S.E.A. battery analyser BC4

User Instructions

100459-02 A

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DESCRIPTION OF THE BC4

The BC4 single battery analyser makes it possible not only to recharge batteries used in the SE4 family of respirators, but also to ascertain the current status of the battery, as well as maintaining the battery in peak condition over long periods of time. Essentially, a battery can be placed in the BC4 and left there until the time comes to use it. However, the BC4 can also provide additional information about the 'health' of the battery, so the user can determine the battery's ability to power the respirator.

Main components
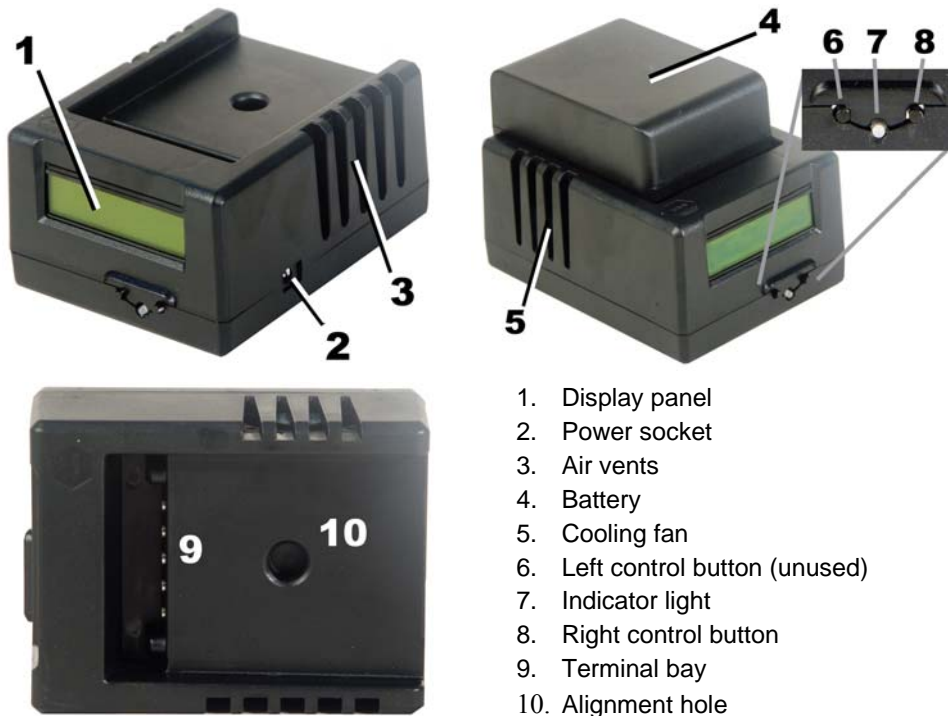
1. Display panel
2. Power socket
3. Air vents
4. Battery
5. Cooling fan
6. Left control button (unused)
7. Indicator light
8. Right control button
9. Terminal bay
10. Alignment hole

BASIC FUNCTIONS

The basic sequence of events in a BC4 that is connected to the electricity supply is as follows:

1. When a battery is inserted in the analyser, the current status of the battery (the internal resistance) is determined. This initial test takes 1–2 minutes, and assesses the general 'health' of the cells. The result is displayed for approximately 1 minute. The BC4 can thus be used as a battery tester, and the battery can be removed at this stage if testing is the only purpose. *NOTE: Do not try to test a fully discharged battery. A completely empty battery will fail.*

2. If the resistance is so poor that the battery fails the initial test, a warning beep will sound and the battery will not be further analysed, conditioned or recharged.

3. If the battery passes the initial test, BC4 checks the temperature of the battery and, if the cell temperature is not within the recommended range, waits for the battery to either cool down or warm up to optimum charging temperature.

4. The BC4 determines the battery's charging status and prepares the battery for the charging cycle accordingly.

5. A conditioning cycle follows, during which the BC4 performs a controlled charge, then a full discharge, and then charges the battery to its maximum capacity.

6. During the discharging and charging process, which can take several hours, the unit can calculate the battery capacity.

7. At the end of the process, the unit will display essential parameters of the charged battery, such as the capacitance and the resistance. The display will show that the battery is 'ready', and a counter will tell (in days and hours) how long the battery has been in the 'ready' state.

8. If the battery is left in the charger for long time periods, the BC4 will perform a monthly discharge-recharge cycle in order to keep the battery in peak condition.

Warnings	Use only with S.E.A.-approved batteries, power supplies and other parts.
	If the battery fails the initial test, it should be replaced. Trying to perform a full recharging cycle on a faulty battery could result in equipment damage. Using a bad battery to power the respirator could result in very short operation times or unexpected shutdowns.
	Never block the air vents or obstruct the fan.

Using the BC4

1. Ensure that the contact points on both the battery and the BC4 are clean.
2. Connect the BC4 to an electric wall socket through the power supply adapter (model PS1). Confirm that the BC4 is powered up by reading the display.
3. Place a battery in the BC4 and press down firmly
4. Watch the display until the display confirms that the battery is fitted. It is preferable to watch the display for approximately one minute until the initial resistance test is completed and the BC4 starts the charging cycle.
5. Use the BC4 at a constant ambient temperature. The ideal ambient temperature is around +21°C (70°F). Insert the battery into the BC4 after the battery has reached the ambient temperature. If the temperature varies during the charging cycle, the measurement accuracy can be reduced.
6. Try to avoid charging a warm battery. Charging the battery at a temperature below +25°C (77°F) gives better results. The battery will not start charging until the temperature in the cells sinks below +32°C (87°F).

GENERAL CONCEPTS

Automatic battery test

The BC4 relies on three basic factors in determining the condition of the battery:

- **Internal temperature:** the battery cells heat up when the battery is in use. Recharging or discharging a battery that is too hot may result in damage to the battery or to the BC4. Hot cells may also prevent the battery from being recharged to full capacity. For this reason, the BC4 waits until a hot battery cools down to the optimum recharging temperature, which ranges from +5°C to +32°C (+40°F to +87°F).
- **Charging resistance:** the internal battery resistance measured between the poles of the battery, expressed in mΩ (milliohm) by applying a charging current. This resistance should be as low as possible. A battery with a charging resistance of 600 mΩ is considered to be in fair condition; a resistance above 1000 mΩ will fail the test and the battery is considered unusable.
- **Discharging resistance:** the resistance measured when applying an electric load to the battery. A discharge resistance below 800 mΩ will pass the test. If the discharge resistance is higher than this, the battery will not adequately power the respirator, and will fail the test.

Routines performed by the BC4

The BC4 battery analyser subjects the battery to the following major operations:

- **Pre-charging:** The BC4 determines the condition of the battery. If the battery performance is very poor, the BC4 attempts to recover the battery for approximately 1 hour.
- **Fast charging:** this 'pumps' energy to the battery cells at the highest possible rate. To fast charge a fully discharged battery usually takes approximately 2 hours.
- **Trickle charging:** Trickle charging means that the battery is 'topped up' at a very low rate in order to pump as much energy as possible into the cells. This is applied at the end of the fast-charge operation, or to an almost-full battery. The trickle charging completes the entire recharging process. The process takes 20 min to 4 hours depending on the condition of the battery.
- **Results display:** When the battery is ready to be used, the display shows the duration of the last recharge, and the parameters of the battery's condition.
- **Discharging:** this operation drains the battery completely. This prepares the battery for a more efficient recharging process.

Long-term routines performed by the BC4

If the battery is left in the analyser, and the analyser is kept connected to the power supply, the BC4 will perform the following operations every 30 days:

- Discharge the battery completely.
- Fast charge the battery.
- Apply trickle charge until the battery is 100% full.
- Repeat the above sequence up to 5 times, depending on user preferences. The user may change the number of repeats at any time. The default is once. The unit resets itself to the default every time a battery is inserted.
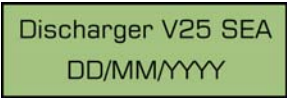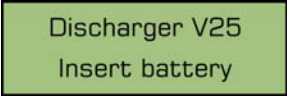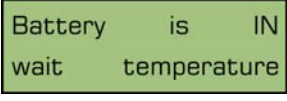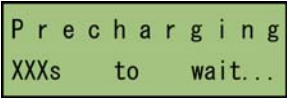
Reconditioning

The discharging/recharging cycle may be repeated sequentially up to 5 times, depending on user preferences. This repeated procedure may be required to 'refresh' a battery that has not

been used for a long time. After this set of repeated cycles, the unit will reset itself to the default of 1 cycle, and the next 30-day reconditioning will comprise a single discharge/charge cycle.

READING THE DISPLAY

The BC4 gives a lot of information about its own operations and procedures, and about the condition of any battery inserted in the unit. The display comprises two parts: a single LED light and a two-line LCD text display.

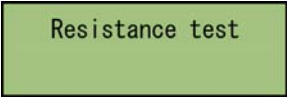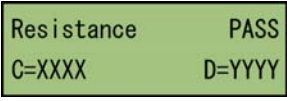| LED	Text display	Description	Action to take
Off		The BC4 is not connected to the power supply, and no battery is inserted.	Connect the BC4 to the power supply.
Rapid flashing RED/GREEN, 5 secs	Discharger V25 SEA DD/MM/YYYY	BC4 has been connected to power supply, system is being stabilised. The software version is displayed.	Wait a few seconds.
Off	Discharger V25 Insert battery	No battery has been inserted.	Insert battery.
Flashing ORANGE	Battery is IN wait temperature	A battery has been inserted. Waiting for the battery temperature to normalise. (If the battery already is of a suitable temperature, this stage will be very brief.)	Wait for normal temperature.
Flashing RED/ORANGE	Precharging XXXs to wait...	The BC4 checks if the battery is OK for fast charging. (If the battery is good, this stage will be very brief.) If the battery is not OK for fast charging, the BC4 will try to recover the battery for 1 hour. (X = number of seconds.)	Wait max 1 hour.
Flashing RED	Precharging... ERR=21 Reason=06	Recovery failed.	Replace battery.
Slow flashing RED/GREEN	Resistance test	The battery's charging and discharging resistances are measured (takes 2 minutes approx.)	Wait.
Flashing GREEN	Resistance PASS C=XXXX D=YYYY	The battery resistance is good. This message is displayed for about 1 minute. (XXXX = charging resistance in mΩ; YYYY = discharging resistance in mΩ.)	Remove battery if you only wished to perform a resistance test, otherwise wait for the cycle to continue.

Flashing RED (no beep)	`Resistance    FAIL` `C=XXXX        D=YYYY`	The battery resistance is marginal. This message is displayed for about 1 minute. (XXXX = charging resistance in mΩ; YYYY = discharging resistance in mΩ.)	Wait.
Flashing RED + beep	`Resistance    FAIL` `C=XXXX        D=YYYY`	Battery is bad. This message is displayed until the battery is removed.	Replace battery.
Steady ORANGE	`Charging   Xh    YYm` `Pumped        NNNNmAh`	Battery is charging normally (may take from 10 minutes up to 4 hours). (X and Y = how many hours and minutes the battery has been charging; NNNN=how much energy has been pumped into the cells.)	Wait.
Slow flashing ORANGE/GREEN	`Disch  Xh   YYm   ZZs` `Drained       NNNNmAh`	The BC4 is discharging the battery. (This normally takes 3–4 hours.) (X, Y and Z = how long the discharge has taken.)	Wait.
Flashing RED + beep	`ERR=AA        Reason=BB`	The BC4 has detected a fault. (AA = type of problem; BB = engineering information.)	Refer to list of error codes in this document; contact S.E.A. for further advice.
Slow flashing GREEN	`Post-trickling...` `P   NNNNmAh    MMMMMs`	Battery is trickle-charging normally (may take from 10 minutes up to 5 hours). (NNNN = how much energy has been pumped into the cells; MMMMM = number of seconds remaining to wait.)	The battery is at least 90% charged and may be used immediately. Or wait for it to be 100% charged.
Steady GREEN	`Ready     Nd     Mh` `D=XXXXmAh   R=YYY`	Battery has been tested, recharged, and is ready to use. (N and M = number of days and hours the battery has been left in the BC4 after it was fully charged; XXXX = discharging capacitance; YYY = discharging resistance.)	Use the battery as normal.
[various]	`Condit    cycles    N`	RIGHT control button has been pressed. Repeated pressing will toggle N from 0 to 5, then start on 0 again. The default is 1. The displayed number is locked in and the display returns to normal if the button is not pressed for a few seconds. (N = number of times the BC4 should recondition or 'train' a battery.)	Keep pressing the RIGHT control button until the desired number of reconditioning cycles is displayed. (See 'CONTROL BUTTONS' below.)

CONTROL BUTTONS

LEFT control button: the function of this button is reserved for future use, and can be customised through software control. The default is 'no action'.

RIGHT control button: by pressing this button repeatedly, the number of automatic discharge/charge cycles can be toggled between 0 and 5. The default is 1. More cycles could result in improved battery performance, but may also decrease the number of times the battery can be recharged. If '0' is selected, no discharging will occur, and the battery will be charged once only. Skipping the discharge cycle means that the BC4 cannot measure the battery capacity, which will be displayed as nil.

BC4-C WITH SERIAL PORT (optional model)

The optional BC4-C model has a serial communication port and can be connected to a personal computer. A customized software program can be supplied with the BC4-C. This program can be used, for example, to plot graphs of the charging/discharging cycles of batteries, or to control many of the parameters of the operation of the BC4-C.

UPGRADABLE FIRMWARE

The BC4 features firmware that can be reprogrammed with operational improvements and new functions as they become available in future. Please contact S.E.A. for more information.

POWER INTERRUPTION

If the power supply to the BC4 is interrupted for any reason, the unit will respond differently depending on the current operation being performed:

If a fully charged battery is fitted and the 'READY' display is showing at the time of the power cut, the unit will display 'Power fail!!!' and beep. When the power is restored, the unit will return to its normal state and continue to show the previous information.

If the power cut occurs during any other operation (charging, discharging, conditioning etc.), the unit will reset. When the power supply is restored, the battery will be treated as if it has just been inserted into the unit. The battery may have to be re-inserted into the unit.

WARRANTY

The BC4 and BC4-C are supplied with a comprehensive 12-month warranty, covering the unit for manufacturing faults (not including wear and tear). Some exclusions apply. Contact S.E.A. for details.

ERROR CODES

If a problem occurs during the discharging/charging cycle, an error message will be displayed on the LCD screen, reading ERR=XX Reason=YY, where XX is an error code indicating the type of error, and YY gives further information to an electronic engineer. The following is a list of types of problems:

ERR=	Type of problem
21	Pre-trickle charging can't restore voltage above 0.8 V/cell. (Probably bad battery. Repeat with good battery. If everything is OK, replace the bad battery)
22	This error code is not used
23	Battery temperature exceeds +60°C (140°F) during charging. (Could be due to a fault in the BC4 or that the battery cells have developed an open or short circuit. Repeat with another battery. If problem persists, replace the BC4. If problem goes away, replace the battery)
24	Temperature sensor error detected during charging. (Could be due to a fault in the BC4 or that the battery cells have developed an open or short circuit. Repeat with another battery. If problem persists, replace the BC4. If problem goes away, replace the battery)
25	Battery is charging more than max time. (Could be due to a fault in the BC4 or that the battery cells have developed an open or short circuit. Repeat with another battery. If problem persists, replace the BC4. If problem goes away, replace the battery)
26	Negative temperature slope is detected during the charging. (Could be due to a fault in the BC4 or that the battery cells have developed an open or short circuit, or that the ambient temperature changed during charging. Repeat last action at a constant ambient temperature and with the internal battery temperature the same as the ambient temperature. If everything is OK, the failure was probably due to rapid changes in the ambient temperature. If fault persists, repeat with another battery. If problem still persists, replace the BC4. If problem goes away, replace the old battery)
27	High current is detected. (Could be a fault in the BC4 or that the battery cells have developed an open or short circuit. Repeat with another battery. If problem persists, replace the BC4. If problem goes away, replace the old battery)
28	Battery is removed during discharging (not implemented)
29	The BC4 jumps to an unexpected stage for an unknown reason. Carefully record the sequence of events (including any messages on the LCD display). Also record any information about the battery before and after the event, and contact S.E.A..
2A	The battery has very high internal resistance. (Likely bad battery. Replace it)
2B	A power failure occurs during the cycle, and the conditioning can not be resumed. (Remove and re-insert battery into the BC4. The entire charging cycle will be repeated)
2C	The battery has developed a high internal resistance during the charging cycle. (Likely bad battery. Replace it)

TECHNICAL SPECIFICATIONS

Supplied AC power	100–240 V, 50–60 Hz
DC power (charging mode, max)	21 V, 2.5 A
Charging current (A)	2
Post-trickle charging current (A)	0.2
Pre-trickle recovery current (A)	0.75
Max critical battery temperature (C)	+62
Max critical PCB temperature (C)	+95
Max allowed charging start temperature (C)	+32
Min allowed charging start temperature (C)	+5
Post-trickle charging duration (min)	
Charged battery (charging cycle <20 min)	30
Discharged battery (charging cycle ≥20 min)	180
Resistance PASS	
Charging (mΩ)	<600
Discharging (mΩ)	<800
Resistance FAIL critical (charging) (mΩ)	>800
Maximum allowed voltage during charging (V)	17
Minimum allowed charging voltage (V)	8
Discharge level (V)	10.5
Discharge current (A)	1
Emergency cut-off current	
Instantaneous (charging state) (A)	3
Exceeding set current for more than 8 s (mA)	200
Pre-programmed charging/discharging cycles	0–5

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