically low battery
- Low pressure
- Pressure line disconnected
- Battery inoperable
- Circuit disconnection
- Incorrect circuit adapter.

Resetting an alarm removes that alarm from the Alarm display and the Active alarms screen, and turns off the visual and audible alerts. An active alarm should only be reset after the situation that caused the alarm has been attended to. If the alarm condition has not been corrected, the alarm will activate again.

The Astral device may automatically clear an alarm when the condition that triggered the alarm is corrected. When an alarm is cleared it no longer displays in the Active alarms screen and the audible and visual alerts cease.

When an alarm is cleared or manually reset, the Alarm display then shows the next highest priority active alarm.

To view a complete alarm history, see the Events log available from the Information menu.

To reset the displayed active alarm:

1. Press to mute the alarm. The button illuminates and flashes.
2. Press again to reset the alarm. The alarm message is removed from the Alarm display. It is also cleared from the Active alarms screen.

Note: You can carry out this procedure with the Active alarms screen open, if you want visibility of all the active alarms as you perform the reset.

To reset all active alarms:

1. Press the Alarm display on the Information bar. The Active alarms screen is displayed.

2. Press **Reset all** to reset multiple alarms. Only those alarms that can be reset, will be reset. Any remaining alarms will require user intervention and correction.
3. Complete any required action to resolve the remaining alarms.
4. Press **OK** to close the Active alarms screen and return to the previous screen.

Adjusting alarm settings

⚠ CAUTION

Adjusting alarm thresholds to maximum or minimum values may render the alarm ineffective.

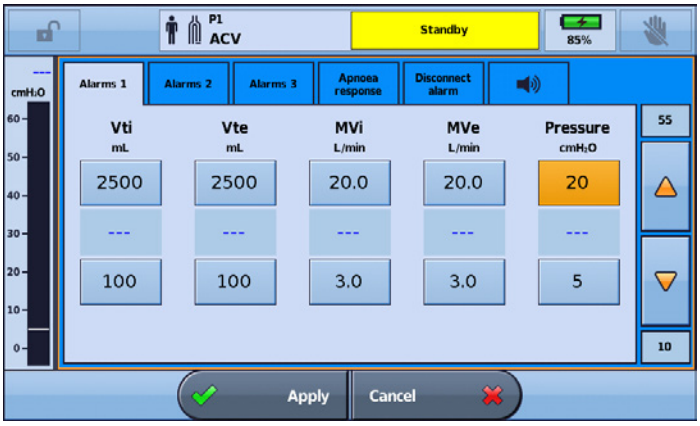
⚠ WARNING

The safety and effectiveness of alarms settings should be verified for each enabled Program.

Note: To adjust the volume of the audible alert, refer to Device settings (see page 31).

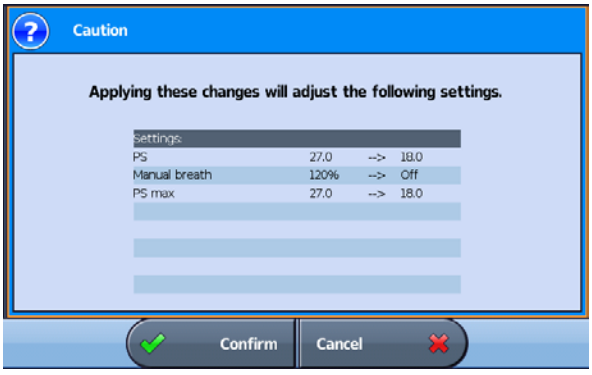
To adjust the alarm settings for the current active program:

1. Access Clinical mode. The Settings screen is displayed.
2. Press .
3. Press the alarm setting that you want to adjust. The selected setting is highlighted in orange and the up and down scroll arrows appear. Minimum and maximum settable values appear with the scroll arrows.



4. Increase or decrease the alarm setting as required.
5. To adjust other alarm settings, select the desired settings and repeat this process. All settings that have been adjusted are displayed with an orange outline.
6. When no further adjustments are required, press **Apply**.

   Note: If a change to the High Pressure alarm setting conflicts with one or more ventilation parameter settings, a confirmation screen is displayed providing a summary of the revised ventilation parameter settings. To accept these settings press Confirm.



Setting the alarm volume

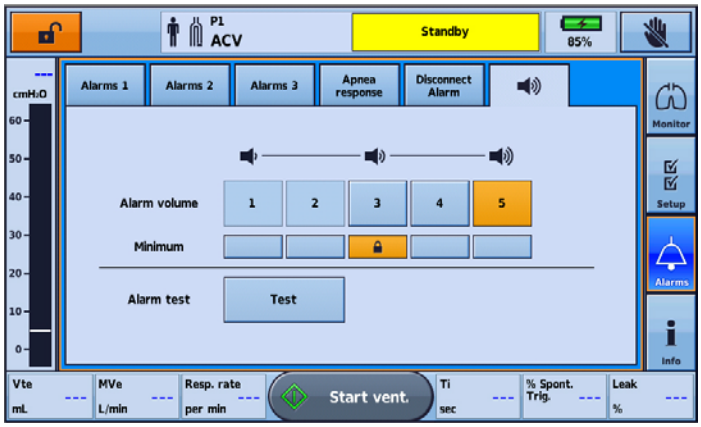
The volume level of the Astral device can be set from one to five (with five being the loudest and the default being three).

It is also possible to set a minimum volume level, where any settings below the minimum are greyed out and disabled from use. This feature is configurable in the Clinical menu only.

⚠ WARNING

- Alarm volume cannot be adjusted separately for individual alarms. Adjusting the alarm volume will change the volume of all alarms, independent of alarm priority level.
- When adjusting alarm volume, ensure that the alarm can be heard above the ambient noise levels that the patient may experience in a variety of settings, including use in noisy environments or inside mobility bags.

In the example below the current alarm volume is '5' however the minimum alarm volume has been set at '3'. The '1' and '2' volume options are now disabled and not able to be selected by the patient or carer.



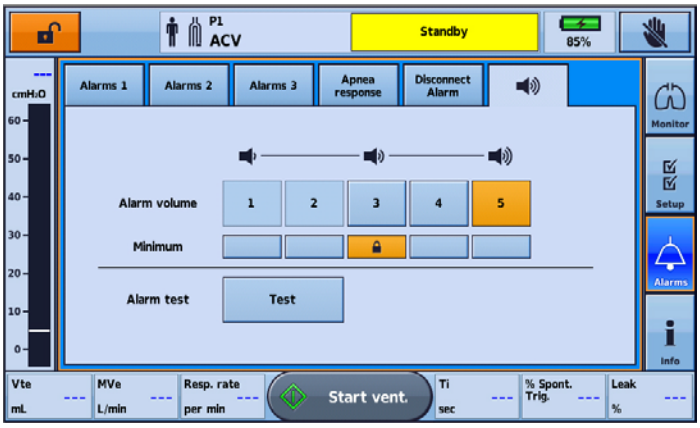
Testing the alarm sounders and indicators

To confirm the alarm will sound as intended, regularly test the alarm.

The Astral device incorporates two alarm sounders. During an alarm condition both sounders are operated in parallel. To confirm the correct operation of each sounder, regularly perform the Alarm test function. During this test each sounder will be operated separately and in sequence.

To test the alarm sounders and indicators:

1. Press . The Alarms screen is displayed.
2. Press . The Alarm volume screen is displayed.



3. Press **Test** to test the alarm. The alarm beeps **twice** and the LED flashes to indicate it is working correctly. Confirm the alarm beeps twice. Confirm the Alarm bar flashes red, then yellow. Confirm the mute button flashes.

⚠ WARNING

If no alarm sounds, do not use the ventilator.

⚠ CAUTION

If only one beep is heard, or the Alarm bar does not flash red, then yellow, return the device for servicing.

Testing the Remote Alarm

The Remote Alarm generates an audible and visual signal when an alarm is triggered on the ventilator.

⚠ CAUTION

A test of the Remote Alarm should be performed prior to initial use and every change of battery. Test the alarm periodically as per the facility policy. For dependent patients perform a test on a daily basis.

To test the Remote alarm, press ⓘ on the Remote Alarm.

The following will occur:

- The alarm LED illuminates and the alarm sounds.
- The LED corresponding to the set volume illuminates.
- The Disconnect LED blinks if the alarm is not connected to the device and lights permanently if connected.
- The battery level LED corresponding to the battery level illuminates. Yellow LED if battery life is low, or green LED if battery life is good. (Replace the battery if the battery life is low).
- If a second Remote Alarm is connected, the second Remote Alarm will also sound.

Testing the alarms

⚠ WARNING

Do not perform alarm tests while the patient is connected to the ventilator.

This section describes functional tests to confirm correct technical operation of Astral alarms. The efficacy of therapy alarm limits should be assessed clinically.

It is recommended that alarms be tested individually. To do so, turn off all alarms except the alarm that is going to be tested. If the ventilator fails any of the alarm tests, see Troubleshooting.

It is not necessary to test all alarms for every alarm condition. There is no specific sequence in which the alarms must be tested.

Many of the following tests require use of a passive test lung.

⚠ CAUTION

When the alarm tests are completed ensure the Astral device is restored to its original state.

Testing the power alarms

Alarm	Test procedure
Using internal battery (External power disconnected)	1. Ensure the Astral device is connected to an external power source. 2. Power on the Astral device. 3. Disconnect the power cord.
Using internal battery (On device start up)	1. Ensure the Astral device is not connected to an external power source. 2. Power on the Astral device.
Low internal battery Critically low battery	1. Ensure the Astral device is powered on and is operating on the internal battery. 2. With a test lung attached continue ventilation until the battery discharges and the alarms activate.
Battery inoperable	1. Remove the internal battery. 2. Connect the Astral device to an external power source. 3. Power on the Astral device.
Total power failure	1. Remove the internal battery. 2. Connect the Astral device to an external power supply. 3. Power on the Astral device. (This will activate the Battery inoperable alarm). 4. Wait five minutes and remove the power cord from the external power source.

Testing the pressure alarms

All pressure alarm tests are conducted using a test lung, single limb circuit and in (A)CV mode.

Alarm	Test procedure
High Pressure	1. Start ventilation. 2. Record the peak inspiratory pressure (PIP). 3. Set the Pressure alarm limit to less than PIP.
Obstruction	1. Start ventilation. 2. Block the exhalation port (eg, when using a proximal valve, pinch the control tube during inspiration).
Low PEEP	1. Start ventilation. 2. Set the PEEP setting to 10 cmH_2O. 3. After 30 seconds disconnect the test lung.
Low Pressure	1. Start ventilation. 2. Record the peak inspiratory pressure (PIP). 3. Set the Low PIP alarm limit above PIP.

Testing the ventilation monitoring alarms

For Astral 150, all ventilation monitoring alarm tests are conducted using a test lung and double limb circuit in (A)CV mode.

For Astral 100, all ventilation monitoring alarm tests are conducted using a test lung and single limb circuit in (A)CV mode.

Set (A)CV mode to defaults and start ventilation.

Alarm	Test procedure
Low Vte	Set the alarm limit above the current volume.
High Vte	Set the alarm limit below the current volume.
Low Vti	Set the alarm limit above the current volume.
High Vti	Set the alarm limit below the current volume.
Low MVe	Set the alarm limit above the current minute volume.
High MVe	Set the alarm limit below the current minute volume.
Low MVi	Set the alarm limit above the current minute volume.
High MVi	Set the alarm limit below the current minute volume.
Low Resp Rate	Set the alarm limit above the set respiratory rate.
High Resp Rate	Set the alarm limit below the set respiratory rate.
Apnea	Set the respiratory rate to Off.

Testing the oximetry alarms

To test oximetry alarms attach a pulse oximeter to the Astral device and connect the sensor to a person.

Alarm	Test procedure
Low SpO_2	Set the alarm limit to 99%.
High SpO_2	Set the alarm limit below the current SpO_2 measure.
Low pulse rate	Set the alarm limit above the current pulse rate.
High pulse rate	Set the alarm limit below the current pulse rate.
No SpO_2 monitoring	With at least one other oximetry alarm enabled, disconnect the oximeter.

Testing the oxygen alarms

To perform these tests an oxygen sensor must be fitted. Tests are performed without supplementary oxygen. Run a Learn Circuit prior to testing.

Alarm Event	Test procedure
Low FiO_2	Start ventilation. Set the alarm limit to 24%.
High FiO_2	Start ventilation. Set the alarm limit to 19%.

Testing the breathing circuit alarms

All breathing circuit alarm tests are conducted in (S)T mode using default settings and a single limb circuit with intentional leak.

Alarm	Test procedure
Disconnection	Refer to Testing the disconnection alarms (see page 108).
High leak	Leave the circuit open and start ventilation.
NV mask/Rebreathing	Block the circuit (no mask attached) and start ventilation. For Mouthpiece circuit only: Attach circuit to test lung via 22mm to 10mm adapter for testing.

Testing the disconnection alarm

Testing of the disconnection alarm should be conducted using a representative breathing circuit configuration, oxygen flow into the circuit (if any), and the final ventilation settings.

The circuit used to test the alarm should include the patient interface (eg, tracheostomy tube / endotracheal tube / mask / mouthpiece) to simulate the patient interface being accidentally detached from the patient. This is a more challenging disconnection for a ventilator to detect than disconnections elsewhere along the circuit.

For invasive interfaces, consider testing with a tracheal tube one size smaller than the patient's tube. This checks that disconnection may still be detected even if the circuit resistance increases somewhat, such as due to secretions within the cannula.

Alarm	Test procedure
Disconnection	1. Ensure patient type and interface type have been correctly configured. 2. Start ventilation and wait a few cycles for ventilation to stabilise. 3. Disconnect the entire circuit (including patient interface, ie, mask, tracheal tube, mouthpiece) then check that the alarm(s) configured to detect circuit disconnection activate. 4. If the disconnection alarm does not sound, the alarm parameters may need adjusting. Refer to Adjusting the disconnection alarm (see page 117).

Alarm settings and conditions

This section details the alarms and their activation conditions. If the alarm has adjustable settings these are described. Unless otherwise noted, alarms are applicable to all modes. Values provided within [square brackets] are the default settings.

As soon as the activation condition is met, the Astral device provides both audible and visual alerts without delay.

Tidal volume alarms

Tidal volume alarms activate when the monitored tidal volume parameter (Vti or Vte) exceeds the Vt alarm setting.

Tidal volume alarms may be used to detect:

- change in patient lung condition
- leak or obstruction in patient circuit or valve.

Alarm	Activates when	Alarm setting (mL)
Low Vti	Inspiratory tidal volume is less than Low Vt for the duration of three breaths at the current average respiratory rate.	Adult: Off, 50 to 2990 [100] Ped: Off, 10 to 995 [25]
High Vti	Inspiratory tidal volume is greater than High Vt for three consecutive breaths.	Adult: Off, 60 to 3000 [2500] Ped: Off, 25 to 1000 [500]
Low Vte	Expiratory tidal volume is less than Low Vt for the duration of three breaths at the current average respiratory rate.	Adult: Off, 50 to 2990 [100] Ped: Off, 10 to 995 [25]
High Vte	Expiratory tidal volume is greater than High Vt for three consecutive breaths	Adult: Off, 60 to 3000 [2500] Ped: Off, 25 to 1000 [500]

⚠ WARNING

The measurement of tidal volumes may be affected by leak.

Minute volume alarms

Minute volume alarms activate when the monitored minute volume parameter (MVi or MVe) exceeds the MV alarm setting (no delay).

Minute volume alarms will not activate during the first 60 seconds of ventilation.

Minute volume alarms may be used to detect:

- change in patient lung condition
- leak or obstruction in patient circuit or valve.

Alarm message	Activates when	Alarm setting (L)
Low MVi	Inspiratory minute ventilation is less than Low MV	Adult: Off, 0.5 to 59.9 [3] Ped: Off, 0.2 to 59.9 [0.5]
High MVi	Inspiratory minute ventilation is greater than High MV	Adult: Off, 0.6 to 60 [20] Ped: Off, 0.3 to 60 [10]
Low MVe	Expiratory minute ventilation is less than Low MV	Adult: Off, 0.5 to 59.9 [3] Ped: Off, 0.2 to 59.9 [0.5]
High MVe	Expiratory minute ventilation is greater than High MV	Adult: Off, 0.6 to 60 [20] Ped: Off, 0.3 to 60 [10]

Respiratory rate alarms

Respiratory rate alarms activate when the average respiratory rate (Resp. rate) exceeds the corresponding alarm setting (no delay).

Respiratory rate alarms will not activate during the first 60 seconds of ventilation.

Alarm message	Activates when	Alarm setting (per min)
Low Resp Rate	Respiratory rate is less than the Low Resp rate setting	Adult: Off, 2 to 79 [4] Ped: Off, 5 to 98 [12]
High Resp Rate	Respiratory rate is greater than the High Resp rate setting	Adult: Off, 3 to 80 [80] Ped: Off, 6 to 99 [99]

Pressure alarms/limits

Pressure alarms include:

- High Pressure
- Obstruction
- Low Pressure
- PEEP.

High pressure

For pressure-target modes, the High Pressure setting acts as a pressure limit, holding pressure-target therapies to 2 cmH_2O less than the High Pressure setting. Refer to Making use of Astral's High Pressure limit on page 83. This allows the clinician to globally limit pressure therapies if required (eg, in the context of mask NIV).

The Astral High Pressure limit acts as a traditional High Pressure alarm for volume target therapies and fault situations, as described below.

When a high inspiratory pressure is detected during volume target modes, the Astral device immediately cycles to the expiratory phase and an information message is displayed. Sustained high pressure will result in the following alarms.

High pressure may be caused by change in patient conditions.

Alarm	Activates when	Alarm setting (cmH_2O)
High Pressure (Medium priority)	For 3 consecutive breaths, the Monitored Pressure exceeds the Pressure alarm setting or the Inspiratory port pressure exceeds 85* cmH_2O.	10 to 80* [40]
High Pressure (High priority)	For 10 consecutive breaths, the Monitored Pressure exceeds the Pressure alarm setting or the Inspiratory port pressure exceeds 85* cmH_2O.	10 to 80* [40]

*Not applicable on all device variants

Note: A high pressure alarm will initially be raised as a Medium priority and will be escalated to High priority if the condition persists.

Obstruction

⚠ WARNING

When an obstruction is detected, ventilation is suspended. Ventilation can only resume when the monitored pressure reduces to below 3 cmH_2O and the monitored expiratory flow reduces below 1 L/min.

Obstruction may be caused by a circuit obstruction. Obstruction can typically be caused by a pinched PEEP valve control tube or a blocked exhalation valve outlet.

Note: The Obstruction alarm will not be triggered if there is an obstruction after the vent, proximal expiratory valve, or Y piece depending on which circuit is used. To detect such a condition, use the Apnea, Low Vt and/or Low MV alarms.

Alarm	Activates when
Obstruction	Using Single Valved and Dual Valved circuits, there is a complete obstruction of the expiratory tube or exhalation valve or inspiratory tube within 5 seconds or 2 breaths, whichever is longer. Using Vented circuits, there is a complete obstruction of the inspiratory tube (ie, between the ventilator and the vent) within 10 seconds. Using Mouthpiece circuits, there is a complete obstruction of the inspiratory tube within 35 seconds or 5 breaths, whichever is longer.

Low pressure

Low pressure may be caused by severe leak.

Note: To allow for mouthpiece ventilation and other exhale to atmosphere configurations, this alarm may be turned off. For more information, refer to Mouthpiece Settings (see page 96).

Alarm	Activates when	Alarm setting (cmH_2O)
Low Pressure	Monitored PIP is less than or equal to the Low PIP alarm setting for two consecutive breaths.	Volume modes ((A)CV, V SIMV) Off, PEEP+2 to 79 [5] (Min is 2 when PEEP set to 'Off')
	Monitored pressure reaches less than half of the set pressure support for two consecutive breaths where measure Ti is greater than or equal to Rise time.	Pressure modes (excluding CPAP) Off / On [On]
	Monitored PIP is less than or equal to set CPAP - 2 cmH_2O.	CPAP mode Off / On [On]

PEEP

PEEP alarms activate when the monitored positive expiratory end pressure parameter (PEEP) exceeds the corresponding alarm setting. When ventilation starts, or after a PEEP setting change, PEEP alarms are temporarily disabled until:

- the monitored PEEP is within 2 cm H_2O of the PEEP setting for three consecutive breaths, or
- 30 seconds has passed.

PEEP alarms may be caused by:

- circuit disconnection
- high leak
- device fault
- obstruction.

Alarm	Activates when	Alarm setting
Low PEEP	Monitored PEEP is less than or equal to 2 cmH_2O below the PEEP ventilation setting for 10 consecutive breaths.	Low PEEP Off / On [On]
High PEEP	Monitored PEEP is greater than 2 cmH_2O above the PEEP setting for 10 consecutive breaths.	N/A

Breathing circuit alarms

Breathing circuit alarms detect adverse conditions in the breathing circuit or circuit configuration.

Breathing circuit alarms may activate under conditions of:

- High leak
- NV mask/Rebreathing
- Flow sensor not calibrated
- Circuit incorrectly configured
- Circuit disconnection.

High leak

Alarm	Activates when	Alarm setting
High Leak (double limb)	The difference between MVe and MVi is greater than the Leak alarm setting for a 10 second period.	Off, 20 to 80 [Off] (%)
High Leak (single limb with intentional leak)	Estimated unintentional leak is greater than the Leak alarm setting for a 20 second period.	5 to 80, Off [40] (L/min)

NV Mask/Rebreathing

Alarm	Activates when	Alarm setting
NV mask/Rebreathing	A non-vented mask is used in a vented circuit. An obstruction of the vents in a vented circuit leading to rebreathing. Rebreathing on a vented circuit using a non-vented mask or on a mouthpiece circuit during continuous exhalation into the circuit. Rebreathing is greater than 20% for vented circuit or 50% for mouthpiece circuit, for 10 consecutive breaths.	Off / On [On] Note: Non-selectable in Mouthpiece mode.

Flow sensor not calibrated

Alarm	Activates when	Alarm setting
Flow sensor not calibrated (double limb)	The expiratory flow sensor is not calibrated. A Learn Circuit should be performed.	N/A

Circuit configuration alarms

Alarm	Activates when	Alarm setting
Incorrect circuit attached	The circuit connected to the ventilator differs from the circuit type setting.	N/A
Incorrect circuit adapter	A single limb circuit with intentional leak or mouthpiece circuit is attached to the ventilator but an incorrect adapter has been fitted.	N/A
Pressure line disconnected	A single limb circuit with expiratory valve is attached but the proximal pressure line is disconnected.	N/A

Disconnection alarm

The disconnection alarm monitors multiple parameters to assess whether the ventilator breathing circuit has become disconnected from the patient.

Note: This alarm should be configured in conjunction with other alarms that can be used to detect circuit disconnection. Refer to the Detecting circuit disconnection and de-cannulation (see page 116) section.

Alarm	Activates when	Alarm setting
Disconnection alarm	The degree of circuit disconnection exceeds a configurable Disconnection Tolerance threshold continuously over a given time period. The alarm will be cleared automatically if the circuit disconnection is resolved. The alarm will not activate if patient expiratory effort is detected, indicated by the symbol below the measured Disconnection value.	5% (low tolerance to disconnection / leak from the circuit) to 95% (high tolerance to disconnection / leak from the circuit)

Note: The alarm can be turned off when a mouthpiece interface is selected or a mask interface is selected while a single limb with intentional leak circuit is in use.

⚠ CAUTION

Be certain that all forms of patient disconnection can be successfully detected, including the patient interface (mask / cannula / endotracheal tube / mouthpiece) detaching from the patient.

Refer to Testing the disconnection alarm on page 108.

Oxygen alarms

High and low FiO_2 alarms are only available when an oxygen sensor is installed. The absence at the start of ventilation, or loss during ventilation, of oxygen monitoring is indicated by the No FiO_2 alarm.

Alarm	Activates when	Alarm setting (FiO_2 %)
Low FiO_2	Measured oxygen is less than FiO_2 for a continuous period of 30 seconds.	Off, 18 to 99 [18]
High FiO_2	Measured oxygen is greater than FiO_2 for a continuous period of 30 seconds.	Off, 19 to 100 [70]
No FiO_2 monitoring	FiO_2 alarms are on, and the connected O_2 sensor is not operating or calibrated correctly.	N/A

Oximetry alarms

The oximetry alarms are only available when the pulse oximeter is connected to the Astral device. The alarms are enabled even when the ventilator is in standby.

The SpO_2 and Pulse rate alarms are automatically disabled when the pulse oximeter is disconnected from the Astral device.

SpO2

Oxygen saturation alarms activate when the monitored SpO_2 parameter exceeds the corresponding alarm setting (no delay).

Alarm	Activates when	Alarm setting (SpO_2 %)
Low SpO_2	Saturation of peripheral oxygen is less than the low SpO_2 setting as measured by the pulse oximeter.	Off, 50 to 99 [85]
High SpO_2	Saturation of peripheral oxygen is greater than the high SpO_2 setting as measured by the pulse oximeter.	Off, 51 to 100 [Off]
No SpO_2 monitoring	SpO_2 alarm settings are on and the pulse oximeter has been disabled or disconnected, or has a degraded signal for more than 10 seconds.	N/A

Pulse rate

Pulse rate alarms activate when the average pulse rate (Pulse) exceeds the corresponding alarm setting (no delay).

Alarm	Activates when	Alarm setting (per/min)
Low pulse rate	Pulse rate is less than the low Pulse setting as measured by the pulse oximeter.	Off, 20 to 249 [30]
High pulse rate	Pulse rate is greater than the high Pulse setting as measured by the pulse oximeter.	Off, 21 to 250 [150]

Apnea alarm

For details on how to configure the Apnea alarm and activation conditions refer to Apnea settings (see page 92).

Ventilation stopped alarm

The ventilation stopped alarm alerts the carer that a user has stopped the ventilator.

This alarm should be enabled if unexpected user intervention is possible.

Alarm	Activates when	Alarm setting
Ventilation stopped	The Stop Vent. button is pressed and Stop Vent. prompt is confirmed.	Off / On [Off]

Power alarms

Power alarms are not adjustable.

⚠ CAUTION

Data cannot be saved while there is a Critically low battery or Battery inoperable alarm. Program selections made while these alarms are active may be lost if the device is restarted. Recording of ventilation data and alarms is suspended.

Alarm	Activates when
Low internal battery	Approximately 20 minutes of ventilation time remaining on internal battery power.
Critically low battery	Approximately 10 minutes of ventilation time remaining on internal battery power.
Total power failure	There is total loss of power due to failure of the internal battery, or a loss of external power while the internal battery is removed or fully depleted/discharged.
Power disconnected	The power source is changed from an external source to the internal battery.
Using internal battery	The Astral device is powered on and is using battery power.
Battery inoperable	The internal battery is faulty or has been removed.
Internal battery degraded	The internal battery is degraded and may not provide a reliable indication of remaining time.

System alarms

System alarms are not adjustable.

Alarm message	Activates when
Safety reset complete	the device activated a restart to resume normal operation.
Last device test failed	ventilation is started after the device self-test fails.
Device overheating	internal component/s of the device are becoming too hot.
System fault	a technical fault is detected within the Astral device at initial power up or during ventilation.
Safety system fault	a technical fault is detected within the Astral device at initial power up or during ventilation.

Detecting circuit disconnection and de-cannulation

Inadvertent disconnection of a circuit component or accidental removal of a cannula poses a hazard to a dependent patient. Astral is equipped with a number of alarms that when used in conjunction with the Disconnection Alarm are able to reliably detect circuit disconnection (including de-cannulation).

The optimal alarm may depend on the therapy target and circuit type as shown in the table below.

⚠ CAUTION

Be certain that all forms of patient disconnection can be successfully detected, including the patient interface (mask / tracheal tube / mouthpiece) detaching from the patient.

Refer to Testing the disconnection alarm on page 108.

Multiple alarms may be required. Independent monitoring can be used as an alternative.

⚠ WARNING

Alarm settings may be sensitive to any changes to the circuit, ventilation settings or co-therapy. Test the effectiveness of the alarm after any of these changes are made.

The following table provides the most appropriate alarms for use in detecting circuit disconnection.

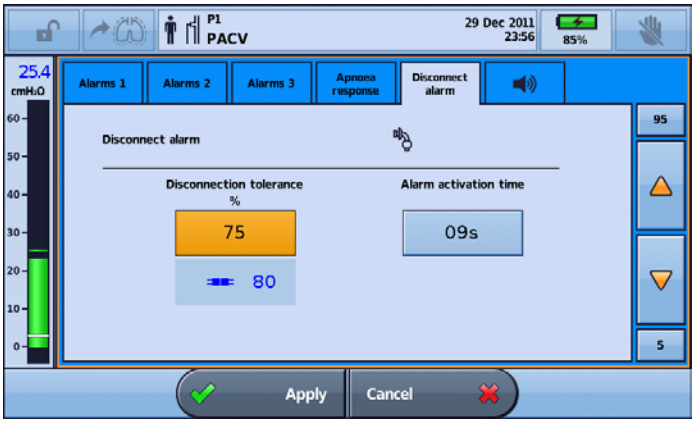
	Pressure target modes	Volume target modes
Single with leak	Disconnection alarm Low pressure alarm Low Vte alarm Low MVe alarm Apnea alarm Leak alarm SpO_2 alarm	N/A
Single with valve	Disconnection alarm Low pressure alarm Low Peep alarm High Vti alarm High MVi alarm Apnea alarm SpO_2 alarm	Disconnection alarm Low pressure alarm Low PEEP alarm Apnea alarm SpO_2 alarm
Double with valve	Disconnection alarm Low pressure alarm Low Vte alarm Low MVe alarm Apnea alarm Leak alarm SpO_2 alarm	
Mouthpiece	Disconnection alarm Low pressure alarm High Vti alarm High MVi alarm Apnea alarm SpO_2 alarm	Disconnection alarm Low pressure alarm Apnea alarm SpO_2 alarm

Astral Disconnection Alarm

The Astral Disconnection Alarm constantly measures circuit resistance to calculate the degree of disconnection (displayed as a percentage). The high priority Disconnection Alarm will activate when the measured disconnection value is greater than the set tolerance for the alarm Activation Time.

The alarm will only activate if the measured disconnection value is continuously above the Disconnection Tolerance for the alarm Activation Time. If the monitored value drops below the set Disconnection Tolerance during this time, the time to alarm activation will reset.

The alarm will not activate if patient expiratory effort is detected, indicated by the symbol below the measured Disconnection value.



Any active alarm will clear when the monitored value drops below the set Disconnection Tolerance.

Adjusting the Disconnection Alarm

There are three settings that can be adjusted to the Disconnection Alarm to suit patient needs:

1. Disconnection Tolerance – to set a higher or lower tolerance to activate the Disconnection Alarm
2. Alarm Activation Time – the time it takes (in seconds) following disconnection for the alarm to activate
3. Disconnection Alarm On/ Off (selected interfaces only).

⚠ CAUTION

Be certain that patient disconnection can be detected, including if the patient interface becomes accidentally detached from the patient (eg, if the tracheostomy tube / endotracheal tube / mask / mouthpiece remains attached to the circuit). For example, to check that accidental decannulation of a tracheostomised patient can be detected, simulate disconnection using a tracheostomy tube one size smaller than the patient's tube.

Refer to Testing the disconnection alarm on page 108.

Setting and testing Disconnection Tolerance

The Disconnection Tolerance threshold represents how 'leaky' a circuit can be – or degree of 'disconnection' – before the Disconnection Alarm is asserted. Disconnection Tolerance is adjustable from 5% (little 'disconnection' will be tolerated before alarm) through to 95% (large degree of 'disconnection' tolerated without alarm).

To assist with alarm adjustment, leakage from the circuit is continuously measured and displayed after each breath. The measured value is scaled to permit direct comparison against the Disconnection Tolerance adjustment range. A measured value greater than or equal to the configured Disconnection Tolerance will be displayed in red, along with an icon depicting a 'disconnected' circuit. If this level of leakage from the circuit were sustained for the Activation Time, the alarm would assert.

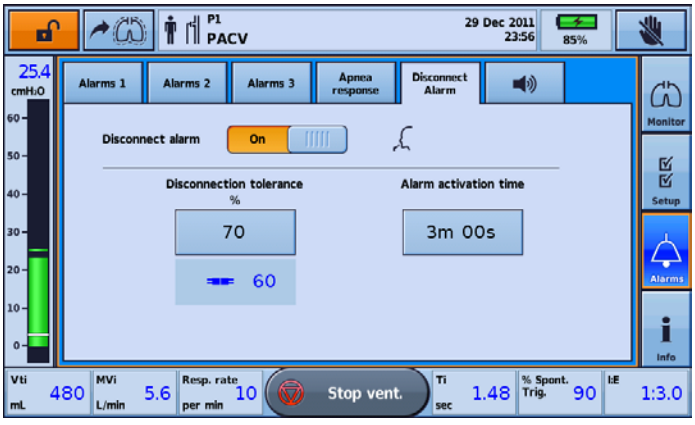
So if simulating disconnection, the measured disconnection should consistently exceed the disconnection tolerance (disconnected icon). By contrast, during ventilation of the patient, the measured disconnection percentage should be mostly below the configured disconnection tolerance.

Some interface types (vented mask and mouthpiece) will allow for the alarm to be turned off.

The default Disconnection Tolerance will change according to the Pediatric/Adult setting and the Interface type selected. Interfaces offering a very high resistance (eg, small diameter tracheal tubes) may require a Lower Disconnection Tolerance setting than the default value.

To access the Disconnection Alarm:

1. Access Clinical mode. The Settings screen is displayed.
2. Select . The Alarms screen is displayed.
3. Select the **Disconnection Alarm** tab.



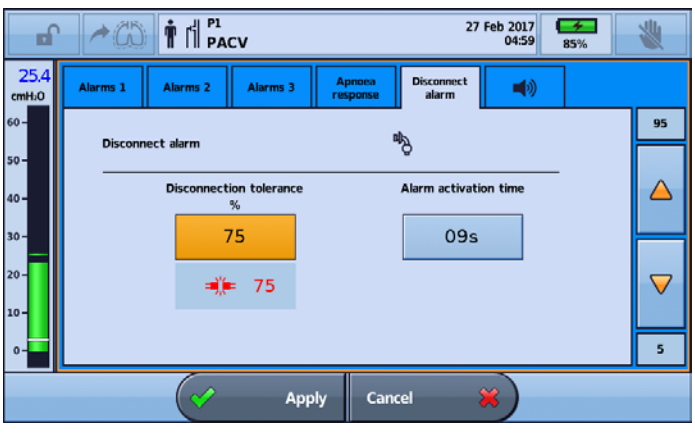
Note: The Disconnection Alarm default setting is ON.

To set the Disconnection Tolerance:

These steps should be performed prior to starting ventilation on the patient.

1. Attach all components of the patient circuit, including interface (a test cannula should be used in the case of a tracheostomy).
2. Start ventilation at the appropriate therapy settings, circuit configuration, and supplemental oxygen (if required).
3. If necessary, adjust the Disconnection Tolerance value until it is exceeded by the measured disconnection value which will turn red.

   Note: The Disconnection Tolerance value should not be set above the measured disconnection value otherwise disconnection or de-cannulation will not be detected.



4. Connect patient to the ventilator and allow breathing to stabilise.
5. Check that the measured disconnection value is below the Disconnection Tolerance value.
6. Adjust the Disconnection Tolerance value based on patient dependency.
7. Press **Apply** to confirm settings.

Note: Setting the Disconnection tolerance too low may result in annoyance alarms and may render the alarm ineffective.

To test the Disconnection Tolerance:

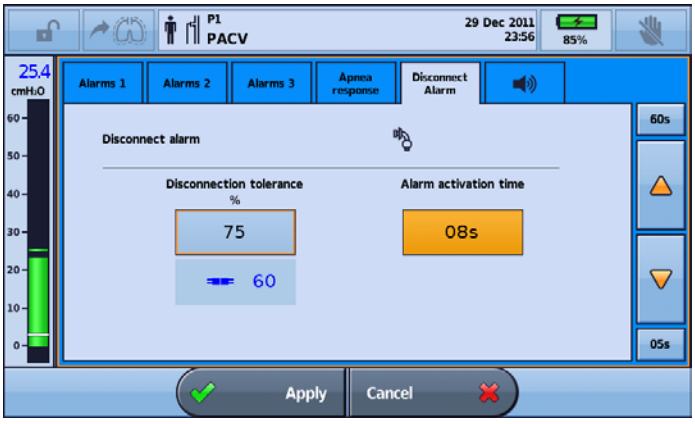
1. Ensure the patient is being ventilated with the appropriate therapy settings, circuit configuration, patient interface and supplemental oxygen (if required).
2. Simulate disconnections to ensure the disconnection value exceeds the Disconnection Tolerance setting. The value and icon will turn red.

Setting Activation Time

The Disconnection Alarm will only activate if the measured disconnection value is continuously greater than or equal to the Disconnection Tolerance for the alarm activation time. If the monitored value drops below the set Disconnection Tolerance during this time, the time to alarm activation will reset.

To set alarm Activation Time:

1. Press Activation Time.
2. Increase or decrease the time based on patient dependency and to take into account activities such as speaking.



3. Press Apply to confirm your changes.

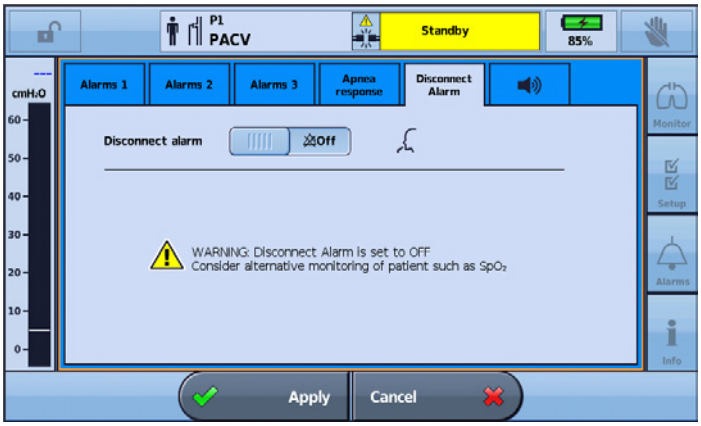
Disabling (or enabling) the Disconnection Alarm

The Disconnection Alarm default setting is ON. To disable the Disconnection Alarm, the patient interface setting must be set to:

- Mouthpiece (for valved circuits), or
- Mask (for leak circuits).

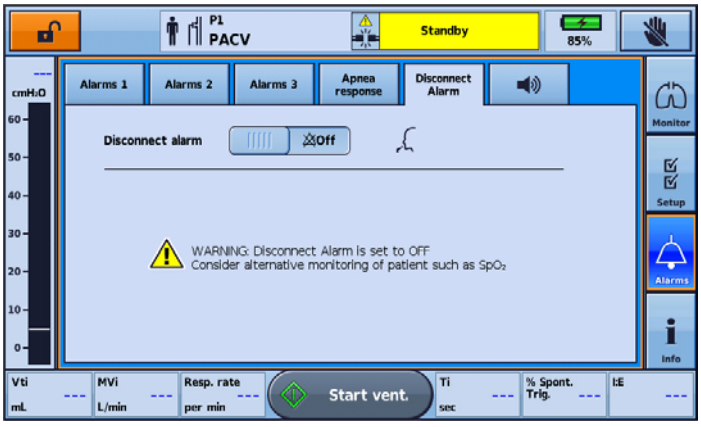
To disable or enable the Disconnection Alarm function:

1. Select the Disconnect Alarm tab.
2. Press the slider to turn ON/OFF. A warning message will be displayed. The slider will not be shown for invasive interfaces or mask with valve circuits.
3. Select Apply from the bottom bar to proceed. An alert message will be displayed.



4. Press Confirm on the bottom bar to continue.

5. Once confirmed, the Disconnect Alarm is disabled and the Disconnect Alarm OFF icon will be displayed next to Standby on the Information bar.



To test the Disconnection Alarm:

These steps should be performed prior to connecting patient to the ventilator.

1. Attach all components of the patient circuit, including interface (a test cannula should be used in the case of a tracheostomy).
2. Start ventilation at the appropriate therapy settings, circuit configuration, and supplemental oxygen (if required).
3. Check that the measured disconnection value turns red and that the Disconnection Alarm activates after the Alarm activation time.

Data management process

Monitoring data from the Astral device can be viewed in the ResScan™ patient management software. Data is transferred from the device to ResScan using a USB stick. Once downloaded to ResScan, the data can be viewed in several report formats to easily monitor treatment results and compliance.

To connect the ResMed USB to the Astral device:

Plug a USB stick into the USB connector at the rear of the device. The symbol is displayed in the Information bar to indicate the USB is attached.

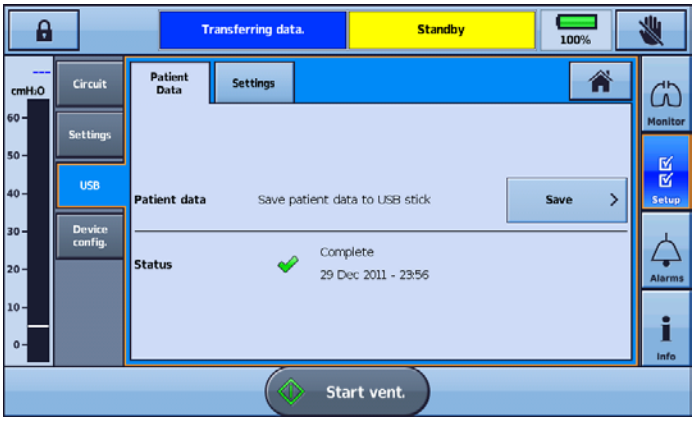
To remove the USB stick, simply pull it out of the USB connector on completion of transfer. If data was being transferred at the time, a message in the Information bar alerts you to a failed transfer.

⚠ WARNING

Only connect devices specially designed and recommended by ResMed to the data communication ports. Connecting other devices could result in patient injury, or damage to the Astral device.

To transfer data:

1. From the **Settings** menu select **Patient Data** from the **USB** sub-menu.
2. Press **Save >**. When the transfer is complete a status message is displayed.



3. Remove the USB stick from the Astral device.
4. At the computer where ResScan is installed, plug the USB stick into the USB port.
5. Follow the download procedure specified in the ResScan User Guide.

Data management summary

The table below summarises the data available for use in ResScan.

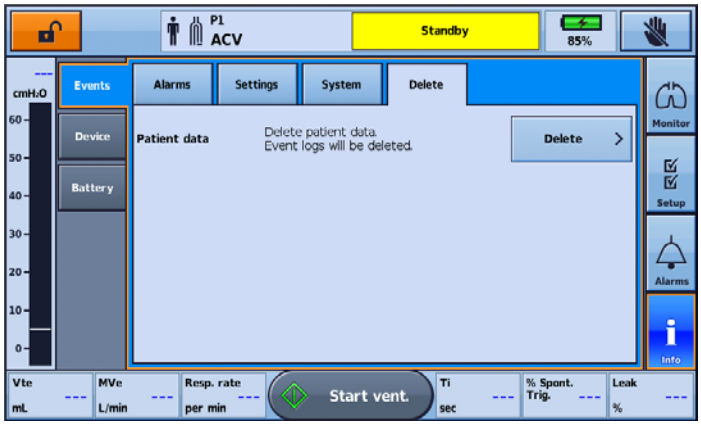
	Detailed data Logged for the last 7 days	Summary data[1] (5th, Median, 95th) Logged for the last 365 days
Pressure	25 Hz	
Flow	25 Hz	
Volume	25 Hz	
PIP	1 Hz	✓
PEEP	1 Hz	✓
Avg. P	1 Hz	✓
Maximum Inspiratory flow	1 Hz	✓
Leak	1 Hz	✓
SpO_2	1 Hz	✓
Pulse	1 Hz	✓
FiO_2	1 Hz	✓
Vt	1 Hz	✓
MV	1 Hz	✓
Va	1 Hz	✓
Resp. rate	1 Hz	✓
I:E ratio	1 Hz	✓
Ti	1 Hz	✓
Te	1 Hz	✓
% Spont. trig		✓
% Spont. cyc		✓
RSBI	1 Hz	✓
AHI[2]		Median
AI[2]		Median

[1] One set of summary data is provided per day for each program used.
[2] The Apnea Index (AI) and Apnea Hypopnea Index (AHI) are only recorded when a single limb circuit with intentional leak is used. AI indicates the number of times per hour that patient flow reduces by more than 75% of nominal flow for a period of 10 seconds or more. AHI indicates the number of times per hour that patient flow reduces by more than 50% of nominal flow for a period of 10 seconds or more.

Deleting patient data

To delete patient data

1. Access Clinical mode.
2. From the main menu, select .
3. From the Events sub menu, select the Delete tab.
4. Select delete. All patient data and event logs will be deleted and patient hours will reset to zero.



Cleaning and maintenance

The cleaning and maintenance described in this section should be carried out regularly.

Refer to the user guides for the patient interface, humidifier and other accessories in use for detailed instructions for care and maintenance of those devices.

⚠ WARNING

- **A patient treated by mechanical ventilation is highly vulnerable to the risks of infection. Dirty or contaminated equipment is a potential source of infection. Clean the Astral device and its accessories regularly.**
- **Always turn off and unplug the device before cleaning and be sure it is dry before plugging back in.**
- **Do not immerse the device, pulse oximeter or power cord in water.**

The Astral device can be cleaned using an anti-bacterial solution on a clean, non-dyed disposable cloth. After replacing any accessory in the patient circuit, ResMed recommends you perform a Learn Circuit.

⚠ CAUTION

Clean only exterior surfaces of the Astral device.

The following cleaning solutions are compatible for use on a weekly basis (except as noted) when cleaning the external surfaces of the Astral device:

- Actichlor Plus
- Bleach (1:10) (May also be known as 'dilute hypochlorite').
- Isopropanol
- Cavicide*
- Mikrozid*

*Suitable for cleaning on a monthly basis only.

Single patient use

For all circuit components, follow the manufacturer's recommendations for cleaning and maintenance.

Weekly

1. Wipe the exterior of the device with a damp cloth using a mild cleaning solution.
2. Inspect the condition of the circuit adapter for entry of moisture or contaminants. Replace as necessary, or at regular intervals not less than once every six months.
3. Test the alarm sounders, refer to Testing the alarm sounders (see page 105).

Monthly

1. Inspect the condition of the air filter and check whether it is blocked by dirt or dust. With normal use, the air filter needs to be replaced every six months (or more often in a dusty environment).
2. Check the charge level of the internal battery by:
   - removing external power and operating the device on internal battery for a minimum of 10 minutes.
   - reviewing the remaining battery capacity, refer to Using the Internal battery (see page 59).
   - restoring external power once the test is complete.

Multi-patient use

⚠ WARNING

- To prevent the risk of cross-contamination, an antibacterial filter, placed on the inspiratory port is mandatory if the device is to be used on multiple patients as under some fault conditions, expired gas may be returned through the inspiratory port.
- The expiratory module, internal antibacterial filter, expiratory flow sensor and blue membrane come into contact with exhaled gases but do not form part of the inspiratory pathway.

In addition to the cleaning and maintenance instructions for single patient use, you must perform the following before the device is provided to a new patient.

Component	Cleaning/ Maintenance method
Device	Refer to Cleaning and maintenance (see page 125).
Double limb adapter (used with Double limb circuits)	For general hygiene the Double limb adapter should be replaced or protected with an antibacterial filter.
Mask	Masks should be reprocessed when used between patients. Refer to the User guide provided with the mask in use.
Patient circuits	Replace or sterilise. Refer to the manufacturer's recommended cleaning instructions.
Humidifier	Refer to the User Guide provided with the humidifier in use.
Internal battery	Check the charge level by removing the external power and operating the device on internal battery for a minimum of ten minutes. Review the remaining battery capacity and restore external power.

Replacing components

Replacing the air filter

Inspect the condition of the air filter and check whether it is blocked by dirt or dust. With normal use, the air filter needs to be replaced every six months (or more often in a dusty environment).

⚠ CAUTION

Do not wash the air filter. The air filter is not washable or reusable.

To remove and replace the air filter

1. Unlock the air filter cover by turning in an anti-clockwise direction.
2. Pull the air filter cover from the device.
3. Pull the air filter from the cover and discard.
4. Insert a new filter into the cover.
5. Insert the air filter and cover back into the device.
6. Turn in a clockwise direction to secure in place.

Replacing the expiratory flow sensor and antibacterial filter (Astral 150 only)

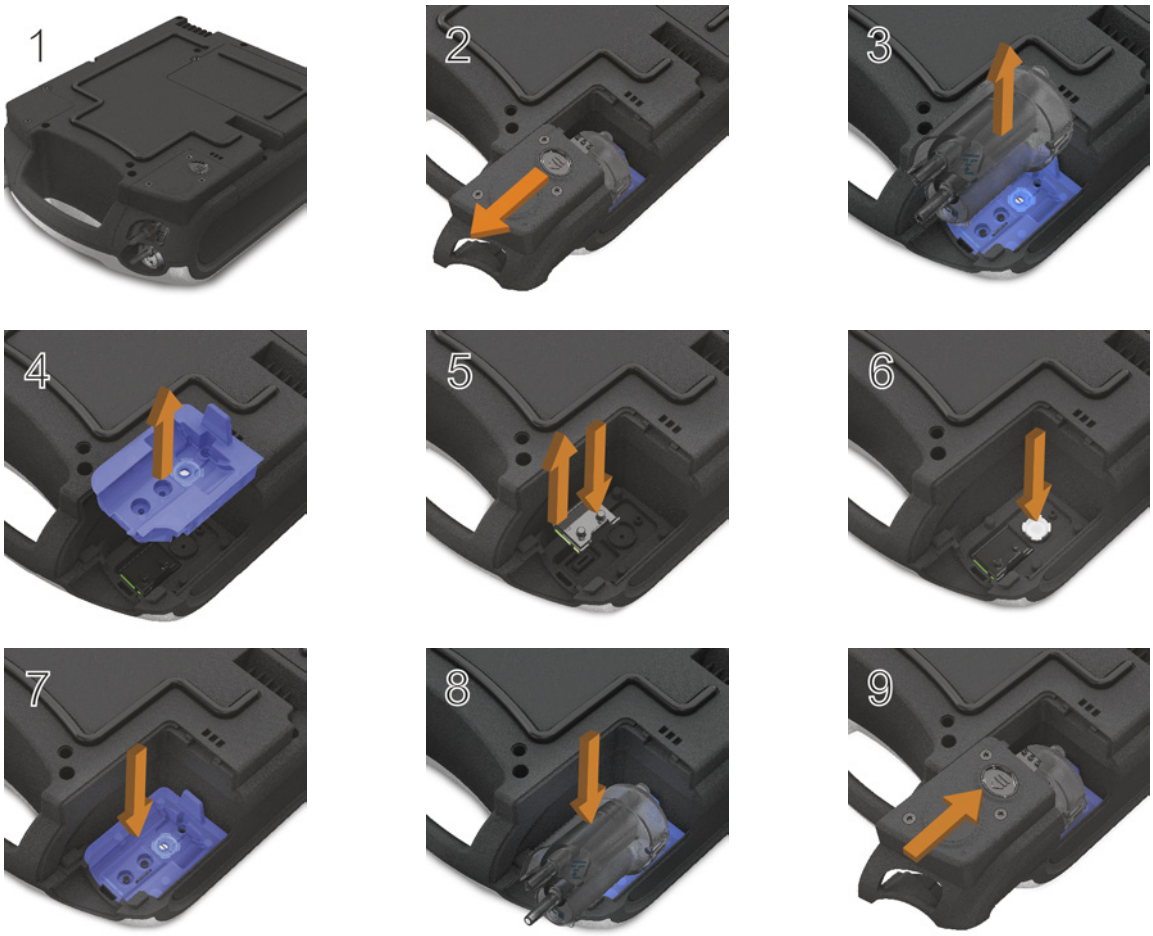
⚠ CAUTION

- **Regularly check the double limb adapter (expiratory valve) for moisture and contaminants. Particular care should be taken when using nebulisers or humidifiers.**
- **When replacing the expiratory flow sensor and antibacterial filter also replace the blue membrane and adapter.**

To remove and replace the expiratory flow sensor and antibacterial filter:

Before replacing the expiratory flow sensor, turn off the device and remove mains power and/or external battery.

1. Turn over the device and place on a soft surface (to protect the LCD screen).
2. Press and hold the eject button. Pull the cover out towards you.
3. Lift out the adapter and discard.
4. Remove the blue membrane (including the white antibacterial filter) and discard.
5. Remove and insert a new expiratory flow sensor.
6. Insert a new antibacterial filter.
7. Insert a new blue membrane ensuring the rear tab and surrounds sit flush in the enclosure.
8. Insert a new adapter, gently pushing down so it sits firmly in place.
9. Place the cover over the enclosure, ensuring the runners on the device and the cover are aligned. Slide the cover back into place until the latch clicks.



⚠ CAUTION

Following the replacement of the Expiratory flow sensor, you must run a Learn Circuit to calibrate the new sensor and ensure accurate therapy and monitoring.

To calibrate the Expiratory flow sensor, connect a double limb circuit. Prior to performing the Learn Circuit, ensure double circuit is selected on the Circuit sub-menu.

Replacing the double limb adapter (expiratory valve)

Regularly check the double limb adapter for moisture and contaminants. Replace as necessary using the procedure as described in **Connecting circuits**.

Replacing the Oxygen sensor

To remove and replace the oxygen sensor (O_2 cell):

Before replacing the O_2 sensor, turn off the device and remove from mains power and/or external battery.

1. Unscrew the cover of the O_2 enclosure.
2. Remove the cover of the O_2 enclosure.
3. Holding on to the tab of the O_2 cell, gently pull the cell up and out of the enclosure. Gently pull the wire to remove it from the connector in the device.

   The device is now ready for the new O_2 cell to be installed.
4. Carefully insert the connector of the new O_2 cell into the socket. This connector can only be inserted one way with the flat section to the wall of the enclosure. Press into place using a blunt tool (eg, a flat-bladed screwdriver).
5. Holding on to the tab of the O_2 cell, gently place the O_2 cell into the enclosure ensuring the wires are tucked into place.
6. Replace the cover and screw into place.

⚠ CAUTION

Following the replacement of the Oxygen sensor, you must run a Learn Circuit to calibrate the new sensor and ensure accurate therapy and monitoring.

Replacing the internal battery

⚠ WARNING

Turn off and disconnect oxygen before replacing the internal battery.

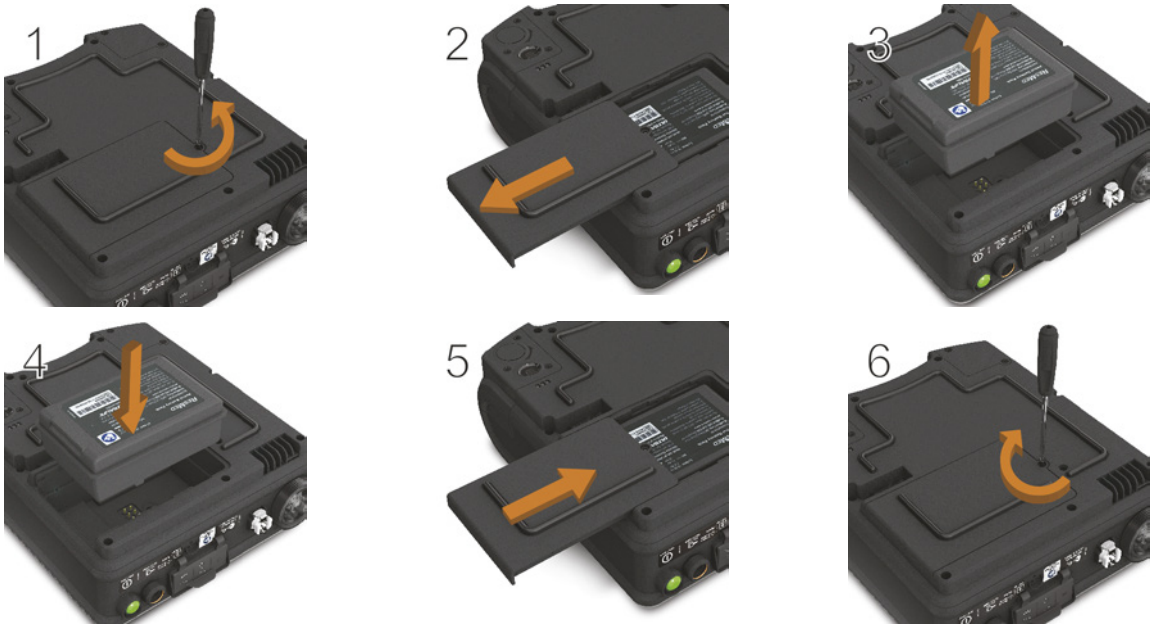
⚠ CAUTION

- Lithium-ion batteries have built-in safety protection circuits, but can still be dangerous if they are not used correctly. Damaged batteries can fail or catch fire.
- As the battery ages, the available capacity decreases. When the remaining battery capacity is low, do not rely on the internal battery as the primary power supply.
- Only recharge the internal battery inside the device or by using a ResMed approved charger. Avoid hard, physical impact on the device.
- Use the internal battery in accordance with the intended use stated in this guide. Damage to equipment or injury can result from modifying the equipment or its operation.
- The internal battery should be replaced every two years or sooner when there is a noticeable reduction in usage time when fully charged.

To remove and replace the internal battery:

Before replacing the internal battery, turn off the Astral device and remove from mains power.

1. Turn over the device and unscrew the battery cover.
2. Remove the battery cover from the device.
3. Remove the battery from the device.
4. Insert a new battery into the battery enclosure. Ensure the connectors on the battery sit face down into the enclosure against the battery connection points on the device.
5. Replace the battery cover.
6. Screw the battery cover securely in place.



Servicing

⚠ WARNING

Inspection and repair should only be performed by an authorized agent. Under no circumstances should you attempt to service or repair the device yourself. Failure to do so could void your Astral device warranty, damage the Astral device or result in possible injury or death.

Note: Retain the original packaging of the Astral device for use when shipping to/from an authorized ResMed Service Centre.

Maintenance Timetable

The Astral device should be serviced by an authorized ResMed Service Centre according to the following schedule. The Astral device is intended to provide safe and reliable operation provided that it is operated and maintained in accordance with the instructions provided by ResMed. As with all electrical devices, if any irregularity becomes apparent, you should exercise caution and have the device inspected by an authorized ResMed Service Centre.

With regular servicing, the expected service life of an Astral device is 8 years.

Servicing schedule from the date of first use:

Recommended service interval	Conducted by	Instructions
Every six months	Personnel who have been trained in the use of Astral	Replacement of the air filter (replace earlier if dirty). Replacement of Single or Double limb circuit adapters if used.
Two years	Qualified technician	Two year Preventative maintenance. Replacement of the internal battery and FiO_2 sensor if fitted.
35,000 hours	Qualified technician	Pneumatic block Preventative maintenance.

Helpful hint!

If Service Reminders are enabled you will get a notification on the device when two year preventative maintenance is nearly due.

Internal Battery

The expected life of the internal battery is two years. The internal battery should be replaced every two years or sooner when there is a noticeable reduction in usage time when fully charged. During storage ensure that internal battery is recharged once every six months.

Helpful hint!

If Service reminders are enabled you will get a notification on the device when there is a measurable reduction in battery usage time.

Device information

Device information, including the Next service due date indicating when the next preventative maintenance is due, can be found by pressing i and selecting Device.

Upgrading software

Software upgrades can only be performed by an authorized service representative. Astral has the ability to be upgraded with a USB stick containing the appropriate software. Please contact your authorized agent for further information.

Additional considerations for hospital or healthcare facilities

Component	Hospital or healthcare facility
Device	Follow the cleaning and maintenance protocol and schedule of the hospital/healthcare facility.
Double limb adapters	For general hygiene, the double limb adapter should be replaced between patients or protected with an antibacterial filter.
Air filter	Replace every six months (or more if necessary).
Mask	Masks should be reprocessed or replaced between patients. Cleaning, disinfection and sterilisation instructions are available from the ResMed website, www.resmed.com/downloads/masks. If you do not have internet access, please contact your ResMed representative.
Patient circuits	Follow the protocol of the hospital/healthcare facility and the recommendations of the manufacturer.
Humidifier	Follow the protocol of the hospital/healthcare facility and the recommendations of the manufacturer.
Antibacterial filter	Replace as required and between patients.

Technical specifications

Operating pressure range	Single limb with valve or double limb with valve: 3 to 50 hPa Single limb with intentional leak: 2 to 50 hPa CPAP: 3 to 20 hPa Maximum working pressure limit: 10 to 80* hPa *Not applicable on all device variants Forced cycling occurs if the Pressure alarm limit is exceeded.
Operating tidal volume range (volume control modes)	Adult patient type: 100 to 2500 mL Pediatric patient type: 50 to 300 mL*
Circuit resistance and compliance range for stated accuracy of monitoring and control**	Pediatric patient setting: Circuit resistance range (circuit with intentional leak): 0 to 8 hPa at 60 L/min Circuit resistance range (circuit with valve): 0 to 20 hPa at 60 L/min Circuit resistance range (mouthpiece circuit): 0 to 5 hPa at 60 L/min Circuit compliance range: 0 to 4 mL / hPa
	Adult patient setting: Circuit resistance range (circuit with intentional leak): 0 to 20 hPa at 120 L/min Circuit resistance range (circuit with valve): 0 to 35 hPa at 120 L/min Circuit resistance range (mouthpiece circuit): 0 to 15 hPa at 120 L/min Circuit compliance range: 0 to 4 mL / hPa
Breathing resistance under single fault***	Pediatric circuit Inspiration: 2.2 hPa (at 15 L/min), 5.3 hPa (at 30 L/min) Expiration: 2.4 hPa (at 15 L/min), 5.0 hPa (at 30 L/min) Adult circuit Inspiration: 5.7 hPa (at 30 L/min), 8.3 hPa (at 60 L/min) Expiration: 4.2 hPa (at 30 L/min), 6.2 hPa (at 60 L/min)
Maximum flow	220 L/min
Inspiratory trigger (nominal) characteristics	Inspiratory trigger occurs when patient flow exceeds trigger setting. Double limb with valve (flow trigger): 0.5 to 15.0 L/min Single limb with valve or double limb with valve: 1.6 to 10.0 L/min (in five steps)**** Single limb with intentional leak: 2.5 to 15.0 L/min (in five steps) Mouthpiece (tube only) circuit: 2.0 to 4.0 L/min (in four steps)
Expiratory cycle (nominal) characteristics	Cycle occurs when inspiratory flow declines to the set percentage of peak inspiratory flow. 5 to 90%
Sound pressure level	35 ± 3 dBA as measured according to ISO 80601-2-72:2015
Sound power level	43 ± 3 dBA as measured according to ISO 80601-2-72:2015
Alarm volume range	56–85 dBA (in five steps) as measured according to IEC60601-1-8:2012
Data storage	7 days of high-resolution airway pressure, respiratory flow and delivered volume (sampled at 25 Hz). 7 days of breath-related therapy data (sampled at 1 Hz). 365 days of statistical data per program.

Dimensions (L x W x H)	285 mm x 215 mm x 93 mm (11.22" x 8.47" x 3.66") Display screen size: 150 mm x 90 mm (5.91" x 3.54")
Weight	3.2 kg (7.1 lb)
Inspiratory port / double limb adapter	22 mm taper, compatible with ISO 5356-1:2004 Anesthetic & Respiratory Equipment – Conical Connectors
Pressure measurement	Internally mounted pressure transducers
Flow measurement	Internally mounted flow transducers
Power supply	AC 100–240V, 50–60Hz, 90 W 3.75 A continuous, 120 W / 5A peak 110V/400 Hz
External DC Power Supply	12 - 24V DC 90 W, 7.5 A / 3.75 A
Internal Battery	Lithium-Ion battery, 14.4 V, 6.6 Ah, 95 Wh Operating hours (standard case): 8 hours with a new battery under normal conditions Test conditions: Adult, (A)CV mode, Vt = 800 mL, PEEP = 5 cmH_2O, Rate = 20 bpm, Ti = 1.0 sec. All other parameters remain at default settings. Operating hours (worst case) > 4 hour run time under the following conditions: Test conditions: Adult, non-vented, PACV mode, Double limb circuit, Pressure Assist = 30 cmH_2O, PEEP = 20 cmH_2O Rate:20 bpm, Ti: 1.0 sec, Rise Time = Min, Safety Vt = Off, Trig = Off. All other parameters remain at default settings. Total lifetime: up to 3,000 hours of normal operation on internal battery Note: Time may vary with different settings and environmental conditions.
Housing construction	Flame retardant engineering thermoplastic
Environmental conditions	Operating temperature: 32°F to 104°F (0°C to 40°C Charging temperature: 41°F to 95°F (5°C to 35°C) Operating humidity: 5 to 93% non-condensing Storage and transport temperature: -4°F to 122°F (-20°C to 50°C) for up to 24 hours Storage and transport temperature: -13°F to 158°F (-25°C to 70°C) for greater than 24 hours Note: Storing the Astral device at temperatures exceeding 122°F (50°C) for extended period of time may accelerate battery aging. This will not affect the safety of the battery or device. Refer to Using the internal battery (see page 59) Storage and transport humidity: 5 to 93% non-condensing It takes 40 minutes* for the device to be ready for use on a patient when removed from storage at the minimum long term temperature and at an ambient temperature of 68°F (20°C). *Assumes that the device is connected to an external AC power. It takes 60 minutes for the device to be ready for use on a patient when removed from storage at the maximum long term temperature and at an ambient temperature of 68°F (20°C). Air pressure: 1100 hPa to 700 hPa Altitude: 9842 ft (3000 m) Note: The performance may be limited below 800 hPa or at altitudes above 6562 ft (2000 m).

	IP22 (Protected against finger sized objects. Protected against dripping water when tilted up to 15 degrees from specified orientation.) When placed horizontally on flat surface, or vertically with handle up. IP21 (Protected against finger sized objects and against vertically dripping water) when placed on a table stand, when used with the ResMed Homecare Stand or when attached to the RCM or RCMH.
Oxygen measurement	Internally mounted oxygen sensor. 1,000,000 % hours at 77°F (25°C)
Electromagnetic compatibility	Product complies with all applicable electromagnetic compatibility requirements (EMC) according to IEC60601-1-2 for Medical Equipment in the home and professional healthcare environments; and emergency medical service environment. It is recommended that mobile communication devices are kept at least one metre away from the device. For further details see "**Guidance and manufacturer's declaration – electromagnetic emissions and immunity**" (see page 144).
Aircraft use	Medical-Portable Electronic Devices (M-PED) that meet the Federal Aviation Administration (FAA) requirements of RTCA/DO-160 can be used during all phases of air travel without further testing or approval by the airline operator. ResMed confirms that the Astral meets the Federal Aviation Administration (FAA) requirements (RTCA/DO-160, section 21, category M) for all phases of air travel. IATA classification for internal battery: UN 3481 – Lithium-Ion batteries contained in equipment.
Automotive use	Product complies with ISO 16750-2 Road Vehicles - Environmental Conditions and Testing for Electrical and Electronic Equipment - Part 2: Electrical Loads" - 2nd Edition 2006, Tests 4.2, 4.3.1.2, 4.3.2, 4.4, 4.6.1 and 4.6.2. The functional status classification shall be Class A. Product complies with ISO7637-2 "Road Vehicles - Electrical Disturbance by Conduction and Coupling - Part 2 Electrical Transient Conduction Along Supply Lines Only" - 2nd Edition 2004, Section 4.4 Transient Immunity Test. The functional status classification shall be Class A to test level III and Class C to test level IV.
Data connections	The Astral device has three data connection ports (USB connector, mini USB connector, and Ethernet port). Only the USB and mini-USB connectors are for customer use. The USB connector is compatible with the ResMed USB stick.
Recommended patient circuit components and compatible accessories	Refer to www.resmed.com/astral/circuits.
IEC 60601-1 classifications	Class II double insulation Type BF Continuous operation Suitable for use with oxygen.

Applied parts	Patient interface (Mask, endotracheal tube, tracheostomy tube or mouthpiece). Oximeter.
Intended operator	Only a Clinician or health care provider can setup and configure the device. A Clinician, health care provider, patient or carer are intended operators of the device.
Operator position	The device is designed to be operated within arm's length. An operator should position their line of sight within an angle of 30 degrees from a plane perpendicular to the screen. The Astral device complies with IEC60601-1:2005 legibility requirements.
Software release compatibility	For information on your device software version, contact your ResMed representative.
This device is not suitable for use in the presence of a flammable anesthetic mixture.	

*The International ventilator standard indicates that Pediatric patient type is intended to be used for a patient receiving less than 300 mL, however Astral permits adjustment of 'Vt' setting parameter up to 500 mL for cases where 'Vt' is set such that it compensates for leak in the breathing circuit.

⚠ WARNING

ResMed does not recommend 500 mL as the upper limit for the pediatric tidal volume use; however, clinicians may choose this upper limit based on their clinical determination.

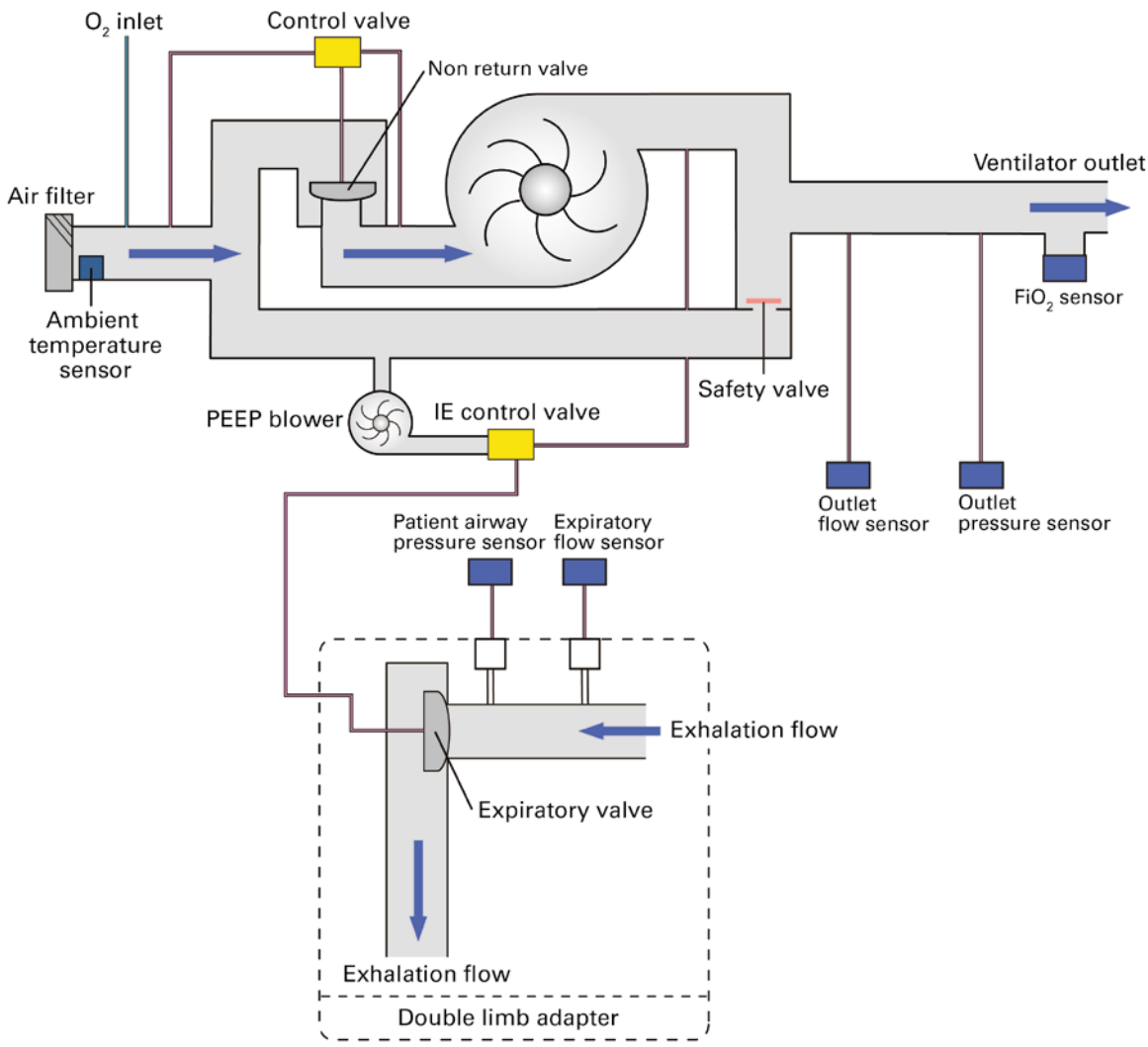
** To achieve specified accuracies, a successful Learn Circuit must be performed.

*** Limits are the sum of device and circuit impedance under single fault leading to device shutdown.

**** Individual configurations may be more sensitive.

The life of oxygen cells is described by hours used multiplied by the % of oxygen used. For example 1 000 000 % hours oxygen cell will last for 20 000 hours at 50% FiO_2 (20 000 x 50 = 1 000 000) or 40 000 hours at 25% FiO_2 (40 000 x 25 - 1 000 000). Astral's oxygen cell will last for 25,000 hours (1041 days) at 40% FiO_2

Pneumatic flow path



⚠ WARNING

Under normal or single fault conditions the entire pneumatic flow path can become contaminated with body fluids or expired gases if antibacterial filters are not installed on the ventilator outlet and double limb adapter exhalation port.

Monitoring

This section specifies the monitored parameters of the Astral device. Monitored therapy parameters are only displayed during ventilation. Other parameters (eg, battery charge level and oximetry data) are monitored even when not ventilating.

The Astral device monitors the following parameters:

Time parameters

Parameter	Updates	Units	Range	Resolution	Accuracy
Ti	End of inhalation	sec	0 to 10	0.01	±(20 ms + 5%)
Te	End of exhalation	sec	0 to 15	0.01	±(20 ms + 5%)
I:E	End of breath	N/A	1:9.9 to 9.9:1	0.1	±10%
Resp. rate	End of breath	1/min	0 to 99	1	±1/min

Volume and flow parameters

Parameter	Updates	Units	Range	Resolution	Accuracy
Flow	Continuous	L/min	-250 to +250	0.1	±1 L/min or 10%*, whichever is greater
Vti	End of inhalation	mL	0 to 3000	1	±10 mL or 10%, whichever is greater
Vte	End of breath	mL	0 to 3000	1	For double limb circuit: ±10 mL or 10%, whichever is greater For single limb with intentional leak: ±15 mL or 15%*, whichever is greater
Va	End of breath	L/min	0 to 99	0,1	±(0.1+15%) L/min*
MVi	End of breath	L/min	0 to 99	0.1	±15% (VTi ≥ 100 mL)
MVe	End of breath	L/min	0 to 99	0.1	±15% (VTe ≥ 100 mL)
Peak Inspiratory Flow (PIF)	End of inhalation	L/min	0 to 250	0.1	±3 L/min or 35% whichever is greater
Measured Unintentional Leak (for intentional leak circuits)	Once per second	L/min	0 to 250	1	N/A

Parameter	Updates	Units	Range	Resolution	Accuracy
Measured Unintentional Leak (for double limb circuit with expiratory valve)	End of breath	%	0 to 100	1	N/A

* When Resp. rate ≥ 8/min, and Pressure ≤ 30 hPa for circuits with intentional leak, and with non-compliant interface.

Pressure parameters

Parameter	Updates	Units	Range	Resolution	Accuracy
Pressure	Continuous	cmH_2O or hPa or mbar	0 to 99	0.1	±(0.5 hPa + 4% of actual pressure)
PIP	End of inhalation	cmH_2O or hPa or mbar	0 to 99	0.1	±15%
PEEP	End of exhalation	cmH_2O or hPa or mbar	0 to 30	0.1	±(0.5 hPa + 4% of actual pressure)
Avg. P	End of breath	cmH_2O or hPa or mbar	0 to 99	0.1	±(0.5 hPa + 4% of actual pressure)

Other parameters

Parameter	Updates	Units	Range	Resolution	Accuracy
RSBI	End of breath	1/min-L	0 to 999	1	N/A
% Spont. Trig.	Start of inhalation	%	0 to 100	1	N/A
% Spont. Cyc.	End of inhalation	%	0 to 100	1	N/A
Measured Battery Time	Once per minute	HH:MM	N/A	1 min	N/A
Measured Battery Charge Level	Once per minute	%	0 to 100	1	N/A
FiO_2*	End of inhalation	%	18 to 100	1	±(2.5% + 2.5% of actual oxygen concentration)**
SpO_2	Once per second	% SpO_2	0 to 100	1	Refer to Nonin Xpod 3012 technical specifications at www.nonin.com
Pulse rate	Once per second	1/min	18 to 321	1	Refer to Nonin Xpod 3012 technical specifications at www.nonin.com.

* FiO_2 monitoring automatically compensates for atmospheric pressure variation.

** The measured FiO_2 sampled at 25 Hz has a response time of <12s to 90% of the final value. The long term output drift is <1% volume oxygen per month.

Notes:

- All flows and volumes are measured at BTPS conditions.
- To achieve specified accuracies, a successful Learn Circuit must be performed prior to measurement testing. Specified accuracies exclude mask compliance.
- Pressure may be displayed in cmH_2O, hPa or mbar. The conversion factor of the pressure units is 1. This means the displayed pressure will have the same values regardless of the unit selected.

Accuracy of controls

The following table shows the setting range and accuracy for the adjustable parameters.

Parameter	Range	Resolution	Accuracy
Delivered Pressure	2 to 50 hPa		±(0.5 hPa + 5% of target)
IPAP	4 to 50 hPa	0.2 hPa	Refer to delivered pressure
EPAP	2 to 25 hPa	0.2 hPa	Refer to delivered pressure
CPAP	3 to 20 hPa	0.2 hPa	Refer to delivered pressure
PEEP	Off, 3 to 20 hPa	0.2 hPa	Refer to delivered pressure
PS	2 to 50 hPa (Valved circuits) 0 to 50 hPa (iVAPS)	0.2 hPa	Refer to delivered pressure
P control	2 to 50 hPa	0.2 hPa	Refer to delivered pressure
Vt (Tidal volume)	Adult: 100 to 2500 mL Ped: 50 to 300 mL*	10 mL 5 mL	Valved circuits: ±12 mL or 10%, whichever is greater
Safety Vt (Safety tidal volume)	Adult: 100 to 2500 mL Ped: 50 to 300 mL*	10 mL 5 mL	Vented circuits: ±15 mL or 15%, whichever is greater Valved circuits: ±12 mL or 10%, whichever is greater
Target Va	1 to 30 L/min	0.1 L/min	±(0.1 +30% of target) L/min; Resp.rate < 12 bpm ±(0.1 +15% of target) L/min; Resp.rate ≥ 12 bpm
Resp. rate	Adult: Off, 2 to 50 bpm Ped: Off, 5 to 80 bpm	1 bpm	±2%
Target patient rate	Adult: 8 to 30 bpm	1 bpm	±2%
Ti (Inspiration time)	(A)CV, V-SIMV (mandatory breaths): 0.3 to 3.0 sec P(A)CV, P-SIMV (mandatory breaths): 0.2 to 5.0 sec P(A)C: 0.3 to 4.0 sec	Adult: 0.1 sec Ped: 0.05 sec	±(20 ms + 5% of setting)
PIF (Peak Inspiratory Flow)	(A)CV, V-SIMV (mandatory breaths): Adult: 10 to 120 L/min Ped: 5 to 60 L/min	1 L/min	N/A
Cycle (expiratory trigger)	5 to 90%, Auto	5%	N/A

Parameter	Range	Resolution	Accuracy
Trigger (inspiratory trigger)	(A)CV, P(A)CV: Off, 0.5 to 15 L/min V-SIMV, PSIMV, PS, CPAP: 0.5 to 15 L/min	0.5 L/min	N/A
Inspiratory Pressure Trigger	(A)CV, P(A)CV: Off, Very Low to Very High PS, P-SIMV, V-SIMV, CPAP: Very Low to Very High		N/A
Trigger sensitivity – Vented	(S)T, P(A)C: Very Low to Very High, Off CPAP: Very Low to Very High		N/A
Trigger sensitivity – Mouthpiece	(A)CV, P(A)CV, PS Off, Low to High, Touch		N/A
Rise Time	Min, 150 to 900 msec	50 ms	N/A
Flow Shape	100 (Constant), 75, 50, 25%		N/A
Ti Min	PS: 0.2 to 4.0 sec (S)T, iVAPS: 0.1 to 4.0 sec	Adult: 0.1 sec Ped: 0.05 sec	N/A
Ti Max	0.3 to 4.0 sec	Adult: 0.1 sec Ped: 0.05 sec	N/A
Apnea Interval	Adult: 15 to 60 sec Ped: 5 to 30 sec	1 sec	±0.5 s
Apnea Resp Rate	Adult: 4 to 50 bpm Ped: 12 to 80 bpm	1 bpm	±2%
Apnea Ti	When Volume Breath option is set to Ti. If Apnea Response is (A)CV + Alarm: 0.3 to 3 sec If Apnea Response is P(A)CV + Alarm: 0.2 to 5 sec	Adult: 0.1 sec Ped: 0.05 sec	±(20 ms + 5% of setting)
Apnea Vt	If Apnea Response is (A)CV + Alarm: Adult: 100 to 2500 mL Ped: 50 to 300 mL**	Adult: 10 mL Ped: 5 mL	Valved circuits: ±12 mL or 10%, whichever is greater
Apnea flow shape	Constant		N/A

Parameter	Range	Resolution	Accuracy
Apnea PIF	When Volume Breath is set to PIF. If Apnea Response is (A)CV + Alarm: Adult: 10 to 120 L/min Ped: 5 to 60 L/min	1 L/min	N/A
Apnea P control	When Apnea Response is P(A)CV + Alarm: 2 to 50 hPa	0.2 hPa	±(0.5 hPa+ 5% of target)
Manual Breath Magnitude	100 to 250%	10%	N/A
Sigh Interval	3 to 60 min	1 min	N/A
Sigh Magnitude	120 to 250%	10%	N/A

* When Resp. rate ≥ 8/min and Pressure ≤ 30 hPa.
**The International ventilator standard indicates that Pediatric patient type is intended to be used for a patient receiving less than 300 mL, however Astral permits adjustment of 'Vt' setting parameter up to 500 mL for cases where 'Vt' is set such that it compensates for leak in the breathing circuit.

⚠ WARNING

ResMed does not recommend 500 mL as the upper limit for the pediatric tidal volume use; however, clinicians may choose this upper limit based on their clinical determination.

Notes:

- All flows and volumes are measured at BTPS conditions.
- To achieve specified accuracies, a successful Learn Circuit must be performed prior to measurement testing.
- Delivered pressure is regulated at the patient port.

Measurement System and Accuracy

The Technical Specifications published above are provided in accordance with ISO 80601-2-72 2015.

Due to the introduction of a new home care standard, manufacturers are required to declare measurement uncertainty.

In accordance with ISO 80601-2-72 2015 the measurement uncertainty of the manufacturer's test equipment is:

For measures of flow	± 2%
For measures of volume	± 2 mL
For measures of pressure	± 1%
For measures of time	± 10 ms

In accordance with ISO 80601-2-72 2015 the tolerance of monitoring parameters inclusive of measurement uncertainty is:

Time parameters	± (30ms + 5%)
Flow parameters	± 12%
Volume parameters	± 12 ml or 12% whichever is greater
Pressure parameters	± (0.5 hPa + 5%)

Ventilator performance comparisons should be made on the basis of wholly including or excluding measurement uncertainty.

Functional variants

Functional variations between Astral 100 and Astral 150.

Feature		Astral 100	Astral 150
Circuit	Single limb with expiratory valve	Y	Y
	Single limb intentional leak	Y	Y
	Mouthpiece (tube only)	Y	Y
	Double limb	N	Y
Therapy	Preset programs	2	4
	Leak therapy modes	Y	Y
	Valve therapy modes	Y	Y
	Apnea ventilation	Y	Y
	Manual breath button	N	Y
	Sigh (pre-programmed)	N	Y
	SpO_2 monitoring	Y	Y
	FiO_2 monitoring	Optional extra	Y*
O_2	Oxygen inlet	Low flow	Low flow

*Not applicable on all device variants.

Guidance and Manufacturer's Declaration Electromagnetic Emissions & Immunity

Medical electrical equipment needs special precautions regarding EMC and needs to be installed and put into service according to EMC information provided in this document.
This declaration currently applies for the following ResMed devices:

- Astral™ Series of Ventilators.

Guidance and manufacturer's declaration—electromagnetic emissions

These devices are intended for use in the electromagnetic environment specified below. The customer or the user of the device should assure that the device is used in such an environment.

Emissions test	Compliance	Electromagnetic environment—guidance
RF emissions CISPR 11	Group 1	The device uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
RF emissions CISPR 11 with or without USB adapter with or without Oximeter adapter	Class B	The device is suitable for use in all establishments, including domestic establishments and those directly connected to the public low-voltage network that supplies buildings used for domestic purposes.
Harmonic Emissions IEC 61000-3-2 with or without specified accessories	Class A	
Voltage Fluctuations/Flicker Emissions IEC 61000-3-3 with or without specified accessories	Complies	

⚠ WARNING

- The device should not be used adjacent to or stacked with other equipment. If adjacent or stacked use is necessary, the device should be observed to verify normal operation in the configuration in which it will be used.
- The use of accessories other than those specified for the device is not recommended. They may result in increased emissions or decreased immunity of the device.
- Additional equipment connected to medical electrical equipment must comply with the respective IEC or ISO standards (eg, IEC 60950 for data processing equipment). Furthermore all configurations shall comply with the requirements for medical electrical systems (see IEC 60601-1-1 or clause 16 of the 3Ed. of IEC 60601-1, respectively). Anybody connecting additional equipment to medical electrical equipment configures a medical system and is therefore responsible that the system complies with the requirements for medical electrical systems. Attention is drawn to the fact that local laws take priority over the above mentioned requirements. If in doubt, consult your local representative or the technical service department.
- Portable RF communications equipment (including peripherals such as antenna cables and external antennas) should be used no closer than 30 cm to any part of the device, including cables specified by the manufacturer. Otherwise, degradation of the performance of this equipment could result.

Guidance and manufacturer's declaration – electromagnetic immunity

These devices are intended for use in the electromagnetic environment specified below. The customer or the user of the device should assure that the device is used in such an environment.

Immunity test	IEC60601-1-2 test level, Ed. 4	Compliance level	Electromagnetic environment—guidance
Electrostatic discharge (ESD) IEC 61000-4-2	±8 kV contact ±15 kV air	±8 kV contact ±15 kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.
Electrical fast transient/burst IEC 61000-4-4	±2 kV for power supply lines ±1 kV for input/output lines	±2 kV for power supply lines ±1 kV for input/output lines	Mains power quality should be that of a typical commercial or hospital environment.
Surge IEC 61000-4-5	±1 kV differential mode ±2 kV common mode	±1 kV differential mode ±2 kV common mode	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	<5% Ut (>95% dip in Ut) for 0.5 cycle 40% Ut (60% dip in Ut) for 5 cycles 70% Ut (30% dip in Ut) for 25 cycles <5% Ut (>95% dip in Ut) for 5 sec	<12V (>95% dip in 240V) for 0.5 cycle 96V (60% dip in 240V) for 5 cycles 168V (30% dip in 240V) for 25 cycles <12V (>95% dip in 240V) for 5 sec	Mains power quality should be that of a typical commercial or hospital environment. If the user of the device requires continued operation during power mains interruptions, it is recommended that the device be powered from an uninterruptible power source. The internal battery will provide backup power of eight hours.
Power frequency (50/60 Hz) magnetic field IEC 61000-4-8	30 A/m	30 A/m	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.
Conducted RF for life support IEC 61000-4-6	3 Vrms outside ISM bands 10 Vrms inside ISM bands	10 Vrms 150 kHz to 80 MHz	Portable and mobile RF communications equipment should be used no closer to any part of the device, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. See separation distance table below. $d = 0.35 \sqrt{P}$ outside ISM bands $d = 1.2 \sqrt{P}$ inside ISM bands

Immunity test	IEC60601-1-2 test level, Ed. 4	Compliance level	Electromagnetic environment—guidance
Radiated RF IEC 61000-4-3	10 V/m 80 MHz to 2.5 GHz for Home environment	10 V/m 80 MHz to 2.5 GHz	**Recommended separation distance for life support equipment** d = 1.2 √P 80 MHz to 800 MHz d = 2.3 √P 800 MHz to 2.5 GHz Where (P) is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and d is the recommended separation distance in meters (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey,[a] should be less than the compliance level in each frequency range.[b] Interference may occur in the vicinity of equipment marked with the following symbol:

[a] Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the device is used exceeds the applicable RF compliance level above, the device should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the device.

[b] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 10 V/m.

Notes:

- Ut is the AC mains voltage prior to application of the test level.
- At 80 MHz and 800 MHz, the higher frequency range applies.
- These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.
- ISM bands: 6.765 to 6.795MHz, 13.533 to 13.567MHz, 26.957 to 27.283MHz and 40.66 to 40.70Mz

Recommended separation distances between portable and mobile RF communications equipment and the life support device

These devices are intended for use in an environment in which radiated RF disturbances are controlled. The customer or the user of the device can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the device as recommended below, according to the maximum output power of the communications equipment.

Rated maximum output power of transmitter (W)	Separation distance according to frequency of transmitter (m)			
	150 kHz to 80 MHz Outside ISM bands $d = 0.35 \sqrt{P}$	150 kHz to 80 MHz Inside ISM bands $d = 1.2 \sqrt{P}$	80 MHz to 800 MHz $d = 1.2 \sqrt{P}$	800MHz to 2.5 GHz $d = 2.3 \sqrt{P}$
0.01	0.1	0.1	0.1	0.2
0.1	0.1	0.4	0.4	0.7
1	0.4	1.2	1.2	2.3
10	1.1	3.8	3.8	7.3
100	3.5	12.0	12.0	23.0

For transmitters rated at a maximum output power not listed above, the recommended separation distance d in metres (m) can be determined using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

Notes:

- At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.
- These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

Potential impact of electromagnetic disturbances

The loss or degradation of the following clinical functions due to electromagnetic disturbances could result in compromised patient safety:

- Accuracy of ventilation control
- Accuracy of monitoring of airway pressure, expired volume and FiO_2
- Therapy alarms.

Detection of this degradation could be observed by the following device behaviour:

- Erratic ventilation delivery
- Rapid fluctuations in monitored parameters
- False activation of therapy or technical alarms (eg, System Fault or Battery comms lost alarms)

Symbols

The following symbols may appear on your product or packaging.

Indicates a Warning or Caution

Follow instructions for use

LOT Batch code

REF Catalogue number

SN Serial number

Humidity Limitation

Temperature Limitation

Keep upright

Keep dry

Fragile, handle with care

Recyclable

Fire if damaged

Manufacturer

EC REP European Authorized Representative

CE 0123 CE Labelling in accordance with EC directive 93/42/EEC

Canadian Standards Association

Rx Only Prescription only (In the US, Federal law restricts these devices to sale by or on the order of a physician.)

Device weight

IP22 Protected against finger sized objects. Protected against dripping water when tilted up to 15 degrees from specified orientation.

Li-Ion Lithium Ion battery

Type BF applied part

Class II equipment

On/Off

Power plug

SpO2 Oximeter connector

Ventilation indicator

Alternating current

Direct current

Battery

Alarm Mute / Reset (Audio Pause)

O_2 Oxygen supply inlet connector

Connector for control line of external expiratory valve

Connector for the breathing pressure measuring line

Expiratory Connector (From Patient)

Inspiratory Connector (To Patient)

USB connector

Ethernet connector

Remote Alarm connector

Remote Alarm Test button

MR unsafe (do not use in the vicinity of an MRI device).

Environmental information

This device should be disposed of separately, not as unsorted municipal waste. To dispose of your device, you should use appropriate collection, reuse and recycling systems available in your region. The use of these collection, reuse and recycling systems is designed to reduce pressure on natural resources and prevent hazardous substances from damaging the environment.

If you need information on these disposal systems, please contact your local waste administration. The crossed-bin symbol invites you to use these disposal systems. If you require information on collection and disposal of your ResMed device please contact your ResMed office, local distributor or go to ResMed.com/environment.

Standards compliance

The Astral meets the following standards:

- IEC 60601-1 Medical Electrical Equipment - General Requirements for Basic Safety and Essential Performance
- IEC 60601-1-2 Medical electrical equipment - Part 1-2: General requirements for basic safety and essential performance - Collateral standard: Electromagnetic compatibility -Requirements and tests
- IEC 60601-1-8 General requirements, test and guidance for alarm systems in medical electrical equipment and medical electrical systems
- IEC 60601-1-11 Medical electrical equipment - Part 1-11: General requirements for basic safety and essential performance - Collateral standard: Requirements for medical electrical equipment and medical electrical systems used in the home healthcare environment
- ISO 80601-2-72 Medical electrical equipment - Part 2-72: Particular requirements for basic safety and essential performance of home healthcare environment ventilators for ventilator-dependent patients

Training and support

For training and support materials, please contact your ResMed representative.

Troubleshooting

If there is a problem, try the following suggestions. If the problem cannot be solved, contact your care provider or ResMed.

Alarm troubleshooting

The most common reason for an alarm to sound is because the system has not been properly assembled or a Learn Circuit has not been correctly performed for each program.

Notes:

- The alarm actions listed below are based on having the appropriate alarm settings for the patient's therapy. When an adjustable alarm is activated, re-confirm the alarm settings.
- The alarm log and alarm settings are maintained when the device is powered down and in the event of a power loss.
- If an alarm activates repeatedly, discontinue use, switch to a backup ventilator and return the device for servicing.

If the alarm log reaches its storage capacity, the oldest data will be discarded to allow new entries to be written to the log.

Alarm message	Action
Apnea	1. Check the patient's status and airway. 2. Verify that the therapy and alarm settings are appropriate. 3. Consider adjusting the trigger settings. 4. Inspect the circuit and proximal lines for leak. Perform a Learn Circuit.
Battery 1 fault	Check battery connections. If problem persists replace External Battery 1 with new external battery.
Battery 2 fault	Check battery connections. If problem persists, replace External Battery 2 with a new external battery.
Battery Inoperable	1. If the device has been stored in extreme temperatures, wait until the device returns to room temperature. 2. If the device has been stored for long periods of time, the battery may have discharged. Connect to mains power. 3. If the alarm persists, replace the battery.
Circuit fault	1. Check the circuit for water or leaks. 2. Perform a Learn Circuit. 3. If the alarm persists, replace the circuit.
Critically low battery	Connect the Astral to mains AC power and allow the battery to recharge.
Device overheating	1. Move the device to a cooler location. 2. Inspect the air inlet for foreign materials. 3. Inspect the air inlet filter. If necessary, replace the air inlet filter. 4. Inspect the cooling fan inlet and outlet for foreign materials. 5. Remove the Astral from the mobility bag. 6. Check the circuit for obstructions. 7. Switch to a lower impedance circuit (if available). 8. Perform a Learn Circuit.
Disconnection alarm	1. Check the patient's status and airway. 2. Inspect the circuit and proximal lines for disconnection or excessive leak. 3. Verify that the therapy and alarm settings are appropriate. 4. Perform a Learn Circuit.

Alarm message	Action
Flow sensor fault	Replace expiratory flow sensor.
Flow sensor not calibrated	Perform a Learn Circuit.
High FiO_2	1. Check the patient's status. 2. Check and adjust the oxygen supply. 3. Verify that therapy and alarm settings are appropriate. 4. Perform a Learn Circuit to recalibrate the oxygen sensor.
High Leak	1. Check the patient's status. 2. Inspect the circuit, expiratory valve and proximal lines for leak. When in use, check for leaks around the mask. 3. When using vented therapy, check the mask type setting. 4. Verify that therapy and alarm settings are appropriate. 5. Perform a Learn Circuit.
High MVe	1. Check the patient's status. 2. Inspect the double limb adapter. If necessary, replace the expiratory valve. 3. Verify that therapy and alarm settings are appropriate. 4. Perform a Learn Circuit.
High MVi	1. Check the patient's status. 2. Inspect the circuit and expiratory module for leaks. 3. Verify that therapy and alarm settings are appropriate. 4. Perform a Learn Circuit.
High PEEP	1. Check the patient's status. 2. Inspect the circuit and expiratory valve for obstruction. When in use, check for obstruction in proximal lines. 3. Verify that therapy and alarm settings are appropriate. 4. Perform a Learn Circuit.
High pressure	1. Check the patient's status and airway. 2. Inspect the circuit for obstruction. 3. Verify that therapy and alarm settings are appropriate. 4. Perform a Learn Circuit.
High pressure protection	The hardware pressure safety limit was exceeded. If problem reoccurs, return the device for service.
High Pulse Rate	1. Check the patient's status. 2. Verify that therapy and alarm settings are appropriate.
High Resp Rate	1. Check the patient's status. 2. Verify that therapy and alarm settings are appropriate. 3. Check and adjust the trigger settings. 4. Check for and correct leak. 5. Perform a Learn Circuit.
High SpO_2	1. Check the patient's status. 2. Verify that therapy and alarm settings are appropriate.

Alarm message	Action
High Vte	1. Check the patient's status. 2. Check double limb circuit adapter for contaminants or water. 3. Inspect the double limb circuit adapter. If necessary, replace the circuit adapter. 4. Verify that therapy and alarm settings are appropriate. 5. Perform a Learn Circuit.
High Vti	1. Check the patient's status. 2. Inspect the circuit and expiratory module for leaks. 3. Verify that therapy and alarm settings are appropriate. 4. Perform a Learn Circuit.
Incorrect circuit adapter	1. Check that the correct circuit adapter is installed for the selected circuit type. 2. Perform a Learn Circuit.
Incorrect circuit attached	1. Check that the circuit is correctly connected and matches the circuit type selected. 2. Inspect the circuit, expiratory valve and proximal lines. 3. Perform a Learn Circuit.
Internal battery degraded	1. Connect the Astral to mains AC power. 2. Return the device for service to replace the internal battery. The internal battery run time indicator may no longer be accurate and should not be relied upon.
Last self-test failed	1. Perform a Learn Circuit. 2. If problem persists, return the device for service.
Low internal battery	Connect the Astral to mains AC power to allow the battery to recharge.
Low FiO_2	1. Check the patient's status. 2. Check for leak. 3. Check the oxygen supply and connections to the device. 4. Verify that therapy and alarm settings are appropriate. 5. Perform a Learn Circuit to recalibrate the oxygen sensor.
Low MVe	1. Check the patient's status and airway. 2. Inspect the circuit and the expiratory valve for obstruction or leaks. 3. Verify that therapy and alarm settings are appropriate. 4. Perform a Learn Circuit.
Low MVi	1. Check the patient's status and airway. 2. Inspect the circuit for obstruction. 3. Verify that therapy and alarm settings are appropriate. 4. Perform a Learn Circuit.
Low PEEP	1. Check the patient's status. 2. Verify that therapy and alarm settings are appropriate. 3. Inspect the circuit and the expiratory valve for obstruction or leaks. When in use, check for obstructions in proximal lines. 4. Perform Learn Circuit.
Low pressure	1. Check all circuit connections, especially the patient interface and the proximal sense line. 2. Verify that therapy and alarm settings are appropriate. 3. Inspect the circuit and expiratory valve for damage or secretions. 4. Perform a Learn Circuit.

Alarm message	Action
Low Pulse Rate	1. Check the patient's status. 2. Verify that therapy and alarm settings are appropriate.
Low Resp Rate	1. Check the patient's status. 2. Inspect the circuit and the proximal lines for leak. 3. Check and adjust settings. 4. Verify that therapy and alarm settings are appropriate. 5. Perform a Learn Circuit.
Low SpO_2	1. Check the patient's status. 2. Verify that therapy and alarm settings are appropriate.
Low Vte	1. Check the patient's status and airway. 2. Inspect the circuit and the circuit adapter for obstruction or leaks or water. 3. Verify that therapy and alarm settings are appropriate. 4. Perform a Learn Circuit.
Low Vti	1. Check the patient's status and airway. 2. Inspect the circuit for obstruction. 3. Verify that therapy and alarm settings are appropriate. 4. Perform a Learn Circuit.
No FiO_2 monitoring	Perform a Learn Circuit to calibrate the oxygen sensor.
No SpO_2 monitoring	1. Check the SpO_2 connection to patient's finger and the Astral. 2. If the alarm persists, use another SpO_2 oximeter or finger sensor.
NV Mask/Rebreathing	For vented circuit: 1. Check that the mask vents are clear and unobstructed. 2. Check the mask type setting. 3. Perform a Learn Circuit. For mouthpiece circuit: Check that the interface is a mouthpiece and that the patient is not continuously exhaling into the circuit.
Obstruction	1. Check the patient's status and airway. 2. Inspect the circuit and the expiratory valve for obstruction. When in use, check for kinks in proximal lines. 3. Check the circuit for water. 4. Perform a Learn Circuit.
PEEP blower failure	1. Check the patient's status. 2. Switch to a back-up ventilator and return the device for service.
Power fault / no charging	1. Check all connections between the ventilator and external battery. 2. Check connection to mains power (if present). This can be caused by the battery temperature being out of range. If problem persists, contact your ResMed Service Centre.
Pressure Line disconnected	1. Check the connection of the proximal sense line. 2. Check the circuit for water. 3. Perform a Learn Circuit.
Safety reset complete	The device detected a fault and was reset. 1. Check the patient's status. 2. If the alarm persists, switch to a back-up ventilator and return the device for service.

Alarm message	Action
Safety system fault	1. Check the patient's status. 2. Transfer the patient to an alternate means of ventilation. 3. Return the device for servicing.
System fault	1. Check the patient's status. 2. Perform a Learn circuit. 3. If problem persists, or the device fails self-test, return the device for service.
Total power failure	1. Check the patient's status and airway. 2. Connect the device to AC mains. 3. Check the battery charge level of the internal and external (if applicable) battery. The total power failure alarm can only be silenced by connecting the device to AC mains power.
Using internal battery	Confirm operation on internal battery is intended or restore external power. If intending to use external power: 1. Check the power cable connection between the mains or battery, the power supply pack and the device. 2. If using an external battery, check the external battery charge level and replace/charge if empty. 3. If using mains AC, check the supply output. 4. If the problem continues, try an alternative external supply type (ie, Mains AC, Mains DC or External Battery).
Ventilation stopped	Confirm it is appropriate to stop ventilation.

Learn Circuit troubleshooting

Error code	Action
001	Hardware fault detected. Contact an authorized Service Centre.
104, 105	During the first step of the Learn Circuit, check that the inspiratory port and air inlet filter of the Astral device are clear of obstructions; and the circuit is not connected to the inspiratory port. Repeat Learn Circuit. If the problem persists, contact an authorized Service Centre.
106	Hardware fault detected. Contact an authorized Service Centre.
113	1. Check that supplemental oxygen is not added during the Learn Circuit. 2. During the first step of the Learn Circuit, check that the inspiratory port and air inlet filter of the Astral device are clear of obstructions; and the circuit is not connected to the inspiratory port. Repeat Learn Circuit. If the problem persists, contact an authorized Service Centre.
121	Device Test cannot detect the correct circuit adapter. Single limb with expiratory valve: 1. Check that the valve control line and proximal pressure line are connected to the single limb adapter correctly. Refer to Connecting a single limb circuit with expiratory valve (see page 39) for further information. 2. Check that the single limb circuit adapter is firmly inserted and adapter cover is installed correctly. Refer to Fitting the circuit adapter (see page 37) for further information. Double limb: 1. Check that the double limb circuit adapter is firmly inserted and adapter cover is installed correctly. Refer to Fitting the circuit adapter (see page 37) for further information. Single limb with intentional leak: 1. Check the single limb leak adapter is firmly inserted and adapter cover is installed correctly. Refer to Fitting the circuit adapter (see page 37) for further information. Repeat Learn Circuit. If the problem persists, contact an authorized Service Centre.
122	Hardware fault detected. Contact an authorized Service Centre.
123	Air Inlet Filter is not detected. Check that the air inlet filter is clean, dry and correctly installed. Replace if necessary. Refer to Replacing the air filter (see page 127). Repeat Learn Circuit. If the problem persists, contact an authorized Service Centre.
124	Ensure that all filters and circuits are disconnected from the inspiratory port. Repeat Learn Circuit. If the problem persists, contact an authorized Service Centre.
125	Hardware fault detected. Contact an authorized Service Centre.

Error code	Action
204	Unable to learn the circuit. 1. Ensure that the circuit is not moved until completion of the test. 2. Check the circuit and attached accessories for blockages. 3. Ensure that there are no sharp bends or kinks in the circuit and the patient end is not blocked. 4. If using humidification, ensure that the humidifier tub is not overfilled. 5. Follow the on-screen instructions carefully: • circuit should not be blocked during step 2 • circuit should be completely blocked during step 3. If problem persists, this circuit may not be compatible with the Astral device. Consider selecting another circuit configuration.
205	The measured circuit resistance exceeds safe operating limits for this device. 1. Check the circuit and attached accessories for blockages. 2. Ensure that there are no sharp bends or kinks in the circuit and the patient end is not blocked. 3. If using humidification, ensure that the humidifier tub is not overfilled. 4. Follow the on-screen instructions carefully: • circuit should not be blocked during step 2 • circuit should be completely blocked during step 3. If problem persists, this circuit may not be compatible with the Astral device. Consider selecting another circuit configuration.
206	Hardware fault detected. Contact an authorized Service Centre.
303	Unable to calibrate oxygen sensor. 1. Check that supplemental oxygen is not added during the Learn Circuit. 2. Repeat Learn Circuit. If the problem persists, replace the oxygen sensor as described in Replacing the Oxygen sensor.
404, 405, 406	Hardware fault detected. Contact an authorized Service Centre.
409	Learn Circuit was unable to complete due to excessive leak from the circuit. 1. Check that the circuit is completely blocked during the third step of the Learn Circuit. 2. Check that the circuit is assembled correctly and there are no leaks in the circuit. 3. Check that the circuit adapter is firmly inserted. 4. This circuit may not be compatible with the Astral device. Try another circuit. Repeat Learn Circuit. If the problem persists, contact an authorized Service Centre.
415	Hardware fault detected. Contact an authorized Service Centre.
420	The measured circuit compliance exceeds safe operating limits for this device. Check that the circuit is assembled correctly and completely blocked during the third step of the Learn Circuit. If problem persists, this circuit may not be compatible with the Astral device. Consider selecting another circuit configuration.
426	Hardware fault detected. Contact an authorized Service Centre.

Error code	Action
504	Unable to learn the circuit. 1. Ensure that the circuit is not moved until completion of the test. 2. Check the circuit and attached accessories for blockages. 3. Ensure that there are no sharp bends or kinks in the circuit and the patient end is not blocked. 4. If using humidification, ensure that the humidifier tub is not overfilled. 5. Follow the on-screen instructions carefully: • circuit should not be blocked during step 2 • circuit should be completely blocked during step 3. If problem persists, this circuit may not be compatible with the Astral device. Consider selecting another circuit configuration.
505	The measured circuit resistance exceeds safe operating limits for this device. 1. Check the circuit and attached accessories for blockages. 2. Ensure that there are no sharp bends or kinks in the circuit and the patient end is not blocked. 3. If using humidification, ensure that the humidifier tub is not overfilled. 4. Follow the on-screen instructions carefully: • circuit should not be blocked during step 2 • circuit should be completely blocked during step 3. If problem persists, this circuit may not be compatible with the Astral device. Consider selecting another circuit configuration.
506, 512	Hardware fault detected. Contact an authorized Service Centre.
600	Unable to calibrate Expiratory Flow Sensor. 1. Check the circuit adapter is clean, dry and firmly inserted. • If the adapter is wet, then removing the adapter and vigorously shaking to clear water can be effective. Re-insert adapter firmly and repeat Learn Circuit. • If the adapter is not clean, then it will need to be replaced. 2. If using a small diameter pediatric breathing circuit, consider using an anti-bacterial filter or a 22-mm adapter on the expiratory adapter port. 3. Repeat Learn Circuit and ensure that the circuit is not moved until completion of the test. If problem persists, then the expiratory flow sensor may need to be replaced.

General troubleshooting

Issue	Action
Condensation forming in circuit	Condensation may form due to high humidity settings and low ambient temperatures. Adjust humidifier settings in accordance with manufacturer's instructions.
Touch screen damaged or non-responsive	If you are unable to power off the Astral device normally, use the following forced shutdown procedure: 1. Disconnect any external power source (eg, AC mains or external battery). 2. Press and hold the green on/off button and the alarm mute/reset button for at least 10 seconds. After 10 seconds the alarm bar will flash yellow. 3. Release both buttons. Astral will then power off. 4. The Astral device can be powered back on by pressing the on/off button and used as intended.
Unable to save data from Astral to USB or USB is not detected by device.	1. Remove and reinsert the USB stick. 2. Use a new USB stick. 3. Remove the AC or external DC power supply, the restart the Astral by switching it off then on. 4. Reformat your USB stick. Note that any data currently saved on the USB will be lost.
Learn Circuit failed	If the Learn Circuit fails and a warning message appears on the top of the Learn Circuit results page, try the following: 1. Check the circuit for Leak. 2. Check the module, the blue membrane and sensor are pressed all the way in and sit flush with the enclosure. 3. Select the pediatric patient type. This will allow higher resistance circuits to pass. (10mm and 15mm corrugated circuits will not pass Learn Circuit with adult patient type selected). 4. Hold the circuit straight to reduce resistance. 5. Ensure that the ventilation and alarms are effective before proceeding further. Note: It is acceptable to use a circuit that gives a caution message as the Astral device will compensate for circuit resistance and compliance.
Flow Sensor failed (Astral 150 only)	If the Flow Sensor fails and a message appears on the bottom of the Learn Circuit results page, try the following: 1. Check the circuit for Leak. 2. Check the expiratory valve, the blue membrane and sensor are pressed all the way in and sit flush with the enclosure. 3. If required, replace the flow sensor by following the instructions in 'Replacing components" in the Cleaning and maintenance section.

Recommendations for suctioning

Suctioning involves application of negative pressure (vacuum) to the airway through a catheter tube to remove airway secretions causing airway obstruction.

Astral supports two methods of suctioning based on the selection of catheter — open and closed.

The need for suctioning can be detected by the ventilator through:

- Increased peak inspiratory pressure during volume-controlled ventilation. To detect this condition, appropriately configure the High Pressure alarm.
- Decreased tidal volume during pressure-controlled ventilation. To detect this condition, appropriately configure the Low Vti alarm
- A deterioration of oxygen saturation. To detect this condition, use a Pulse Oximeter and appropriately configure the Low SpO_2 alarm.

If patient pre or post suctioning oxygenation is required, it can be achieved by the following means (or a combination of the following means):

- adjusting the low flow oxygen input to increase delivered FiO_2
- patient hyperventilation using the Astral Manual breath feature (take care to allow sufficient exhalation time to avoid breath stacking).

SpO_2 monitoring can be used during pre and post oxygenation, during and after suctioning to assess the patient condition.

For **open suctioning**, the ventilation circuit may be temporarily disconnected to allow suctioning. Due to this disconnection the PEEP, Low Inspiratory Pressure, and/or Minute Ventilation alarms may be triggered. Press to pre-silence alarms for two minutes.

To facilitate suctioning, the SpO_2 and Pulse rate monitors continue to display if ventilation is temporarily stopped.

For **closed suctioning**, due to the vacuum pressure applied while ventilating, Tidal volume, Minute volume and/or PEEP alarms may be triggered. Press to pre-silence alarms for two minutes.

⚠ CAUTION

Following open or closed suctioning, restore the patient circuit and check ventilation is correctly restored.

To assess the patient condition and the effectiveness of the secretions removal, peak inspiratory flow (during pressure-controlled ventilation), peak inspiratory pressure (during volume-controlled ventilation) or tidal volume during pressure-controlled ventilation, as well as SpO_2 can be monitored.

Astral places no restrictions on which ventilation mode is used while suctioning. Astral may respond differently depending on the mode and therapy settings. It is recommended that the 'expected response' is clearly documented in the patient care plan.

Limited warranty

ResMed Ltd (hereafter 'ResMed') warrants that your ResMed product shall be free from defects in material and workmanship from the date of purchase for the period specified below.

Product	Warranty period
• Mask systems (including mask frame, cushion, headgear and tubing)—excluding single-use devices • Accessories—excluding single-use devices • Flex-type finger pulse sensors • Humidifier water tubs	90 days
• Batteries for use in ResMed internal and external battery systems	6 months
• Clip-type finger pulse sensors • CPAP and bilevel device data modules • Oximeters and CPAP and bilevel device oximeter adapters • Humidifiers and humidifier cleanable water tubs • Titration control devices	1 year
• CPAP, bilevel and ventilation devices (including external power supply units) • Battery accessories • Portable diagnostic/screening devices	2 years

This warranty is only available to the initial consumer. It is not transferable.
If the product fails under conditions of normal use, ResMed will repair or replace, at its option, the defective product or any of its components.
This Limited Warranty does not cover: a) any damage caused as a result of improper use, abuse, modification or alteration of the product; b) repairs carried out by any service organization that has not been expressly authorized by ResMed to perform such repairs; c) any damage or contamination due to cigarette, pipe, cigar or other smoke; and d) any damage caused by water being spilled on or into an electronic device.
Warranty is void on product sold, or resold, outside the region of original purchase.
Warranty claims on defective product must be made by the initial consumer at the point of purchase.
This warranty replaces all other expressed or implied warranties, including any implied warranty of merchantability or fitness for a particular purpose. Some regions or states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.
ResMed shall not be responsible for any incidental or consequential damages claimed to have resulted from the sale, installation or use of any ResMed product. Some regions or states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation may not apply to you.
This warranty gives you specific legal rights, and you may also have other rights which vary from region to region. For further information on your warranty rights, contact your local ResMed dealer or ResMed office.

Appendix A: Definitions

Ventilation settings definitions

The available settings will vary with the selection of the ventilation mode. Each mode details the settings available.

Setting	Definition
Apnea Definition	Apnea Definition sets the type of breath which must be delayed for an apnea to be detected.
Apnea Interval (T apnea)	Apnea Interval (T apnea) sets the period without breath or spontaneous breath required for an apnea to be detected.
Apnea Response	Apnea Response sets the behaviour of the ventilator when an apnea is detected.
Circuit Type	Circuit Type sets whether a Double limb circuit, Single limb circuit with expiratory valve or Single limb circuit with intentional leak is in use.
CPAP	Continuous Positive Airway Pressure (CPAP) sets the pressure maintained throughout a spontaneous breath.
Cycle	Cycle (also known as Expiratory Trigger) sets the threshold where start of expiration within a breath is detected.
EPAP	Expiratory Positive Airway Pressure (EPAP) sets the pressure to be delivered to the patient during expiration.
Flow shape	Sets the target flow waveform for the delivery of mandatory controlled volume breaths.
Inspiratory duration option (Insp Duration Option)	Inspiratory duration option (Insp Duration Option) sets whether Inspiration Time (Ti) or Peak Inspiratory Flow (PIF) is used to configure volume controlled breaths.
Interface type	Invasive, mask, or mouthpiece
Interval	Sigh interval sets the period between sigh breaths.
IPAP	Inspiratory Positive Airway Pressure (IPAP) sets the pressure to be delivered to the patient during inspiration.
Magnitude	Magnitude sets the size of the manual or sigh breath delivered relative to the size of the normal ventilation breath. Separate magnitude settings are available for configuration of manual or sigh breaths.
Manual Breath	Manual Breath sets whether a manual breath is available for delivery.
Mask Type	Mask Type sets the type of mask or in-line vent in use when the circuit type is single with leak.
Max EPAP	Maximum Expiratory Positive Airway Pressure (Max EPAP) sets the maximum pressure to be delivered to the patient during expiration to maintain upper airway patency.
Max PS	Maximum Pressure Support (Max PS) sets the maximum pressure support above EPAP allowed to achieve the Target Va.
Min EPAP	Minimum Expiratory Positive Pressure (Min EPAP) sets the minimum pressure allowed to be delivered to the patient during expiration to maintain upper airway patency. The Min EPAP should be set to treat any lower airway condition.
Min PS	Minimum Pressure Support (Min PS) sets the minimum pressure support above EPAP allowed to achieve the Target Va (iVAPS).
P control	Pressure control (P control) sets the pressure support above PEEP to be delivered during inspiration for pressure assisted breaths.

Setting	Definition
P control max	Maximum allowed pressure control (P control max) sets the maximum pressure control above PEEP allowed to achieve the target safety volume.
Patient type	Select from Adult or Pediatric. This setting configures the default values and ranges available for ventilation settings and determines circuit resistance acceptance criteria applied in the Learn Circuit.
PEEP	Positive End Expiratory Pressure (PEEP) sets the pressure maintained during exhalation.
PIF	Peak Inspiratory Flow (PIF) sets the maximum delivered flow for volume controlled breaths.
PS	Sets the pressure support above PEEP to be delivered during inspiration for pressure supported breaths (spontaneous breaths).
PS Max	Maximum allowed Pressure Support (PS Max) sets the maximum pressure support above PEEP allowed to achieve the target safety tidal volume.
Pt Height	Patient Height (Pt Height) is used to estimate the patient's anatomical deadspace and Ideal Body Weight (IBW).
Resp. rate	Respiratory rate (Resp. rate) sets the breaths per minute (bpm) to be delivered by the ventilator to the patient. The measured respiratory rate may be greater due to patient triggered breaths.
Rise Time	Rise time sets the time taken for the ventilator to reach inspiratory pressure for pressure controlled breaths.
Safety Vt	Safety tidal volume sets the target minimum tidal volume (Vt) for each ventilator delivered breath.
Sigh Alert	Sigh alert sets whether the ventilator gives a single beep just prior to delivery of a sigh breath.
Sigh Breath	Sigh Breath sets whether a magnified breath (a sigh breath) will be delivered at the sigh interval.
Target Pt Rate	Target Patient Rate (Target Pt Rate) sets the upper boundary for the iVAPS intelligent Backup Rate (iBR).
Target Va	Target Alveolar Minute Ventilation (Target Va) sets the servo-ventilation target for iVAPS.
Ti	Inspiration time (Ti) sets the duration of the inspiratory phase of a breath.
Ti Max	Maximum inspiratory time (Ti Max) sets the maximum duration of the inspiratory phase of a breath.
Ti Min	Minimum Inspiratory Time (Ti Min) set the minimum duration of the inspiratory phase of a breath.
Trigger	Sets the trigger threshold above which the ventilator triggers a new breath. The trigger is blocked for the first 300 ms following the start of exhalation.
Trigger type	Trigger type sets whether a pressure based trigger threshold or flow based trigger threshold is used when a Double circuit is selected.
Vt	The Tidal Volume (Vt) sets the volume of gas, measured in mL, to be delivered to the patient in a mandatory controlled volume breath.

Measured and calculated parameter definitions

The following measured and calculated parameters are displayed during configuration or during ventilation. Each Ventilation mode details the parameters displayed.

Parameter	Definition
FiO_2	Average of percentage of Oxygen delivered to circuit.
I:E	I:E is the ratio of the inspiratory period to the expiratory period. The measured I:E ratio is displayed as a monitored parameter during ventilation. The expected I:E ratio is calculated and displayed on the settings screens if the Resp. rate setting is not set to Off.
Leak	Leak is the average unintentional leak. It is reported as a percentage for Double limb circuits and as a flow for Single limb circuits with intentional leak. The measured Leak is displayed as a monitored parameter during ventilation.
MV	Minute Ventilation (MV) is the product of the Target Patient Rate (Target Pt Rate) and expired tidal volume averaged over the last eight breaths. The MV is displayed as a calculated parameter during iVAPS configuration.
MVe	Expiratory Minute Volume (MVe) is the product of the respiratory rate and expired tidal volume averaged over the last eight breaths. The measured MVe is displayed as a monitored parameter during ventilation.
MVi	Inspiratory Minute Volume (MVi) is the product of the respiratory rate and inspired tidal volume averaged over the last eight breaths. The measured MVi is displayed as a monitored parameter during ventilation.
Pressure	Pressure is the current airway pressure of the patient as measured at the patient port. The measured Pressure is displayed as a monitored parameter during ventilation.
PEEP	End expiratory pressure (PEEP) is the airway pressure measured 50 ms prior to the end of the last expiration. The measured PEEP is displayed as a monitored parameter during ventilation.
Pmean	Mean airway pressure of the patient over the last breath.
% Spont cycle	% Spont cycle is the percentage of breaths that are spontaneously cycled over the past 20 breaths.
% Spont trig	% Spont trig is the percentage of breaths that are spontaneously triggered over the last 20 breaths. The measured %Spont Trig is displayed as a monitored parameter during ventilation.
PIF	Peak Inspiratory Flow (PIF) is the maximum flow reached during the last inspiration. The measured PIF is displayed as a monitored parameter during ventilation. The expected PIF is calculated and displayed for volume controlled breaths on the settings screens when the Inspiratory Phase Duration Option is set to Ti.
PIP	Peak Inspiratory Pressure (PIP) is the maximum airway pressure reached during the last inspiration. The measured PIP is displayed as a monitored parameter during ventilation.
Pulse rate	The measured Pulse rate (pulse) is displayed as a monitored parameter when a pulse oximeter is used.

Parameter	Definition
Resp. rate	Respiratory rate (Resp. rate) is the number of breaths per minute averaged over the last eight breaths. The measured Resp. rate is displayed as a monitored parameter during ventilation.
RSBI	Rapid Shallow Breathing Index (RSBI) is calculated by dividing the breath rate by Tidal Volume. The measured RSBI is displayed as a monitored parameter during ventilation.
SpO_2	The measured functional Oxygen Saturation (SpO_2) is displayed as a monitored parameter when a pulse oximeter is used.
Te	Expiratory time Te is the period in seconds of the last expiratory phase.
Ti	Inspiratory time Ti is the period in seconds of the last inspiratory phase. The measured Ti is displayed as a monitored parameter during ventilation. The expected Ti is calculated and displayed for volume controlled breaths on the settings screens when the Inspiratory Phase Duration Option is set to PIF.
Va	Alveolar Minute Ventilation (Va) is calculated by (Tidal Volume - Deadspace) x Resp. Rate. The measured Va is shown as a monitored parameter during ventilation.
Vte	Expiratory Tidal Volume (Vte) is the volume expired during the last breath. The measured Vte is displayed as a monitored parameter during ventilation.
Vti	Inspiratory Tidal Volume (VTi) is the volume inspired during the last breath. The measured VTi is displayed as a monitored parameter during ventilation.
Average Vt	Average Tidal Volume (Average Vt) is the average volume expired during the last five minutes of ventilation. The Average Vt is displayed as a calculation parameter during iVAPS configuration.
Average Vt/kg	Average Tidal Volume per kg (Average Vt/kg) is the Average Vt divided by Ideal Body Weight (IBW). The Average Vt is displayed as a calculation parameter during iVAPS configuration.

Appendix B: Ventilation parameters

The following table provides a summary of the Astral device parameter ranges and the [default settings].

Ventilation Parameters summary table

Parameter	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation				Setting
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS	
Respiratory rate	✓	✓	✓	✓	✓	✓	✓	✓			(A)CV, P(A)CV, P(A)C • Adult: Off, 2 to 50 [15] • Ped: Off, 5 to 80 [15] Mandatory breaths: V-SIMV, P-SIMV • Adult: 2 to 50 [15], • Ped: 5 to 80 [15] PS, (S)T • Adult: Off, 2 to 50 [15] • Ped: Off, 5 to 80 [15]
EPAP (cmH_2O)							✓	✓		✓	2 to 25 [5]
Min EPAP (cmH_2O)										✓	2 to 25 [5] Only when AutoEPAP is turned ON.
Max EPAP (cmH_2O)										✓	2 to 25 [15] Only when AutoEPAP is turned ON.
PEEP (cmH_2O)	✓	✓	✓	✓	✓						Off, 3.0 to 20.0 [5.0]
CPAP (cmH_2O)						✓			✓		3.0 to 20.0 [5.0]
P Control (cmH_2O)		✓		✓							Adult: 2 to 50 [7] Ped: 2 to 50 [7]

Parameter	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation				Setting
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS	
PS (cmH_2O)			✓	✓	✓						PS • Adult: 2 to 50 [7] • Ped: 2 to 50 [7] Spontaneous breaths: V-SIMV, P-SIMV • Adult: 2 to 50 [7] • Ped: 2 to 50 [7]
Min PS (cmH_2O)										✓	0 to 50 [2]
Max PS (cmH_2O)										✓	AutoEPAP Off: 0 to 50 [20] AutoEPAP On: 8 to 50 [20]
IPAP (cmH_2O)							✓	✓			Adult: 4 to 50 [12] Ped: 4 to 50 [12]
Vt (mL)	✓				✓						V-SIMV (mandatory breaths), (A)CV • Adult: 100 to 2,500 [500] • Ped: 50 to 300 [100]*
PIF (L/min)	✓				✓						When Volume Breath option is set to PIF: (A)CV, V-SIMV (mandatory breaths) • Adult: 10 to 120 [50] • Ped: 5 to 60 [10]
Ti (sec)	✓	✓		✓	✓			✓			When Volume Breath option is set to Ti: (A)CV, V-SIMV (mandatory breaths) • Adult: 0.3 to 3.0 [1.0] • Ped: 0.3 to 3.0 [0.6] P(A)CV, P-SIMV (mandatory breaths) • Adult: 0.2 to 5.0 [1.0] • Ped: 0.2 to 5.0 [0.6] P(A)C • Adult: 0.3 to 4.0 [1.0] • Ped: 0.3 to 4.0 [0.6]

Parameter	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation				Setting
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS	
Cycle (%)			✓	✓	✓		✓			✓	P-SIMV, V-SIMV (spontaneous breaths), PS 5 to 90 [25%] (leak) 5 to 90 [Auto] (valve) Cycle is fixed at 15% for valve, 10% for leak.
Trigger type	✓	✓	✓	✓	✓	✓					Flow/Pressure (double limb circuit only)
Trigger (sensitivity) [Trigger type = Flow] (L/min)	✓	✓	✓	✓	✓	✓					When Trigger Type is set to Flow trigger (double limb circuit only) (A)CV, P(A)CV • Adult: Off, 0.5 to 15 [1.0] • Ped: Off, 0.5 to 15 [0.5] V-SIMV, PSIMV, PS, CPAP • Adult:0.5 to 15 [1.0] • Ped:0.5 to 15 [0.5]
Trigger (sensitivity) [Trigger type = Pressure]	✓	✓	✓	✓	✓	✓					When Trigger Type is set to Pressure trigger (double and single limb circuit) (A)CV, P(A)CV Off, Very Low to Very High [Medium] PS, P-SIMV, V-SIMV, CPAP Very Low to Very High [Medium]
Trigger (sensitivity) [Vented]							✓	✓	✓	✓	(S)T, P(A)C Off, Very Low to Very High [Medium] CPAP, iVAPS Very Low to Very High [Medium]
Rise Time (msec)		✓	✓	✓	✓		✓	✓		✓	Min, 150 to 900 [200]
Flow Shape (%)	✓				✓						100 (Constant), 75, 50, 25 [100]

Parameter	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation				Setting
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS	
Ti Min (sec)			✓				✓			✓	PS 0.2 to 4.0 [0.2] (S)T, iVAPS 0.1 to 4.0 [0.2] Ti Min is fixed at: • 0.2 for P-SIMV, V-SIMV, and CPAP (valved) • 0.1 for CPAP (leak)
Ti Max (Maximum Inspiration Time) (sec)			✓				✓			✓	Adult: 0.3 to 4.0 [1.5] Ped: 0.3 to 4.0 [0.8] Ti Max is fixed at: • The lesser of ((2/3) x (60/f)) or 4 for P-SIMV and V-SIMV • 4 for CPAP (leak) • 3 for CPAP (valved) Adult • 1.5 for CPAP (valved) Pediatric
Pt Height							✓	✓	✓	✓	Adult: cm: 110 to 250 [175] inches: 44 to 100 [70]
Target Pt Rate										✓	8 to 30 [15]
Target Va (L/min)										✓	1 to 30 [5.2]

*The International ventilator standard indicates that Pediatric patient type is intended to be used for a patient receiving less than 300 mL, however Astral permits adjustment of 'Vt' setting parameter up to 500 mL for cases where 'Vt' is set such that it compensates for leak in the breathing circuit.

⚠ WARNING

ResMed does not recommend 500 mL as the upper limit for the pediatric tidal volume use; however, clinicians may choose this upper limit based on their clinical determination.

Ventilation displayed parameters

The following therapy parameters are displayed on the device but cannot be changed directly. They are determined by the adjustable parameters and internal algorithms.

Parameters	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation				Setting
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS	
I:E Ratio	✓	✓						✓			Displayed if Respiratory Rate not set to Off
PIF (L/min)	✓				✓						When Volume Breath option is set to Ti, PIF is display only.
Ti (sec)	✓				✓						When Volume Breath option is set to PIF, Ti is display only.
MV (L/min)										✓	Displayed in iVAPS Settings page
Average Vt (mL)										✓	Displayed in iVAPS Settings page
Average Vt/kg (mL/kg (IBW))										✓	Displayed in iVAPS Settings page

Supplementary Features

The following table indicates the supplementary features applicable to each ventilation mode. The adjustable parameters, the available setting range and default are displayed.

Features	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation				Setting
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS	
Manual Breath	✓	✓	✓	✓	✓						Off / On [Off]
Manual Breath Magnitude (%)	✓	✓	✓	✓	✓						100 to 250 [150]

Features	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation				Setting
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS	
Sigh Breath	✓	✓									Off / On [Off]
Sigh Alert	✓	✓									Off / On [Off]
Sigh Interval (min)	✓	✓									3 to 60 [10]
Sigh Magnitude (%)	✓	✓									120 to 250 [150]
Apnea Response (%)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Valve Ventilation: Alarm Only, (A)CV+Alarm, P(A)CV+Alarm, Off Leak Ventilation: Alarm Only, Off
Apnea Interval (Tapnea) (min: sec)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Adult: 15s to 60s [20s]* Ped: 5s to 30s [10s]
Apnea Resp Rate (1/min)	✓	✓	✓	✓	✓	✓					Adult: 4 to 50 [15] Ped: 12 to 80 [15]
Apnea Detection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	No Breath / No Spont Breath [No Breath]
Apnea Ti (sec)	✓	✓	✓	✓	✓	✓					When Volume Breath option is set to Ti: If Apnea Response is (A)CV + Alarm: • Adult: 0.3 to 3 [1.0] • Ped: 0.3 to 3 [0.6] If Apnea Response is P(A)CV + Alarm: • Adult: 0.2 to 5.0 [1.0] • Ped: 0.2 to 5.0 [0.6]

Features	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation				Setting
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS	
Apnea Vt (mL)	✓	✓	✓	✓	✓	✓					If Apnea Response is (A)CV + Alarm: Adult: 100 to 2500 [500] Ped: 50 to 500 [100]
Apnea Flow Shape (%)	✓	✓	✓	✓	✓	✓					Constant
Apnea PIF (L/min)	✓	✓	✓	✓	✓	✓					When the Volume Breath is set to PIF. If Apnea Response is (A)CV + Alarm: • Adult: 10 to 120 [50] • Ped: 5 to 60 [10]
Apnea P Control (cm H_2O)	✓	✓	✓	✓	✓	✓					If Apnea Response is P(A)CV + Alarm: • Adult: 2 to 50 [7] • Ped: 2 to 50 [7]
Safety Vt (mL)		✓	✓				✓	✓			Adult: Off, 100 to 2500 [Off] Ped: Off, 50 to 500 [Off]
Max PS			✓								PS setting to 50 [PS +5]
P control max (cm H_2O)		✓									P control to 50 [P control +5]
IPAP Max							✓	✓			IPAP to 50 [IPAP +5]

*Adult Tapnea can be extended to 15min when the mouthpiece interface is selected.

Supplementary Features displayed parameters

The following therapy parameters are displayed on the device but cannot be changed directly. They are determined by the adjustable parameters and internal algorithms.

Parameter	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation			
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS
Manual Breath Ti (sec)	✓	✓	✓	✓	✓					
Manual Breath PIF (L/min)	✓				✓					
Manual Breath Vt (mL)	✓				✓					
Manual Breath P Control (cmH_2O)		✓		✓						
Manual Breath PS (cmH_2O)			✓							
Sigh Ti (sec)	✓	✓								
Sigh PIF (L/min)	✓	✓								
Sigh Vt (mL)	✓									
Sigh P Control		✓								
Apnea I:E	✓	✓	✓	✓	✓	✓				
Apnea Flow Shape (%) Flow shape = Constant	✓	✓	✓	✓	✓	✓				

Parameter	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation			
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS
Apnea PIF Display (L/min)	✓	✓	✓	✓	✓	✓				
Apnea Ti Display (Inspiration Time)	✓	✓	✓	✓	✓	✓				
Apnea Rise Time (msec)	✓	✓	✓	✓	✓	✓				

Appendix C: Alarm parameters

The following table provides a summary of the Astral device alarm settings and the default settings.

Alarm	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation				Setting
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS	
Vti - Low (Tidal Volume) (mL)	✓	✓	✓	✓	✓	✓					Adult: Off, 50 to 2990 [100] Ped: Off, 10 to 995 [25]
Vti - High (Tidal Volume) (mL)	✓	✓	✓	✓	✓	✓					Adult: Off, 60 to 3000 [2500] Ped: Off, 25 to 1000 [500]
Vte - Low (Tidal Volume) (mL)	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓	✓	✓	Adult: Off, 50 to 2990 [100] Ped: Off, 10 to 995 [25]
Vte - High (Tidal Volume) (mL)	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓	✓	✓	Adult: Off, 60 to 3000 [2500] Ped: Off, 25 to 1000 [500]
MVi - Low (Minute ventilation) (L/min)	✓	✓	✓	✓	✓	✓					Adult: Off, 0.5 to 59.9 [3.0] Ped: Off, 0.2 to 59.9 [0.5]
MVi- High (Minute ventilation) (L/min)	✓	✓	✓	✓	✓	✓					Adult: Off, 0.6 to 60 [20.0] Ped: Off, 0.3 to 60 [10.0]
MVe - Low (Minute ventilation (L/min)	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓	✓	✓	Adult: Off, 0.5 to 59.9 [3.0] Ped: Off, 0.2 to 59.9 [0.5]
MVe- High (Minute ventilation) (L/min)	✓*	✓*	✓*	✓*	✓*	✓*	✓	✓	✓	✓	Adult: Off, 0.6 to 60 [20.0] Ped: Off, 0.3 to 60 [10.0]
Low Resp rate (1/min)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Adult: Off, 2 to 79 [4] Ped: Off, 5 to 98 [12]
High Resp rate (1/min)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Adult: Off, 3 to 80 [80] Ped: Off, 6 to 99 [99]
Pressure - High (High Airway Pressure) (cmH_2O)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10 to 80* [40] *Not applicable on all device variants

Alarm	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation				Setting
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS	
Pressure - Low (Peak Inspiratory Pressure) (cmH_2O)	✓				✓						Off, 2 to 79 [5]
Pressure - Low (Peak Inspiratory Pressure) (cmH_2O)		✓	✓	✓		✓	✓	✓	✓	✓	Off / On [On]
Disconnection (L/min)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Off# / On [On] #only allowed with a mouthpiece interface or mask interface in single vented circuit
Disconnection tolerance (%)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Invasive/mouthpiece: 5 to 95 [40] Mask: 5 to 95 [60]
Disconnection alarm activation time (sec)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Invasive and Mask: Adult: 5 to 60 [9] Ped: 5 to 30 [8] Mouthpiece: Adult: 5 to 900 [15] Ped: 5 to 30 [13]
Low PEEP	✓**	✓**	✓**	✓	✓	✓	✓	✓	✓	✓	Off / On [On]
Vent Stopped	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Off / On [Off]
Leak (%)	✓*	✓*	✓*	✓*	✓*	✓*					Off, 20 to 80 [Off]
Leak (L/min)							✓	✓	✓	✓	Off / 5 to 80 [40]
NV mask/Rebreathing	✓	✓	✓				✓	✓	✓	✓	Off / On [On]

Alarm	Valve Ventilation and Mouthpiece Circuit						Leak Ventilation				Setting
	ACV	P(A)CV	PS	P-SIMV	V-SIMV	CPAP	(S)T	P(A)C	CPAP	iVAPS	
FiO_2 - Low (%)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Off, 18 to 99 [Off]
FiO_2 - High (%)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Off, 19 to 100 [Off]
SpO_2 - Low (%)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Off, 50 to 99 [85]
SpO_2 - High (%)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Off, 51 to 100 [Off]
Pulse - Low (1/min)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Off, 20 to 249 [30]
Pulse - High (1/min)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Off, 21 to 250 [150]

* For Double limb circuits only.
** Not applicable for Mouthpiece circuit.

Note: Some default settings are different for Mouthpiece circuit.

MANUFACTURER **ResMed Ltd**
1 Elizabeth Macarthur Drive, Bella Vista NSW 2153 Australia

See ResMed.com for other ResMed locations worldwide. Astral, AirView and ResScan are trademarks and/or registered trademarks of the ResMed family of companies. For patent and other intellectual property information, see ResMed.com/ip. Actichlor is a trademark of Ecolab US. Inc. Aerogen and Aeroneb are registered trademarks of Aerogen, Inc. CaviCide is a trademark of Metrex. Mikrozid is a trademark of Schülke & Mayr. NONIN is a trademark of Nonin Medical, Inc. Velcro is a trademark of Velcro Industries B.V.
© 2018 ResMed Ltd. 278563/1 2018-05

ResMed.com