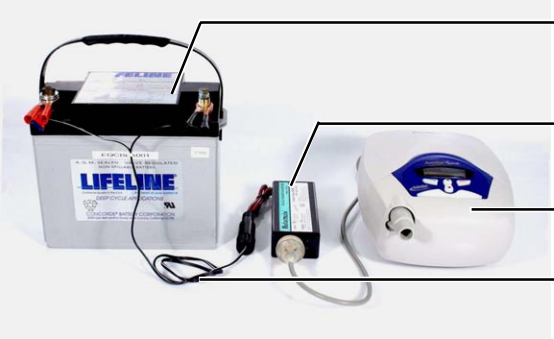
RESMED TECHNICAL SERVICES

Tech Note: Powering ResMed products with batteries

August 2005

Many people choose to use CPAP devices running on battery power in situations where mains power is not available, such as on camping holidays, or in boats and motorhomes. Some people use battery power in remote areas where mains power may not be supplied, or as a backup in areas prone to power failure. This Tech Note will help you understand the requirements for running a flow generator or humidifier from battery power.



Battery
- lead-acid battery such as a deep cycle or marine battery
- typically 12 or 24 volts DC power

Inverter
- converts battery power into mains power
- typically either 110V or 240V AC

Flow generator

Cable adapter
- connects inverter directly to battery
- optional but recommended to reduce power loss

Most common set of equipment:

Does the following describe your situation?
You wish to run a ResMed CPAP unit from a battery, and

- the CPAP was manufactured in the year 2000 or later (it has a serial number beginning with 2000 or higher)
- you do NOT intend to use a humidifer while running on battery power, and
- you intend to use the battery for a single night before recharging it.

Then the following set of equipment will be suitable:

- ResMed flow generator such as S6, S7, S8, AutoSet T or AutoSet Spirit (but no humidifier)
- a modified sine wave inverter with continuous power rating of 150 watts or higher (available at electronics stores)
- a marine battery or deep-cycle battery rated at 50 amp-hours or higher (ask a battery supplier for help choosing one)

Other situations:

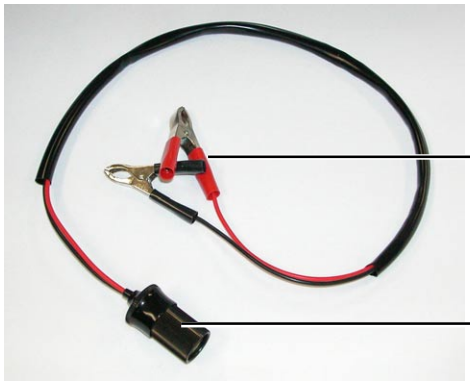
If you have different requirements (such as needing to run a HumidAire 2i or HumidAire 3i humidifier, using a converter, running a VPAP, or needing to use battery power for longer than one night before recharging), then please read this whole document to ensure that you choose the best set of equipment for your needs.

Connecting a converter/ inverter to a battery

Most converters and inverters come with a car cigarette lighter plug fitted to provide a connection to the car battery. They can be connected to an auxiliary battery via the cigarette lighter outlet of a car or 4WD vehicle.

If you need to connect directly to the battery terminals (such as if you carry the battery away from the vehicle), you will need an adapter cable. Refer to the photograph below.

This cable provides a more energy-efficient connection than using the car cigarette lighter socket, because it by-passes the car electrical system.



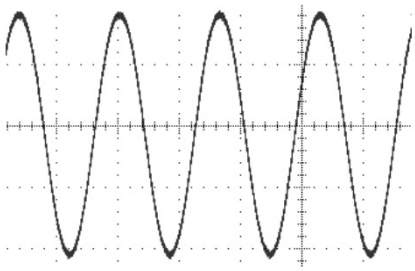
Warning Do not attempt to start the vehicle engine while using the CPAP/VPAP unit powered from the vehicle battery as dangerous voltage spikes are produced that can damage the unit.

Further information about inverters

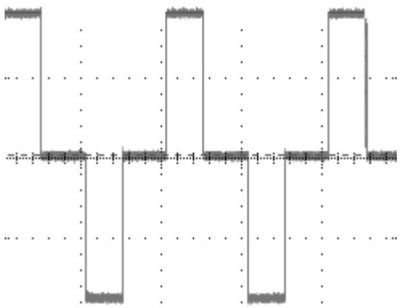
Types of inverters

There are several different types of inverters available. The most common types are pure sine wave or modified sine wave. A pure sine wave inverter produces an output waveform that is the same as a domestic power outlet. They are more difficult to manufacture and are the most expensive type. The outputs of the two different types look like this:

Pure sine wave



Modified sine wave



Power ratings

In addition to the output waveform, inverters also carry a power rating. This indicates the amount of power the inverter is capable of delivering. Most inverters will have a continuous rating and a surge or peak rating. The continuous rating indicates the power level it is capable of delivering under sustained use without overload. The surge or peak rating refers to a level that can be delivered for short periods. How long the inverter is capable of delivering its surge rated power output for will vary from one manufacturer to another.

Requirements for ResMed flow generators

Late model flow generators

For flow generators manufactured in 2000 or later, there is no special requirement with regard to inverter type. Any modified sine wave inverter with a power rating of 150 watts or more is suitable.

Note: *VPAP II units require an inverter rated at 200 watts. Refer to the table below.*

Early model flow generators

For flow generators manufactured in 1999 or earlier, we recommend the use of a Powerbox PS-200-2 inverter. This model is also branded as Motormate PS-200-2.

Requirements for ResMed humidifiers

For use with the HumidAire™ 2i or HumidAire™ 3i, a pure sine wave inverter with a continuous power rating of 200 watts is suitable - refer to the table below.

Warning Other ResMed heated humidifiers must not be used with inverters. Damage to the unit or serious injury to the user may result. If you are using another brand of heated humidifier, check with the manufacturer for their recommendation.

The following table is a guide to the correct type of inverter. Power ratings quoted are continuous ratings:

Product	Inverter type
SULLIVAN® III, SULLIVAN V	Powerbox PS-200-2
S6™, S7™, AutoSet™ T, AutoSet™ Spirit, VPAP™ III Series	Modified sine wave 150 watt
S7, AutoSet Spirit, VPAP III + HumidAire™ 2i humidifier	Pure sine wave 200 watt
S8™ Escape, S8 AutoSet	Modified sine wave 150 watt
S8™ Escape, S8 AutoSet + HumidAire™ 3i humidifier	Pure sine wave 200 watt
HumidAire heated humidifier	**Must not be used with inverters !**
VPAP II LCD series	Modified sine wave 200 watt

Warning It is also recommended that the inverter is certified by an accredited testing and certification organisation, such as VDE, TUV or BSI in addition to CE markings for EU countries or UL markings for the USA. Please contact your local ResMed office for more information.

Batteries for CPAP and VPAP use

The most common application for using battery power for CPAPs is on camping, caravan, motorhome or boating holidays. Your vehicle or vessel should be fitted with an auxiliary battery for powering the CPAP or other accessories, and an electronic or manual isolator for the main battery. This will enable both batteries to be recharged while the motor is running, yet will not drain the main battery while the CPAP is in use. It will also ensure that the main battery used for engine starting is not completely discharged. Consult your auto or marine electrician for installation of a dual-battery system.
Ideally you would use a genuine deep-cycle battery and if your budget allows, this is the best option. For most circumstances, however, a marine battery is quite adequate and represents a good compromise between deep-cycle capability and cost effectiveness.

Calculating battery size

The size of battery required will vary with each application, depending on the treatment pressure and the length of time used before recharge. The following tables may be used as a guide to determining the required battery size:

CPAP and auto CPAP powered with inverter

Product	Treatment pressure* (cm H_2O)	Current draw at 12 V DC (amps)	Battery size for 8 hours use (amp-hours) (includes 50% Safety Margin)
SULLIVAN III, SULLIVAN V	6	2.31	28
	8	2.69	32
	10	3.05	37
	12	3.51	42
	16	4.44	53
	20	5.22	63
S6 CPAP, S7 CPAP	6	1.24	15
	8	1.42	17
	10	1.52	18
	12	1.65	20
	16	1.95	23
	20	2.22	27
AutoSet T, AutoSet Spirit	6	1.39	16
	8	1.48	18
	10	1.61	19
	12	1.69	20
	16	1.96	23
	20	2.28	27
AutoSet Spirit + HumidAire 2i, S7 + HumidAire 2i	6	3.56	43
	8	3.68	44
	10	3.80	46
	12	3.93	47
	16	4.25	51
	20	4.52	54

** As treatment pressure varies widely with automatic devices, 95th percentile pressure is used for AutoSet Spirit and AutoSet T calculations*

CPAP and auto CPAP powered with inverter (continued)

Product	Treatment pressure* (cm H_2O)	Current draw at 12 V DC (amps)	Battery size for 8 hours use (amp-hours) (includes 50% Safety Margin)
S8 Escape	6	1.02	12
	8	1.12	13
	10	1.24	15
	12	1.36	16
	16	1.62	19
	20	1.90	23
S8 Escape + HumidAire 3i	6	3.75	45
	8	3.84	46
	10	3.96	48
	12	4.09	49
	16	4.34	52
	20	4.63	56
S8 AutoSet Vantage	6	1.13	14
	8	1.27	15
	10	1.40	17
	12	1.52	18
	16	1.81	22
	20	2.12	25
S8 AutoSet Vantage + HumidAire 3i	6	3.86	46
	8	4.00	48
	10	4.12	50
	12	4.25	51
	16	4.54	54
	20	4.85	58

* *As treatment pressure varies widely with automatic devices, 95th percentile pressure is used for S8 AutoSet Vantage calculations*

Using a converter to power your CPAP

Several S8 CPAP devices have a 12 volt DC power input which enable them to run from a 12 volt or 24 volt battery using a ResMed converter, P/N 33942.

- This converter is more efficient than an inverter.
- The converter provides electrical protection to the CPAP device in the event that the adapter leads are connected incorrectly to the battery.
- The converter provides regulation of the battery voltage: a fully charged battery has a terminal voltage of 13.5 volts and will reduce as the battery is discharged.
- The converter will shutdown automatically when the voltage drops below 10.5 volts for a 12 volt battery, or 21 volts for a 24 volt battery. This will protect the battery from damage due to being allowed to fully discharge.
- The converter provides electrical isolation to the CPAP device.

CPAP and auto CPAP powered with converter

Product	Treatment pressure* (cm H_2O)	Current draw at 12 V DC (amps)	Battery size for 8 hours use (amp-hours)
S8 Escape	6	0.80	10
	8	0.90	11
	10	1.02	12
	12	1.12	13
	16	1.37	16
	20	1.66	20
S8 AutoSet Vantage	6	0.90	11
	8	0.98	12
	10	1.09	13
	12	1.21	14
	16	1.46	18
	20	1.73	21

** As treatment pressure varies widely with automatic devices, 95th percentile pressure is used for S8 AutoSet Vantage calculations*

VPAP powered with inverter

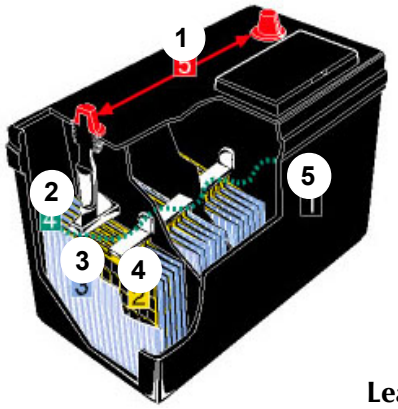
Product	IPAP pressure (cm H_2O)	Current draw at 12 V DC (amps)	Battery size for 8 hours use (amp-hours) (includes 50% Safety Margin)
VPAP II LCD	5	1.40	17
	10	1.64	20
	15	1.90	23
	20	2.18	26
	25	2.49	30
VPAP III and VPAP III ST	5	1.19	15
	10	1.42	17
	15	1.67	20
	20	1.93	23
	25	2.21	27
VPAP III and VPAP III ST + HumidAire 2i	5	3.57	43
	10	3.81	46
	15	4.06	49
	20	4.32	52
	25	4.59	55
VPAP III ST-A	5	1.65	20
	10	1.86	22
	15	2.11	25
	20	2.41	29
	25	2.76	33
	30	3.15	38
VPAP III ST-A + HumidAire 2i	5	4.04	48
	10	4.25	51
	15	4.49	54
	20	4.79	58
	25	5.15	62
	30	5.54	66

***Note**: The values in the table are based on a respiratory rate of 15 breaths per minute for the VPAP II models and 20 breaths per minute for the VPAP III models . Power consumption (and recommended battery capacity) will increase with higher respiratory rates.*

Further information about batteries

Battery basics

The kind of batteries typically used to run CPAPs are rechargeable lead-acid batteries. They work on a simple principle: two dissimilar metals are immersed in an electrolyte and this produces a flow of electrical current between the two metals. This is a flooded lead-acid battery. Modern rechargeable batteries usually have 6 banks of plates or cells producing 2.11 volts per cell, for a terminal voltage of 12.66 volts.



1. Terminals
2. Plates
3. Electrolyte
4. Cell wall
5. Outer case

Lead-acid battery construction

Types of batteries

Not all batteries are created equal. They are manufactured differently for different purposes.

Automotive batteries

Modern car batteries are designed to supply a surge of high current to crank the engine of a car. This is achieved by manufacturing the battery with a large number of thin plates to maximise the surface area of the plates. The plates are composed of a lead "sponge", similar in appearance to a very fine foam sponge. If subjected to deep discharge, this sponge will quickly be consumed and fall to the bottom of the cells. Automotive batteries should never be discharged by more than about 30% before recharge. A car battery will only last about 30 deep cycles, while they may last for thousands of cycles in normal starting use (2-5% discharge).

Automotive batteries are rated in Cold Cranking Amps (CCA). This is the amount of current that the battery is able to supply for 30 seconds at -20°C while maintaining a terminal voltage of a 7.2 volts or more.

Deep-cycle batteries

The major difference between a true deep cycle battery and other types of batteries is that the plates are solid lead. They are manufactured with much thicker plates in each cell and can be discharged as much as 80% or more.

Deep-cycle batteries are rated in amp-hours (AH): this means the current that can be drawn from the battery for a specified time, for example, a battery rated at 50 AH is able to supply 1 amp for 50 hours, or 2 amps for 25 hours and so on. This only works up to a point, as there are constraints on the maximum performance.

***Note**: There is no direct correlation between CCA and AH - one can not be calculated from the other*

Marine batteries

Marine batteries are manufactured with thick plates in their cells to facilitate deeper discharges and are also rated in amp-hours. Most marine batteries are not true deep-cycle, but a type of hybrid. Most marine batteries may be safely discharged up to 60% before recharging.

Caution Check with the battery manufacturer for recommendations of discharge rate. The information supplied should be used as a guide only.

Other types of batteries

AGM, or Absorbed Glass Mat

A newer type of sealed battery uses Absorbed Glass Mats, or AGM between the plates. This is a very fine fibre boron-silicate glass mat. These batteries have all the advantages of gelled batteries (see below), but can take much more severe use. The plates in AGM batteries are tightly packed and rigidly mounted, and will withstand shock and vibration much better than any conventional battery.
AGM batteries have several advantages over both gelled and flooded batteries, at about the same cost as gelled batteries:

- Since all the electrolyte is contained in the glass mats, they cannot spill, even if broken. This also means that since they are non-hazardous, the shipping costs are lower. In addition, since there is no liquid to freeze and expand, they are practically immune to freezing damage.
- The charging voltages are the same as for any standard battery - there is no need for any special adjustments or problems with incompatible chargers.
- AGM batteries have a very low self-discharge - from 1% to 3% per month is typical. This means that they can sit in storage for much longer periods without charging.

Gelled electrolyte

Gelled batteries, or gel cells contain acid that has been "gelled" by the addition of silica gel, turning the acid into a solid mass that looks like thick jelly. The advantage of these batteries is that it is impossible to spill acid even if the battery is broken.
A disadvantage of gel cells is that they must be charged at a lower voltage than flooded or AGM batteries. If overcharged, voids can develop in the gel which will never heal, causing a loss in battery capacity. In hot climates, water loss can be enough over 2-4 years to cause premature battery death.

Battery maintenance

Lead-acid batteries are perishable. During the discharge process, soft lead sulphate crystals are formed in the pores and on the surfaces of the positive and negative plates inside the battery. This creation of hard crystals is commonly called lead sulphation and it accounts for over 80% of deep-cycle battery failures. The longer sulphation occurs, the larger and harder the lead sulphate crystals become. The positive plates will be light brown and the negative plates will be a dull, off-white colour. These crystals lessen a battery's capacity and its ability to be recharged. Recharge as soon after discharge as possible, and if the battery is to be stored for more than two weeks, top up the charge frequently. This is the best way to prevent sulphation.

1. Add a battery conditioner in accordance with the manufacturer's instructions. This is a chemical additive which prolongs battery life.
2. Check electrolyte levels regularly and top up only with demineralised water as required.
3. Buy a hydrometer and check the specific gravity of the electrolyte in each cell of the battery. This will detect damaged or collapsed cells before they leave you stranded with a useless battery.

Storing a battery

1. If the battery has filler caps, check the electrolyte level in each cell. If required, add only demineralised water to the recommended level, but do not overfill.
2. Clean the top of the battery and the terminal posts.
3. Fully charge the battery.
4. Store it in a dry, cool place (above freezing), where it can be easily recharged.
5. Most importantly, prevent sulphation by keeping the battery charged at 100% state-of-charge level by frequent recharging. Once every two weeks is recommended.

Caution Always check with the battery manufacturer for charging instructions. Damage to the cells or reduction in service life may result from incorrect charging.

Further information

For more information about the use of inverters with ResMed products, contact your local ResMed office.

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