Electronic controller for Closed Circuit Rebreather

USER'S MANUAL

version 1.0

Table of Contents

1. INTRODUCTION

This manual covers the use of ECCR controller and its accessories. The set consists of:

- ECCR controller (primary handset) and its charger;

- head-up display;

- pin plugs for primary and secondary controllers and head-up display;

4 pins
Head-up display

6 pins
Secondary handset

10 pins
Primary handset

- connection board (analog or digital).

1.1 How to Use this Manual

There are three parts of this manual, covering surface and underwater modes as well as general care and maintenance of the ECCR controller, software version 1.23. The current version of manual is always available for read and download at help.eccr.pl.
The manual covers each of the modes and the basic operation of the ECCR controller. While this manual is a useful guide for learning more about your rebreather's controller, it does not replace formal training with certified scuba instructor.

1.2 Important - Please Read

With the purchase and / or use of the ECCR controller, you hereby agree to the "Tecdiving Limitation of Liability" as provided un the appendix of this manual.

2. DEFINITIONS

Throughout this manual, there will be a variety of terms that a prospective or new rebreather diver may not be familiar with. This section will define these terms as they relate to this manual, as well as define the warning, caution, and notice symbols located throughout this text.

Terms:

- **Bailout:** Open circuit SCUBA used as redundancy while diving a rebreather.
- **Bar:** Unit of measure equal to approximately one atmosphere. Used to calculate pressure at depth as well as PO_2.
- **Battery:** Power source located in the primary handset used to power the ECCR controller electronics. Status is measured in both volts and percentage of full charge.
- **Bottom Time:** Total elapsed time spent underwater.
- **Calibration:** Process used to align the oxygen sensor's millivolt output with a known PO_2.
- **CCR:** Closed Circuit Rebreather.
- **Cell Cartridge:** Removable cell carrier that houses the oxygen sensors.
- **Cell Warning:** Alarm which notifies the diver an oxygen sensor malfunction or dangerous loop PO_2.
- **Ceiling:** The shallowest depth one can ascend to at the current tissues' saturation level.
- **Carbon Dioxide (CO_2):** The byproduct of oxygen metabolism in the body.
- **Decompression:** Reduction of ambient pressure experienced during the ascent from a dive. This term is also used to describe the mandatory stops a diver will need to make as they ascend from a dive.
- **Desaturation (desat):** The amount of time required for a diver's tissues to off gas all excess inert gas at the surface.
- **Head:** CCR electronics component which houses the cell car tridge, oxygen injection solenoid as well as handset and HUD Connections.
- **Head-Up Display (HUD):** Display mounted to the rebreather mouthpiece which indicates the status of the breathing loop via flashing LEDs.
- **Loop:** Internal volume of the CCR comprised of the mouthpiece, breathing hoses, counterlungs, scrubber canister, and head.
- **Millivolt (mV):** Unit of measure equal to one thousandth of a volt. Millivolts are used to measure the amount of current generated by an oxygen sensor.
- **No Stop Time:** Available time a diver can spend at the current depth without incurring a mandatory decompression obligation.
- **OC:** Open Circuit SCUBA.
- **Oxygen Sensors (cells):** Electro-galvanic fuel cell which generates an electric current when exposed to oxygen, used for sensing the PO_2 in the breathing loop.
- **Piezo switch:** Pressure sensitive switch used to navigate the ECCR controller and make adjustments to the unit's settings.

- **PPO_2/PO_2:** Par tial pressure of oxygen; the concentration of oxygen in a breathing gas. PO_2 is determined by the fraction of oxygen in the gas and the absolute pressure exer ted on the gas (PPO_2 = fraction of oxygen x absolute pressure).
- **Primary Handset:** Housing containing the main electronics, battery, screen and two piezo switches for user interface.
- **Scrubber/Stack:** Terms used interchangeably to describe the CCR's carbon dioxide scrubber canister, usually used when describing scrubber/ stack duration remaining.
- **Setpoint:** User defined target loop PO_2.
- **Surface Interval (surf. int.):** Elapsed time spent on the surface after completing a dive.
- **TTS:** Time to surface, describes the total time required for the diver to ascend to the surface from their current position in the water. This includes the ascent at a rate of 7 meters/23 feet per minute as well as all required decompression obligations.
- **Gradient Factors (GF):** Values used to allow a diver to add conservatism to the Buhlmann decompression algorithm.
- **Solenoid:** Valve which injects oxygen into the breathing loop when activated by the ECCR controller.

Warning, Caution, and Notice Statements

Throughout this manual, there are special warning, caution and notice statements that highlight key information that need special attention. These notices are highlighted in the following format:

WARNING - describe potentially hazardous situations, if not avoided, could result in serious injury or death. Avoid these situations under any circumstances.

CAUTION - indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE - used to notify the user of information regarding installation, operation, maintenance, performance, general tips that are important, or statements describing a procedure or situation that might cause damage to the device but is unrelated to physical injury.

3. INHERENT RISKS ASSOCIATED WITH DIVING A REBREATHER

There are many inherent risks associated with scuba diving, and diving a rebreather increases some of these risks. It is important to recognise and understand these risks and how to manage them, always obtain proper training from a qualified instructor, and remain current with your skills and knowledge.

3.1 Risks and Their Management

Scuba diving may carry serious inherent risks that can result in serious injury or death if not managed properly. These risks include, but are not limited to, decompression sickness, oxygen toxicity, hypoxia, hyperoxia, drowning, hypercapnia or other CO2 related maladies, barotrauma including arterial gas embolism, other hyperbaric injuries, equipment malfunction or failure and risks arising from improper and/or negligent operation of equipment. While these risks are always present while diving a rebreather, they can be managed and even reduced by receiving proper training, diving within the limits of your training and experience, using proper pre-dive checklists, following manufacturer guidelines, staying current with your knowledge and skills, remaining physically and mentally fit to dive, and seeking further training from a qualified professional when you are looking to extend the limits of your training and experience or whenever there is an extended period of inactivity in your rebreather diving activities. If you do not acknowledge, understand or accept these risks, you must not dive the unit with ECCR controller.

3.2 Explaining Risk

It is just as important for your close relatives to understand and accept the risks and potential consequences associated with diving a rebreather. If they are not willing to accept the consequences of your diving activities, you should not dive the ECCR controller.

3.3 Remaining Current and Fit to Dive

Remaining physically and mentally fit to dive is critical for your safety in the water. While annual physicals are an excellent way to have your fitness assessed by a medical professional, it is also essential to assess your physical and mental readiness prior to every dive. If it doesn't feel right, it is not right. No dive is worth your life, and you should feel comfortable terminating any dive at any time for any reason. After any extended period of rebreather diving inactivity, it is important to seek refresher training from a qualified professional, and take it slow for the first few dives while building your skills and comfort level back up gradually.

3.4 Summary

While diving a rebreather is a fun and exciting activity, it does pose inherent risks that cannot be avoided entirely. It is your responsibility to understand and accept these risks and be willing to accept the responsibility of keeping current and fit to dive prior to diving the unit with ECCR controller. If you are not willing to accept these risks and responsibilities, you should not dive the unit with ECCR controller.

4. OPERATION OVERVIEW

This chapter will cover the basic functions and operation of the ECCR controller, including how to navigate the displays, change settings, and overall system display information.

4.1 Activating the ECCR controller

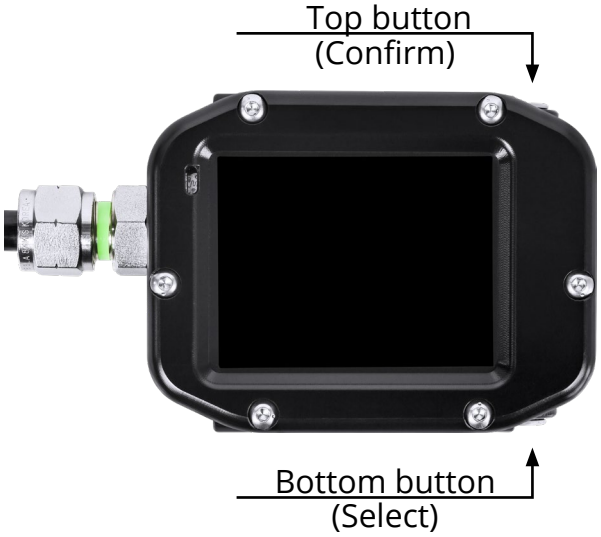
The ECCR controller can be activated 3 ways: manually, via the wet switches, or via the pressure sensor. The wet switches and pressure sensor activate the electronics in the event the user enters the water with the handset turned off (see Ch. 5, Underwater Mode, Activating Underwater Mode for more info regarding wet switch and pressure sensor activation). To activate the electronics manually, simply press and hold both piezo switches simultaneously until the initial screen appears on the display. If the primary handset is connected to the head, you will likely hear the solenoid activating (apparent "clicking" sound). This is normal and the reason for it will be explained later in this manual.

4.2 Buttons

TThe ECCR controller (primary handset) has two piezo switches or "buttons" located ergonomically on the top and bottom of the handset. This section will define the buttons and their functions as well explain the basic navigation of the displays and settings.

For the purposes of this text, we will define the buttons as:

- **Bottom button: Select.** This button allows you to scroll through the available options on the display, the chosen option will be highlighted or boxed in red.
- **Top button: Confirm.** Confirms the highlighted option, which either changes the option to the next available setting or increases the numerical value by one (1).
- **Both buttons simultaneously: Next Menu.** Changes displayed menu to the next available menu.



4.3 System Information

The full colour display of the ECCR controller primary handset allows the user to quickly identify information that may require immediate attention while underwater, and to assist with navigating the menus and changing settings. For the purpose of navigating menus and changing settings on the surface, the colours are primarily used to easily highlight selections and changes being made.

Underwater, the text colour is used to highlight critical information that may need attention:

Green:	Value is within pre-determined or acceptable range.
Yellow:	Value is approaching unacceptable levels, not yet dangerous but requires the diver's attention.
Red:	**WARNING!** Value is now outside of acceptable and safe operating range, the ECCR controller may not be capable of operation as desired. Potentially dangerous and requires immediate action to avoid serious injury or death.

4.4 Deactivating the ECCR controller

The ECCR controller electronics can only be turned off while in surface mode. To deactivate the electronics, use the next menu function until you reach the "switch unit off" display. Scroll to "yes" and press and hold the select button until the handset powers down.

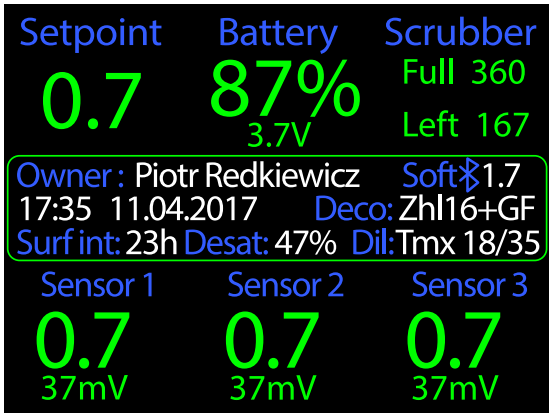
4.5 Summary

The ECCR controller's ergonomic buttons and colour display make navigating the primary handset simple and efficient. You will find that after only a short period you will become proficient in navigating the menus and adjusting settings.

5. SURFACE MODE

Surface mode refers to the displays available when the diver is on the surface, where most of the user-configurable settings are adjusted prior to a dive.

5.1 Primary Surface Display



This is the first display that appears when the ECCR controller powers up and gives general information about the controller including:

- **Setpoint:** The current user selected setpoint.
- **Battery:** Battery status shown in percentage of full as well as a voltage reading. The battery colour coding is as follows:

Green:	Battery is greater than 60% charged.
Yellow:	Battery is greater than 30% but less than 60% charged, this requires attention.
Red:	Battery is less than 30% charged, this requires immediate action.

- **Scrubber:** Full illustrates the duration of a new scrubber.
- **Left:** Illustrates the duration remaining on the existing scrubber as shown:

Green:	Scrubber has greater than 50% duration remaining.
Yellow:	Scrubber has less than 50% but more than 25% duration remaining, this requires attention.
Red:	Scrubber has less than 25% duration remaining, this requires immediate action.

- **Owner:** Name of the ECCR controller owner, this can only be modified by the Tecdiving factory.
- **Soft:** indicates the current software version of the ECCR controller
- **Date and Time**
- **Deco:** The current decompression algorithm selected.
- **Surf int:** Time on the surface since the last dive (in hours).
- **Desat:** Indicates the divers current tissue saturation percentage.
- **Dil:** Displays the current diluent gas activated.
- **Sensor 1, 2, 3:** Displays the PO_2 reading as well as the millivolt (mV) output for each oxygen sensor.
- **The oxygen sensor colour coding is as follows:**

Green: PO_2 value is within 15% of the user selected setpoint.

Yellow: PO_2 value is greater than 15% but within 25% of the user selected setpoint, is less than 0.5 but greater than 0.4, or greater than 1.5 but less than 1.6, this requires attention.

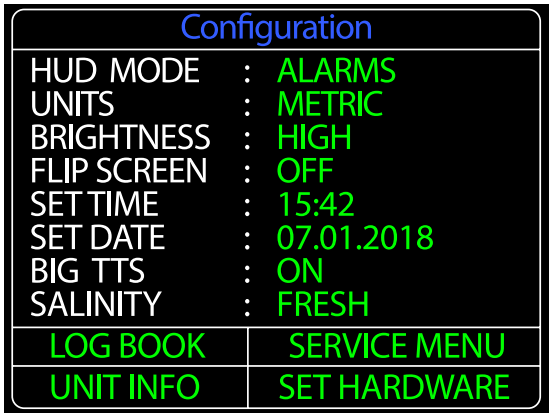
Red: PO2 value is more that 25% away from the user selected setpoint, is less than .4, or more than 1.6, this requires immediate action.

5.2 Change Setpoint

The change setpoint menu allows the user to quickly select a pre-defined setpoint. Also displayed on this screen is the current PO_2 (average), time, depth, and current setpoint. To change the setpoint, press the SELECT button until the desired setpoint is circled in red and then press the CONFIRM button. You will see the "current setpoint" value change to the selected setpoint, and the change was successful. It is important to note the ECCR controller will only allow you to select a setpoint that it is capable of achieving. For example, a PO_2 of greater than 1.9 is not achievable on the surface, so the ECCR controller will not allow you to select any setpoint greater than 1.0 from the available options.

5.3 Configuration

The configuration menu allows the user to configure following options:



- **HUD Mode:** Allows the user to set the Head-Up Display in one of 3 configurations:
  > **Alarms** - The HUD's blue LED will flash once every 3 seconds when all systems are functioning normally and no immediate attention or action from the diver is required.

The HUD's red LED will flash once every second as an alarm indicating the scrubber duration remaining, battery charge level, or PO_2 value needs the diver's attention or immediate action.

> **PPO_2** - The HUD will flash in a coded sequence to inform the diver of the average PO_2 value:

 x1	One red flash followed by 3 sec pause	PPO_2 - 0.1 under 1 = 0.9
 x2	Two red flashes followed by 3 sec pause	PPO_2 - 0.2 under 1 = 0.8
 x3	Three red flashes followed by 3 sec pause	PPO_2 - 0.3 under 1 = 0.7
 x4	Four red flashes followed by 3 sec pause	PPO_2 - 0.4 under 1 = 0.6
 x5	Five red flashes followed by 3 sec pause	PPO_2 - 0.5 under 1 = 0.5
 x6	Six red flashes followed by 3 sec pause	PPO_2 - 0.6 under 1 = 0.4
 x7	Seven red flashes followed by 3 sec pause	PPO_2 - 0.7 under 1 = 0.3
 x8	Eight red flashes followed by 3 sec pause	PPO_2 - 0.8 under 1 = 0.2
 x9	Nine red flashes followed by 3 sec pause	LOW PPO_2 constant warning
 x1	One blue flash followed by 3 sec pause	PPO_2 - 0.1 over 1 = 1.1
 x2	Two blue flashes followed by 3 sec pause	PPO_2 - 0.2 over 1 = 1.2
 x3	Three blue flashes followed by 3 sec pause	PPO_2 - 0.3 over 1 = 1.3
 x4	Four blue flashes followed by 3 sec pause	PPO_2 - 0.4 over 1 = 1.4
 x5	Five blue flashes followed by 3 sec pause	PPO_2 - 0.5 over 1 = 1.5
 x6	Six blue flashes followed by 3 sec pause	PPO_2 - 0.6 over 1 = 1.6
	Red and blue flash simultaneously followed by a 3 second pause	PPO_2 = 1

> **Sequential** - This mode is the same as PPO_2 mode, however instead of averaging the cell readings, the HUD will indicate each of the 3 sensors individually in a sequential pattern (one at a time starting with cell 1, going on to 2 and 3 then loop back to cell 1).
  - For example: One blue flash: 3 second pause, 2 blue flashes, 3 second pause, 1 blue flash, 3 second pause would indicate: Sensor 1 = 1.1; Sensor 2 = 1.2; Sensor 3 = 1.1

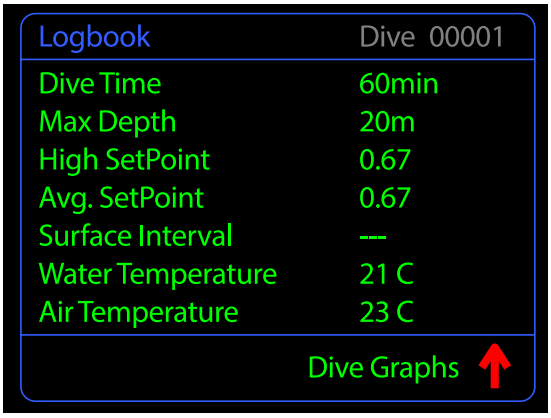
- **Units:** Allows the user to configure the ECCR controller to display in either imperial or metric units of measure.
- **Brightness:** User can select one of several display brightness settings:
  > **Auto** - auto mode senses ambient light level and adjusts the brightness automatically (less ambient light, lower the brightness setting; more ambient light, higher the brightness setting).
  > **Low** - the lowest brightness setting consumes the least amount of power.
  > **Medium -** the medium brightness setting consumes an intermediate amount of power.
  > **High -** the highest brightness setting consumes the most power.
- **Flip Screen:** if the user would like to wear the primary handset on the right wrist, they can turn flip screen on to turn the display upside down.
- **Set Time:** user can set current time for accurate dive logging.
- **Set Date:** user can set date for accurate dive logging.
- **Big TTS:** when turned on, the Time To Surface (TTS) will be displayed on the basic display in underwater mode. The TTS will alternate with dive time in the top right corner of the display. The TTS will display for 2 seconds and the dive time will display for 6 seconds.
- **Salnity:** choice between fresh or salt water.

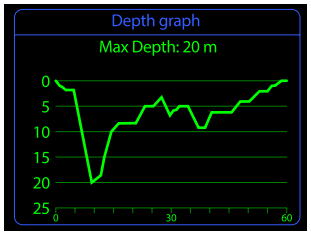
There are additional options available in the configuration menu such as:

- **Log Book:** The logbook displays dives logged on the ECCR controller primary handset. The main display includes information about dive numbers and dates of recent dives. To access details of a particular dive, it has to be highlighted (scroll button) and then chosen (select button). Once a dive is selected you can view the following information:

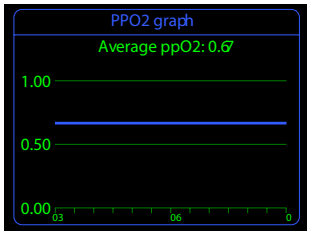
  - Dive number
  - Date and time of star ting the dive
  - Dive time
  - Maximum depth
  - Setpoint information
  - Surface interval
  - Water temperature
  - Air temperature

When viewing the dive, pressing the confirm button will take the user to the dive graphs where they can view the following (pressing the confirm button will scroll form one graph to the next):

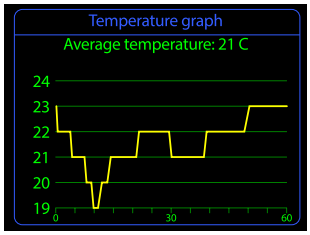




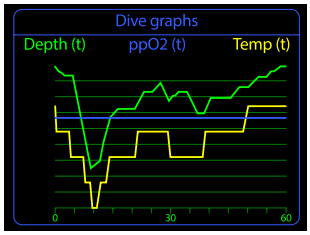
Depth graph



PPO_2 graph



Temperature graph

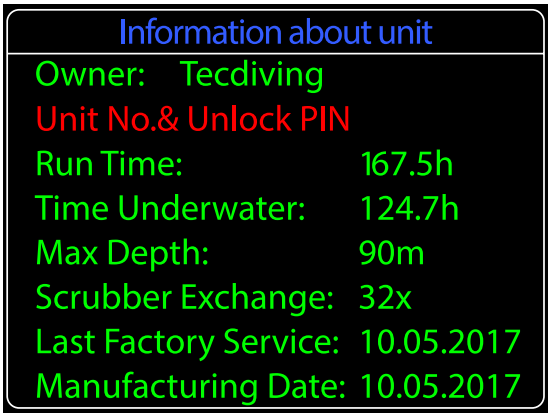


Consolidated graph (depth, PO_2 and temp.)

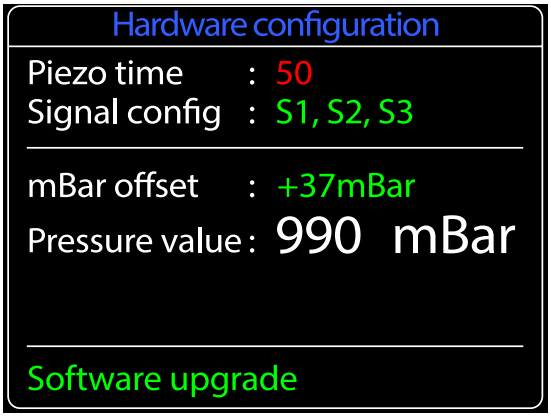
- **Service Menu:**

The service menu is accessed and utilized only when conducting ECCR controller factory service and testing only. Unauthorized use of this option will lock the ECCR controller electronics.

- **Unit Info:** displays detailed ECCR controller information for the life to date of the unit including:
  - > **Unit No. and Unlock PIN:** this function opens the menu to enter feature unlock PIN and displays the Unit No (different than the serial number stamped on the back of the handset).
  - > **Run Time:** the total time the unit has been turned on.
  - > **Time Underwater:** the total time the unit has been in underwater mode.
  - > **Max. Depth:** maximum depth of all dives conducted.
  - > **Scrubber Exchange:** number of times the scrubber timer has been reset.
  - > **Last Factory Service:** date the last factory service was performed.
  - > **Manufacturing Date:** production date of the unit.



- **Hardware Configuration:** the user can set the piezo switch press duration (button sensitivity) as well as configure the order in which the oxygen sensors are displayed.



  > **Piezo time:** changes the duration in which you must hold the piezo switches down in order for the button to register a press. The lower the value selected, the shorter the duration and the more sensitive the buttons will be to pushes. If you find you are accidentally changing settings unintentionally, you may want to increase the piezo time to make the button pushes less sensitive. It is important to note, changing this setting does not affect how much force is required to push the button, only how long you must hold it before it registers.
  > **Signal Config:** allows the user to configure the order in which the oxygen sensors are displayed on the handset. This is valuable to ensure your primary and secondary handsets are reading sensors in the same order and the values are consistent.
  > **mBar Offset:** allows the user to adjust the milli bar value based on the actual known atmospheric pressure to offset the slight deviance due to the pressure sensor accuracy. This will allow for a slightly more accurate calibration, but is not required for normal operation.
  > **Pressure value:** displays measured pressure.
  > **Software upgrade:** allows to upgrade the software version to a newer one if available.

5.4 Setpoint Setup

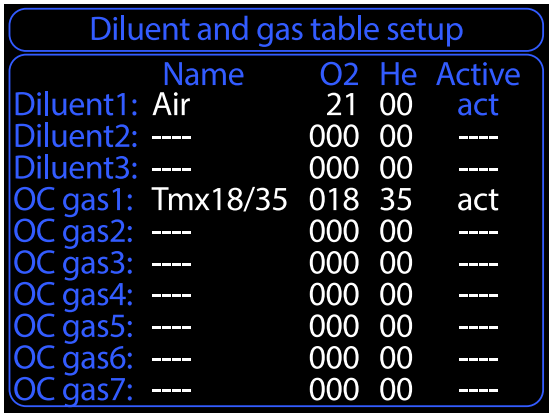
In standard surface mode, the setpoint setup menu enables the user to define their preferred low and high setpoints. The selectable range for both SP1 and SP2 is from 0.5 through 1.6. To define a setpoint value, press the SELECT button until the setpoint you would like to adjust is flashing and press the select button. This will highlight the setpoint in red, and further pushes of the CONFIRM button will increase the value by 0.1. When you have reached the desired value, press the SELECT button to move to the next setpoint. When you are finished, you can use the next menu function to scroll to the next menu.

5.5 Diluent and Gas Table Setup (only available when deco is enabled)

The diluent and gas table setup is where the user will define their diluent and open circuit gases.

In order to adjust the oxygen (O_2) and helium (He) values, the gas must be deactivated.

To deactivate and adjust a diluent gas, simply scroll to the "---" in the "Active" column of another diluent gas and press CONFIRM. This will activate that diluent gas (indicated by "act"), and you will now be able to adjust the values of the desired diluent gas. To adjust the O_2 and He percentages, scroll to the value you wish to adjust and press the CONFIRM button to increase the value by 1% per push. When a value is at the desired level, press the SELECT button to move to the next value or gas.



To deactivate and adjust an open circuit bailout gas (OC gas x), simply scroll to "act" for the corresponding OC gas you would like to adjust, and press CONFIRM. This gas will now be deactivated (indicated by "---"), and you can adjust the O_2 and He values.

5.6 Decompression Settings

The use of nitrox and/or trimix requires specialized training. Do not attempt to dive with any diluent gas other than standard air without specialized training and certification.

Modifying decompression settings can have drastic and negative effects on a diver's decompression profile, resulting in serious injury or death. By modifying any values in the Decompression Settings menu, a diver acknowledges that they fully understand the implications of doing so.

- **Model:** user may select Zhl16+GF or No Deco. When No Deco is selected, tissue loading calculations are not displayed, and it is extremely important the diver uses another means (secondary handset and/or constant PO_2 CCR computer) to calculate decompression status.
- **Gr. Factor Hi:** allows the user to adjust the high gradient factor.
- **Gr. Factor Lo:** allows the user to adjust the low gradient factor.
- **Last Deco Stop:** allows the user to select between 2 predetermined values (3 meters/10 feet, or 6 meters/20 feet) for their final decompression stop.
- **Dive Planner:** user can enter the parameters of the dive and calculate the expected decompression obligation.

5.7 Other Settings

- **Underwater:** the user may select "sensor" or "permanent".
- **Sensor:** uses the ECCR controller's depth pressure sensor and/or wet switch to activate "underwater mode".
- **Permanent:** places the primary handset into "underwater mode" permanently, enabling the user to view the underwater mode displays and settings while on land.

The ECCR controller will not power down while in underwater mode. If "permanent" is selected, the user must select "sensor" when they wish to shut the ECCR controller down. Failure to do so will result in the handset remaining on and discharging the battery. The ECCR controller has an automatic timer that will not allow the handset to enter surface mode until it has been on the surface for 60 seconds. This timer will also prevent the handset from entering surface mode for 60 seconds after "sensor" has been re-selected while on the surface.

5.8 Scrubber Settings

This display allows the diver to configure the scrubber settings based on the scrubber canister option installed on their rebreather with ECCR controller as well as reset the scrubber countdown timer when the CO_2 absorbent is replaced.

- **Stack Changed:** indicates the duration since the CO_2 absorbent was last changed. The colour coding is as follows:

  Green: Scrubber was replaced within the past 50 days.

  Yellow: It has been more than 50 days, but less than 150 days since the last scrubber replacement.

  Red: It has been more than 150 days since the scrubber was replaced.

- **Current Stack Time:** indicates the duration remaining on the current scrubber canister. This duration is determined by subtracting the elapsed dive time since the last scrubber exchange from the set stack time value.
- **Set Stack Time:** allows the user to configure the scrubber duration based on the CO_2 canister installed on their rebreather with ECCR controller. See the rebreather's manual or contact the manufacturer for details regarding scrubber canister options and durations.

A user should ONLY reset the stack time in accordance with the CO_2 absorbent canister option iinstalled on their rebreather with ECCR controller. This is a maximum scrubber duration based on optimal conditions, and additional precautions should be taken when other factors may reduce scrubber duration (increased workload, cold water, depths exceeding 40 meters/130 feet). Exceeding the scrubber duration may result in serious injury or death.

- **Reset Stack Time and Scrubber Exchange:** allows the user to reset the scrubber countdown timer when the CO_2 absorbent material has been replaced.

A user should OLNY reset the stack timer when CO_2 absorbent material has been replaced with unused approved CO_2 absorbent using proper scrubber packing procedures. Please refer to your rebreather manufacturer's manual and your instructor for instructions on scrubber packing procedures for the rebreather. Failure to do so may result in serious injury or death.

5.9 Sensors and Calibration

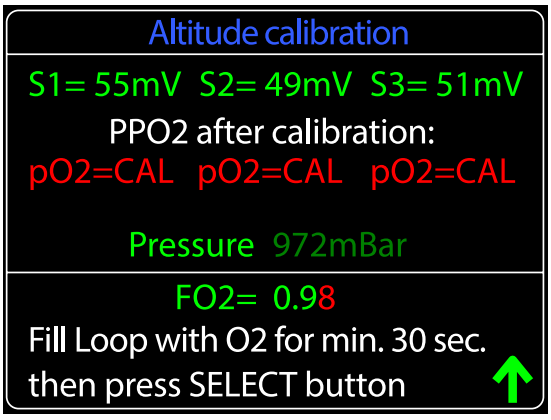
Proper oxygen sensor care, calibration, and replacement is essential for proper CCR Function. Users should only install rebreather's manufacturer approved oxygen sensors in their ECCR electroncis. Oxygen sensors should be replaced after 18 months of manufacture, 12 months of installation, when mV output begins to degrade, the cell becomes non-linear or current limited, or the sensor fails to calibrate successfully, whichever comes first. Failure to do so may result in serious injury or death.

- **Sensor Age:** indicates the elapsed time in days since the sensor was installed in the unit. The colour coding is as follows:

  Green: Sensor was replaced within the past 150 days.

  Yellow: Sensor was replaced between 150 and 300 days ago.

  Red: Sensor was replaced more than 300 days ago, and the user should be prepared to replace it within the next 60 days.
- **Last Calibration:** indicates the elapsed time in days since the unit was last calibrated.
- **Diluent PPO_2:** fraction of oxygen in the activated diluent.
- **Altitude Calibration:** allows the user to enter altitude calibration menu, to be used when calibrating the ECCR controller electronics at altitude or when calibrating using a calibration gas other than pure oxygen.



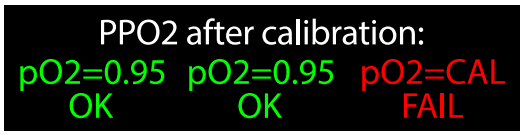
  > **S1, S2, S3: voltage** (given in millivolt) of each oxygen sensor.

  > **PPO_2 after calibration:** PO_2 reading of each cell after successful calibration. CAL will be displayed if a sensor has been calibrated incorrectly, indicating the unit will need to be re-calibrated. Colour coding is consistent with deviation from setpoint PO_2 colouring used in other displays.

  > **Pressure:** current atmospheric pressure.

  > **FO_2:** Current fraction of oxygen in the calibration gas as defined by the user. FO_2 can be adjusted from 0.96 to 0.99 by scrolling to the value to be edited and pressing the select button to select the value to match the calibration gas being used.

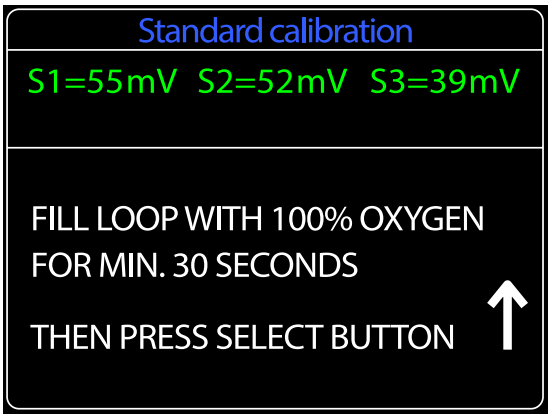
> Fill Loop with O_2 for a minimum of 30 seconds then press the SELECT Button. After flushing the loop or head (if calibration caps are used) with oxygen, scroll to the up arrow icon and press the select button to calibrate the ECCR controller electronics to the oxygen sensor's mV reading output. A sensor that has calibrated successfully will be GREEN and have OK listed below it. A failed sensor will be RED and FAIL will be displayed below it.

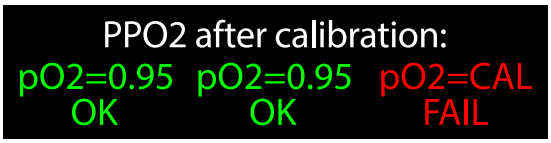


In order for the sensor to be calibrated correctly, its voltage value must be in the range of 37mV–62mV. In case of a failed calibration, the process has to be repeated until each sensor's reading is "OK," or the sensor may need to be replaced. A dive should never be started with a known oxygen sensor failure or failed calibration.

Successful calibration does not ensure a properly functioning oxygen sensor. It is advised to check periodically the sensors for linearity and current limiting, as well as track each sensors mV output. Failure to do so may result in serious injury or death.

- **Standard Calibration:** Allows the user to enter the standard calibration menu to calibrate the ECCR controller electronics using 100% oxygen at or near sea level.
  > **S1, S2, S3:** voltage (given in millivolts) of each oxygen sensor.
  > **Fill Loop** with oxygen for a minimum of 30 seconds then press the SELECT button. After flushing the loop or head (if calibration caps are used) with oxygen, scroll to the up arrow icon and press the SELECT button to calibrate the ECCR controller electronics to the oxygen sensor's mV reading output. A sensor that has calibrated successfully will be GREEN and have OK listed below it. A failed sensor will be RED and FAIL will be displayed below it.



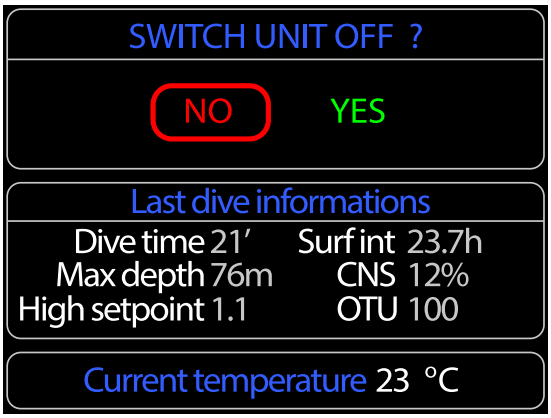


While the ECCR controller electronics incorporate sensor failure modes which estimate loop PO_2 and continue to function when one or more sensors fail, it is never appropriate to begin a dive with a known malfunctioning oxygen sensor. Attempting to do so can lead to serious injury or death.

- In the case of a single oxygen sensor failing to calibrate, the cell voting protocol is switched off, and average of the other two sensors is taken.
- In case of the failure of two sensors, the reading of the third sensor is taken as average PPO_2 and SOLENOID IS PERMANENTLY SWITCHED OFF.
- In case of all three sensors failure, no information about PPO_2 is given and SOLENOID IS PERMANENTLY SWITCHED OFF.

5.10 Switch Unit Off

- **Dive time:** Duration of the last recorded dive.
- **Max depth:** Maximum depth of the last dive.
- **High setpoint:** Maximum setpoint value set during the last dive.
- **Surf int:** Surface interval since the last dive.
- **CNS:** Current value of CNS oxygen exposure.
- **OTU:** Current value of oxygen tolerance units.



5.11 Summary

Surface mode offers a wide variety of user definable options that the user should spend a considerable amount of time familiarizing themselves with and configuring the ECCR controller electronics to suit their preferences.

6. UNDERWATER MODE

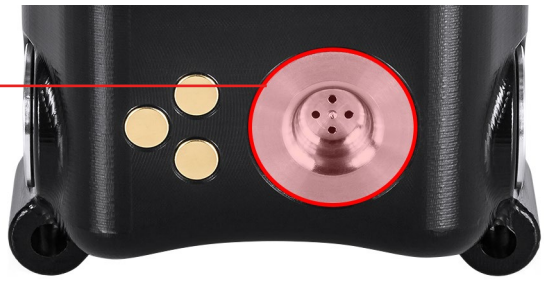
The ECCR controller electronics underwater mode allows the user quick access to critical dive related information, while allowing the user to change settings and configurations as the dive parameters change. Most of the underwater displays and configurations are very similar to the surface mode displays, with one primary difference; every display in underwater mode includes the average PO_2, dive time and current depth.

6.1 Activating Underwater Mode

Underwater mode can be activated in one of three ways:

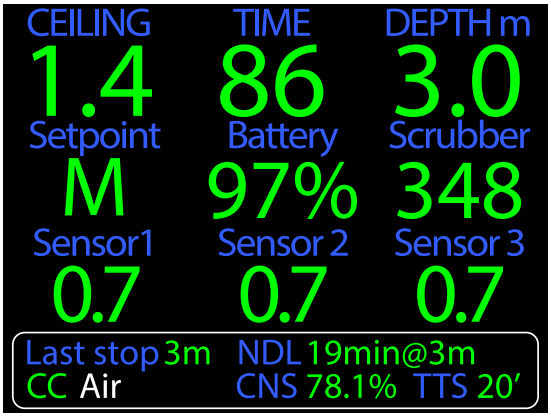
- **Wet contacts:** the board detects the increase of electric conductivity caused by water appearing between the contact (marked red) and ground contact (marked blue). Completing the circuit of these contacts causes the device to power on (if currently off) and switch into underwater mode.

- **Depth sensor:** the depth sensor is placed on the side of the controller housing and is protected from mechanical damages by a metal shield (marked red). The pressure sensor is calibrated by the factory to read a measuring range of 0 to 30 Bar.



6.2 Primary Underwater Display (Decompression Mode Activated)

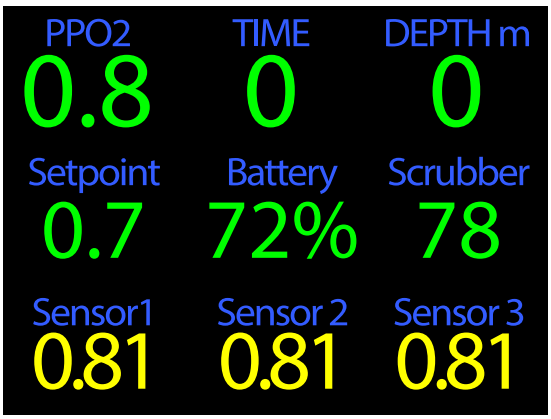
With decompression mode activated, the primary underwater display will give the user a complete overview of the dive and rebreather status. Information included in this display include:



- **Ceiling:** the shallowest depth given one can ascend to at the current tissues' saturation.
- **Time:** elapsed time of the current dive.
- **Depth:** current depth.
- **Setpoint:** current user selected setpoint.
- **Battery:** status of battery (displayed in % of full charge).
- **Scrubber:** remaining scrubber duration.
- **Sensor 1, Sensor 2, Sensor 3:** current PO_2 value for each oxygen sensor.
- **Last Stop:** user selected last stop depth.
- **Stop:** time and depth of the first required decompression stop when the diver begins to ascend.

- **Gas:** current gas (diluent or OC bailout) selected by the user.
- **CNS:** current CNS%
- **TTS:** total time to surface, the amount of time in minutes that it will take for the diver to reach the surface, includes ascent at 7 meters/23 feet per minute, and all required decompression stops.

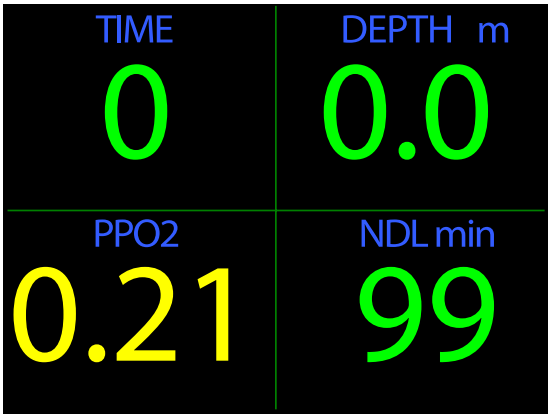
6.3 Primary Underwater Display (Decompression Mode De-Activated)



With decompression mode deactivated, most of the same information will be displayed on the primary underwater display, minus decompression related data.

- PPO_2: Because the diver's decompression obligation is not being displayed, "ceiling" is replaced with PPO_2. This displays the average PPO_2 of the oxygen sensors or the PO_2 of the OC bailout gas if in OC bailout mode.

6.4 Basic Underwater Display

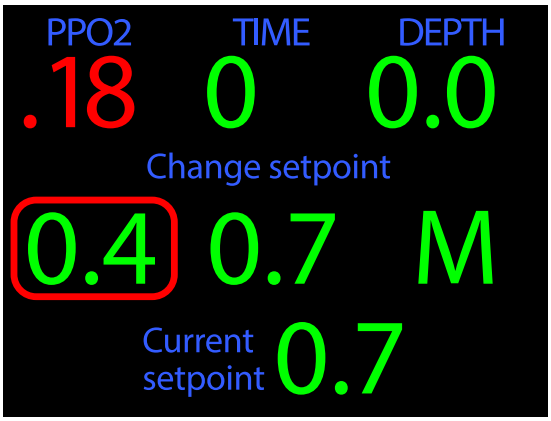


The basic underwater display is designed to be a quick reference of the most critical dive information, displayed in large, easy to read font. This display is found by pressing the confirm button once while in the primary underwater display. Here you will find the following information:

- **Time:** elapsed dive time underwater of the current dive, displayed in the top left corner of the display. When "big TTS" is activated in the configuration mode, this display will alternate between TTS and Time (Time is displayed for 6 seconds, TTS is displayed for 2 seconds).
- **TTS:** time To Surface, only displayed when "big TTS" is turned on in the configuration mode, this display will alternate between TTS and Time (Time is displayed for 6 seconds, TTS is displayed for 2 seconds).
- **Depth:** current depth
- **PPO_2:** average PO_2 currently in the breathing loop.
- **NDL min:** NDL remaining on the current dive. When the user enters decompression, "NDL" will be replace by "Stop," which indicates the time and depth of the first required decompression stop.

6.5 Change or Review Setpoint Options

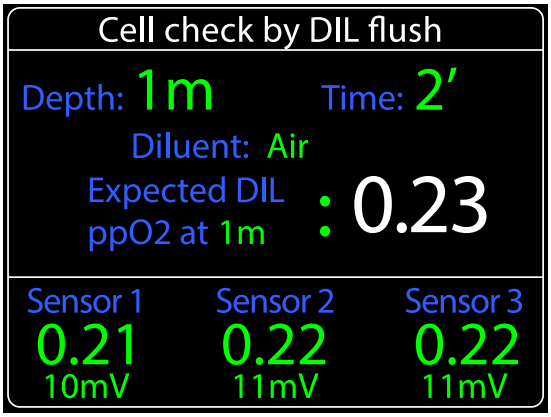
The change setpoint menu allows the user to quickly select a pre-defined setpoint or manual (M) mode. Also displayed on this screen are the current PO_2 (average), time, depth, and current setpoint. To change the setpoint, press the SELECT button until the desired setpoint is circled in red and then press the CONFIRM button. You will see the "current setpoint" value change to the selected setpoint, and the change was successful.



ECCR controller will only allow the user to select a setpoint that it is capable of achieving. For example, a PO_2 of greater than 1.0 is not achievable on the surface, so the ECCR controller will not allow you to select any setpoint greater than 1.0 from the available options.

6.6 Cell Check by DIL Flush

This display allows the user to quickly identify what the expected PO_2 of the diluent gas should be for oxygen sensor verification purposes. On this display, you will see:



- **Depth:** current depth
- **Time:** current elapsed dive time.
- **Diluent:** current diluent gas mix
- **Expected DIL PPO_2:** expected PO_2 of the diluent gas at the current depth.
- **Sensor 1/2/3:** current reading of oxygen sensors. The readings may be shown in one of the three colours due to deviation from expected DIL PPO_2 value:

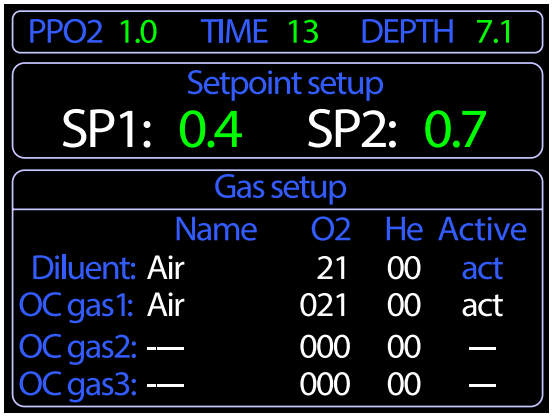
Green: PO_2 value is within 15% of the expected value.

Yellow: PO_2 value deviation is greater than 15%, but within 25%

Red: PO_2 value deviation is more that 25%

A diluent flush resulting in a positive validation of an oxygen sensor does not guarantee that sensor's health. Your rebreather instructor will train you in proper sensor validation techniques. If an oxygen sensor's health comes into question at any point in a dive, the dive should be aborted immediately. Do not attempt to continue a dive with a questionable oxygen sensor.

6.7 Setpoint Setup And Gas Table (Decompression Mode Activated)



The setpoint setup menu while in underwater mode is identical to surface mode, with the addition of the current average PPO_2, dive time, and depth listed at the top. This allows the user to monitor critical dive data while configuring setpoint underwater.

The setpoint setup menu enables the user to define their preferred low and high setpoints and gas set up. By pressing SELECT button you move through SP1, SP2 and values of oxygen and helium in gas setup table.

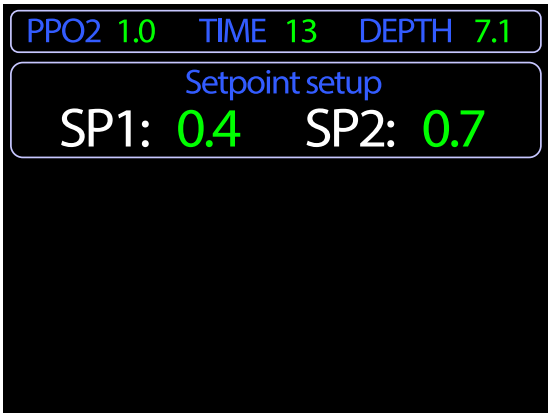
The selectable range for both SP1 and SP2 is from 0.5 through 1.6. To define a setpoint value, press the SELECT button until the setpoint you would like to adjust is flashing and press the CONFIRM button. This will highlight the setpoint in red, and further pushes of the CONFIRM button will increase the value by 0.1. When you have reached the desired value, press the SELECT button to move to the next value.

The diluent and gas table setup is where the user will define their diluent and open circuit bailout gases.

The Diluent gas is marked as active (in blue colour) and is impossible to deactivate. However, its values can be changed, simply select the desired digit in the O2 or He column and press confirm. This will change the value of 1. To move to the next digit / value, press Select button. To deactivate and adjust values of one of the three open circuit bailout gases (OC gas x), simply scroll to the "act" in the "Active" column of that gas and press confirm. This gas will now be deactivated (indicated by "- - -") and you will now be able to adjust the values of the desired gas. To adjust the O2 and He percentages, scroll to the value you wish to adjust and press the CONFIRM button to increase the value by 1 per push. When a value is at the desired level, press the SELECT button to move to the next value or gas. The sum of Oxygen and Helium values in one gas mix cannot be greater than 100.

When you are finished, you can use the next menu function to scroll to the next menu.

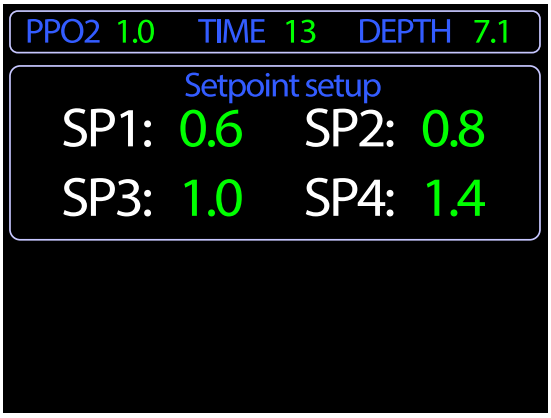
6.8 Setpoint Setup And Gas Table (Decompression Mode De-Activated)



The setpoint setup menu while in underwater mode is identical to surface mode, with the addition of the current average PPO_2, dive time, and depth listed at the top. This allows the user to monitor critical dive data while configuring setpoint underwater.

The setpoint setup menu enables the user to define their preferred low and high setpoints and gas set up. By pressing SELECT button you move through SP1, SP2 and values of oxygen and helium in gas setup table. The selectable range for both SP1 and SP2 is from 0.5 through 1.6. To define a setpoint value, press the SELECT button until the setpoint you would like to adjust is flashing and press the CONFIRM button. This will highlight the setpoint in red, and further pushes of the CONFIRM button will increase the value by 0.1. When you have reached the desired value, press the SELECT button to move to the next setpoint.

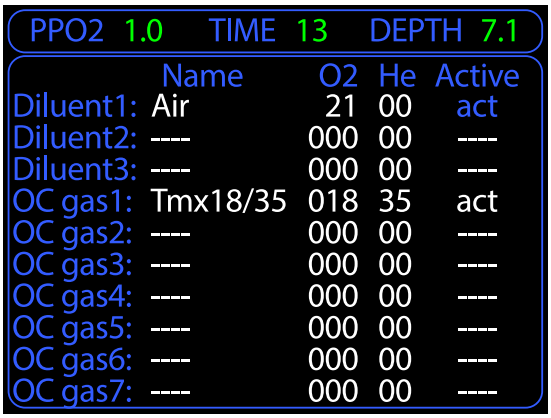
6.9 Setpoint Setup - Extended Mode (Decompression Mode Activated)



The setpoint setup menu while in underwater mode is identical to surface mode, with the addition of the current average PPO2, dive time, and depth listed at the top. This allows the user to monitor critical dive data while configuring setpoint underwater.

6.10 Gas Mix List Configuration - Extended Mode (Decompression Mode Activated)

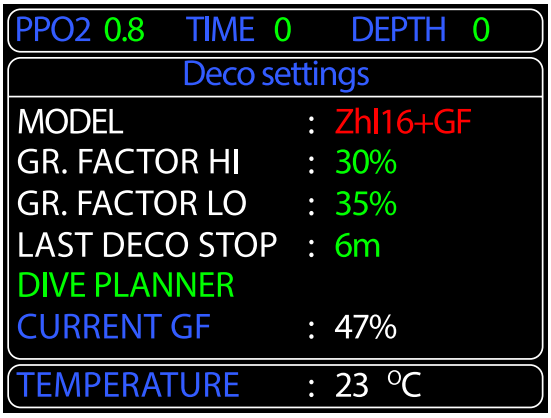
The gas mix setup menu in underwater mode is identical to surface mode, with the addition of the current average PPO_2, dive time, and depth listed at the top. This allows the user to monitor critical dive data while configuring gasses while underwater.



6.11 Setpoint Setup - Extended Mode (Decompression Mode De-Activated)

See "Setpoint Setup" information listed above in section 6.9.

6.12 Decompression Settings

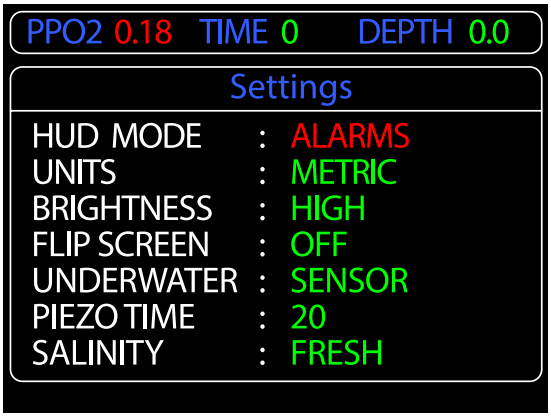


The decompression settings menu in underwater mode allows the user to make adjustments to the decompression related configurations during the dive. The user can adjust:

- **Model:** enables and disables the decompression mode.
- **GR. Factor HI:** adjusts the high gradient factor value.
- **GR. Factor Lo:** adjusts the low gradient factor value.
- **Last Deco Stop:** depth the last decompression stop is to be conducted.
- **Dive Planner:** this function is disabled in underwater mode.

Other information listed on this screen is the basic dive information across the top, which includes average PPO_2, elapsed dive time, and current depth; as well as the current gradient factor which is determining the stop depth and time and the current water temperature.

6.13 Settings



The settings menu allows the user quick access to general handset configurations such as:

- **HUD Mode:** allows the user to choose between Alarms, PPO_2, and Sequential mode.
- **Units:** user can define their preferred unit selection, Imperial or Metric.
- **Brightness:** allows the user to adjust the brightness settings.
- **Flip Screen:** allows the user to inver t the screen.
- **Underwater:** allows the user to choose between "Permanent" and "Sensor" for dive detection.
- **Piezo Time:** user can adjust the sensitivity of the piezo switches.
- **Salinity:** choice between fresh and sea water

6.14 Calculating Decompression

The ECCR controller's electronics utilize Bühlmann's ZHL16+GF decompression algorithm, providing reliable and user configurable decompression information.

After activating the controller, the decompression data is loaded from the non-volatile memory. In the vent of damage or complete battery discharge resulting in a loss of decompression information, the following warning will be displayed. Once decompression information is lost, the ECCR controller can no longer be relied on for accurate ecompression information for repetitive dives, as it will not account for residual tissue loading.

For the decompression calculation to be valid, the appropriate diluent or open circuit bailout gas must be selected on the ECCR controller.

When a dive commences the decompression model is initiated and the procedure of calculating the tissues' saturation starts. The feature works continuously in real-time which makes it possible to switch the displayed decompression data on/off at any point, without the risk of losing the calculations or the correctness of displayed data. The saturation levels of particular tissues in the decompression model are updated (recalculated) in fixed time frames, (every 2 seconds). Current data about depth and gas mix selected are used in calculations.

Apart from the tissues' saturation, all the decompression stops (depth and time of the stops), TTS, CNS and OTU are also calculated in the continuous mode (every 2 seconds), therefore values of these parameters may change during the dive. All tissue loading and unloading calculations are based on the average PO_2 of the cells which are not voted out by the internal voting logic.

Total Time to Surface (TTS) takes into account the time of all the decompression stops and the ascent speed, 7 meters / 23 feet per minute (-0.7 Bar/min). The descent speed is calculated at the level of 15 meters / 50 feet per minute (1.5 Bar/min).

The same decompression algorithm is used for the dive planner and calculations of current decompression status on a dive.

At the completion of the dive, the device switches into surface mode, while the decompression algorithm continues its work, calculating the tissues' desaturation for atmospheric pressure and gas mix. Air is assumed as the active gas mix for the entire time while the device is at the surface.

When the device is switched off, the controller saves in the non-volatile memory the data used by the decompression algorithm: saturation level of particular tissues, CNS, date and time of the dive.

6.15 Summary

While underwater mode still allows a variety of configuration choices, the goal is to offer the most critical information and make it as easily accessible as possible. The majority of the configuration settings should be set prior to the dive; however, it is still possible for the user to make important adjustments under water. It is extremely important that the user takes some time to familiarize themselves with underwater mode and ensure the ECCR controller is configured to their liking.

7. PPO_2 MEASUREMENT

The ECCR controller electronics use a 3-sensor voting logic or a 2-sensor averaging algorithm (in the event one sensor fails on a dive) to measure the average oxygen partial pressure in the breathing loop. Understanding these algorithms is important so the user can quickly identify warnings and accurately validate oxygen sensor readings to terminate the dive appropriately. The voting logic uses the following process while in closed circuit mode:

- Recalculating the voltage values into PPO_2 values for each sensor based on the sensor calibration data (defined by the user during unit calibration).
- The algorithm is updated to adjust amount of oxygen coming from solenoid.
- Checking the error table for each sensor to verify that the sensor is calibrated properly and within the appropriate range.
- Rejecting the way of calculating the average PPO_2 value:
  - > with one sensor switched off (set calibration error), taking the value of mathematical mean from the other two sensors to be the average PPO_2 value;
  - > with two sensors switched off, taking the value shown by the working sensor as the average PPO_2 value;
  - > with all the sensors calibrated, calculating the average with voting logic:
    - calculating the difference between sensors 1 and 2
    - calculating the difference between sensors 2 and 3
    - calculating the difference between sensors 1 and 3
  - > the cell with the greatest deviation is voted out if the deviation is greater than 15%. Otherwise, they remain part of the average PPO_2.

If the value of the sensor marked in the previous step as 'to be checked' is more than 15% and at least of 0.02[1] absolute value from the mean of the other two sensors, reject the reading of this sensor when calculating the average PPO_2 ('*' on the display and arithmetic mean of two sensors), otherwise use for calculations the average PPO_2 (arithmetic mean of three sensors). All readings in absolute values.

While in open circuit mode, the ECCR controller electronics calculate the PO_2 based on the current open circuit gas selected and the current depth.

7.1 Summary

Understanding the basic function of the voting logic and averaging algorithms will help the user quickly and accurately recognize, diagnose, and validate oxygen sensor warnings in order to terminate the dive as appropriate.

1 Taking the value of the deviation of 0.02 bar of oxygen partial pressure prevents rejection of properly working sensors during the PPO_2 measurements on a low level (below the value of 0.15). It does not matter during the dive or normal usage, but improves the accuracy and stability of reading the PPO_2 in the range close to zero.

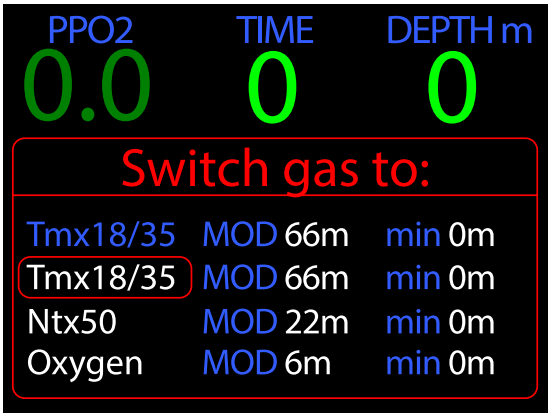
8. BAILOUT MODE

Open circuit bailout mode allows the user to switch the ECCR controller electronics to open circuit. This will automatically switch the setpoint to manual mode (setpoint of 0.4), and will calculate decompression and TTS based off of the open circuit gasses that have been activated by the user.

8.1 Bailout Menu

To reach the bailout menu from either the primary or basic underwater display, simply press the select button once. This will bring you to the bailout menu. The bailout menu displays:

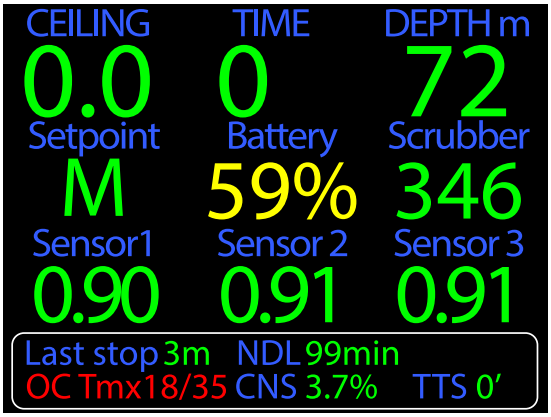
- **PO_2 (in CC mode):** Current average PO_2 in the loop.
- **OC PO_2 (in OC mode):** Current PO_2 of the open circuit gas selected based on current depth.
- **Time:** Elapsed dive time for current dive.
- **Depth:** Current depth.
- **Switch gas to:**
  - > The activated diluent (shown in blue text, its maximum operating depth (MOD), and its minimum operating depth (min).
  - > All activated open circuit gasses (shown in white text if safe at that depth, shown in red if the user is currently below the gasses MOD or above its min), their MOD and min.



To bailout to open circuit, simply scroll through the "switch gas to" menu until the gas you would like to switch to is highlighted with the red boxand press the confirm button. This will switch the ECCR controller to the open circuit gas you have selected, and take the you directly back to the primary underwater display. On the primary display, note:

- The setpoint has been changed to "M"
- The gas listed is now the open circuit gas you selected, and displayed in red text.

Switching to the basic underwater display, the user will notice one difference. The PPO_2 display has been changed to "OC PPO_2", which now indicates the PO_2 of the open circuit gas selected at the current depth. As the user ascends, the ECCR controller allows them to switch to other open circuit gasses that have been activated. To do so, simply enter the bailout menu and select a new open circuit gas. Also, as the diver ascends, if the PO_2 inside the loop drops below 0.4, the solenoid will activate and the unit will inject oxygen. The user must be conscious of this and closely continue to monitor the loop PO_2 and volume to avoid an uncontrolled ascent.



The ECCR controller will allow the user to select a gas that is outside of its maximum or minimum operating depth. It is the user's responsibility to follow acceptable gas switching procedures and confirm the open circuit gas they are breathing is safe at their current depth. Switching to the wrong gas can cause serious injury or death.

To switch back to closed circuit mode:

- Enter the bailout menu
- Highlight the diluent gas
- Press confirm button

This will switch the unit back to closed circuit and take the user directly back to the primary underwater display.

8.2 Summary

Familiarity of the ECCR controller's OC Bailout mode is essential for every user. This mode allows the user to quickly switch the electronics to open circuit, dropping the setpoint to manual mode and calculating a proper ascent schedule based on the gasses available.

9. BATTERY LIFE AND CHARGING

The ECCR controller electronics rely on the battery located in the primary handset for proper operation. As such, it is critical that the user verifies the battery holds sufficient charge to conduct the dive prior to entering the water. It is highly recommended that the user fully charge the ECCR controller electronics prior to each use.

9.1 Battery Life

The ECCR controller electronics are powered by a built-in Li-Ion 3.7V 1.95Ah battery. In sleep mode, the device draws current in the range of microamperes. The battery discharge time in this mode depends on the self-discharge current of the battery.

During usage, the battery discharge time depends on multiple factors:

- Selected display brightness.
- Time of the solenoid being open (more oxygen used, higher the power consumption).
- Ambient temperature (lower temperature, lower battery efficiency and shorter battery life).
- The number of battery charge cycles (each charging / discharging cycle lowers the battery capacity causing shorter working time after charging; maximum battery life span is 600 cycles).
- Age of the battery (over the course of time, the cells' electrodes undergo partial degradation, which lowers the battery efficiency and its working time af ter charging; it is advised to replace the battery at minimum, every 2 years).

Battery duration:

- **Surface Mode (inactive solenoid):**
  - Display brightness "LOW": up to 35 hours
  - Display brightness "MEDIUM": up to 28 hours
  - Display brightness "HIGH»: up to 20 hours
- **Continuous solenoid activation:**
  - Up to 7 hours
- T**ypical dive solenoid activation:**
  - Up to 15 hours

The controller's battery is equipped with a protective circuit board which prevents overcharge, short circuit and over discharge, which could damage the cells. In case of complete discharge, the protective board disconnects the battery from the controller's base plate. In this event, the device is immediately switched off. Should this happen during a dive, the controller will continue to maintain the setpoint with the chosen PPO_2, but all decompression data is erased and the user should not rely on an ECCR controller decompression

information for the remainder of the dive. Complete discharge of the battery causes the real-time clock to stop and current date and time settings to be reset.

All the configuration parameters of the controller are stored in nonvolatile memory and are not affected by a power supply failure.

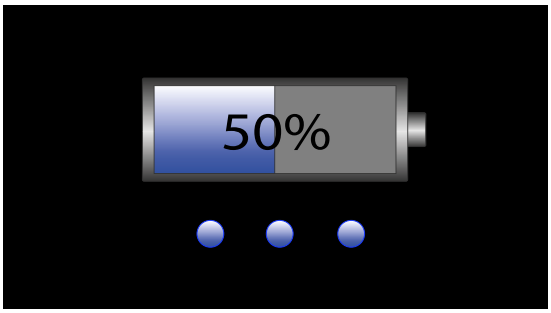
9.2 Charging

Do not connect the ECCR electronics to any power supply or charging device other than the genuine ECCR charger supplied with the Controller. Doing so may cause permanent damage to the electronics and the potential for fire or explosion exists.

The charger should be first connected to the handset and then to a low voltage DC power supply 5VDC of minimum current efficiency 300mAh equipped with USB port. It can be connected to a computer's USB port (min. 300mA). Proper connection of the charger to a power supply is signaled with the green diode. Charging is underway when the red diode is illuminated (charging current > 20mA).

If the controller should shut down during the charging process, it switches into charging mode and shows the percentage level of battery charge:

- The animation under the battery icon signals a proper charging process. Switching the handset off during charging will shorten the charging process.



Charger's work status is as follows:

Green LED	Red LED	
Off	Off	– lack of power supply – damaged power supply – power cord/charger not connected
On	Off	– charger plugged in, not charging – battery fully charged – controller disconnected from the charger – charger's contact points are dirty – dirty or corroded controller's contact points – charger incorrectly connected to the controller
On	On	– charging process operating properly

9.3 Summary

Proper battery charging and maintenance is essential for proper function of the ECCR controller electronics.

10. BEFORE DIVING THE ECCR CONTROLLER ELECTRONICS

It is essential for the user to check the status and settings of the ECCR controller electronics prior to every dive to ensure proper function. This section will describe the critical functions and settings that must be verified prior to starting a dive.

Failure to ensure the proper function of the ECCR controller electronics prior to entering the water can result in serious injury or death. It is the diver's responsibility to ensure all systems are functional prior to and during the dive.

Activate the ECCR controller before diving and make all necessary settings changes on the surface and review the following:

- Check the ECCR controller for damage before diving.
- Before entering the water check on the surface screen:
  - Battery level
  - Personal settings
  - Diluent and OC gases are configured correctly
  - FO_2 setting matches the gasses used for the dive
  - Correct time and date
  - Units
- Conduct a thorough pre-dive check ensuring all CCR functions and diving equipment are per forming correctly.

Oxygen can have toxic effects on the human body. Be aware of oxygen toxicity effects when using oxygen enriched gas mixtures.

Before each dive, check the battery power and recharge the battery, if necessary. Recharge the battery when the ECCR controller has not been used for an extended time. Low temperatures can affect battery performance. Pay special attention to the charge level of the battery during cold-water dives.

Before each dive you must verify if the settings displayed by the ECCR controller correspond to the used gases and the desired personal settings.

Independently analyze the gas composition of oxygen, diluent, and OC bailout cylinders and ensure that the ECCR controller electronics are programmed for these gases.

10.1 Summary

The user should take special care to ensure the ECCR controller electronics are functioning and configured properly prior to each dive. Failing to do so can result in serious injury or death. It is the diver's responsibility to ensure all systems are functional prior to and during the dive.

11. CARE AND MAINTENANCE

While the ECCR controller electronic package is a robust product, proper care and maintenance is essential for a long and reliable service life.

During transportation protect your ECCR controller from mechanical shock and excessive temperatures.

Never try to open the sealed HUD, internal head electronics or the handset of the ECCR controller.

The ECCR controller should be inspected for mechanical damage and cracks before and after each dive to ensure it is working properly.

Always protect your ECCR controller from shock, excessive temperatures, chemicals and mechanical tampering. Protect the lens of the ECCR controller and avoid scratches.

After diving, always rinse the EECR in clean fresh water to avoid corrosion and salt/mineral buildup.

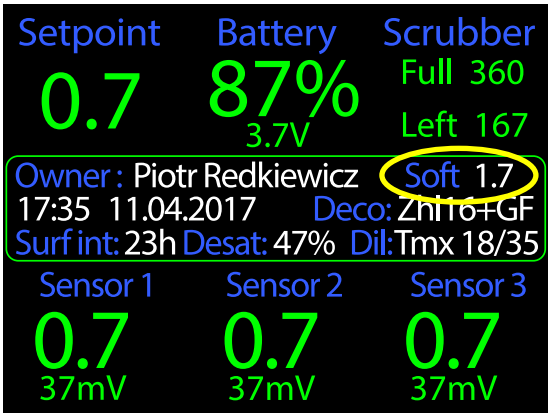
If you notice any sign of moisture in the HUD or handset, discontinue the use of the ECCR controller until it can be serviced by an authorized ECCR controller service center.

11.1 Summary

Proper care and maintenance of your ECCR controller electronics will help ensure years of reliable use.

12. SOFTWARE UPDATE

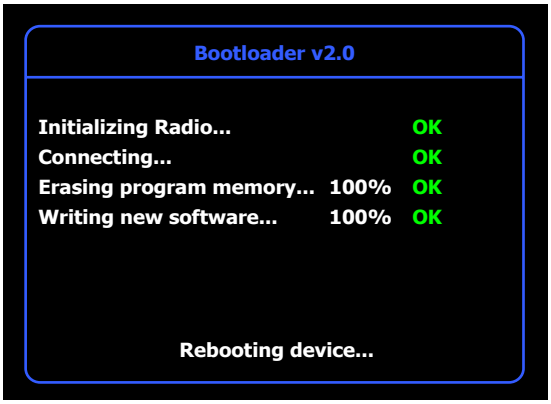
Operation of the device is controlled by the so called firmware. This firmware, provided by the device manufacturer, can be updated to a newer version directly by the user. A selected block of the device's code, the so-called bootloader, is responsible for the update process (replacing the current version with the newer version). This program is triggered using the configuration menu option. It supports the hardware layer, is responsible for establishing a connection with the computer, for erasing the current firmware of the device, for downloading a new firmware version and verifying the correctness of the loaded code.

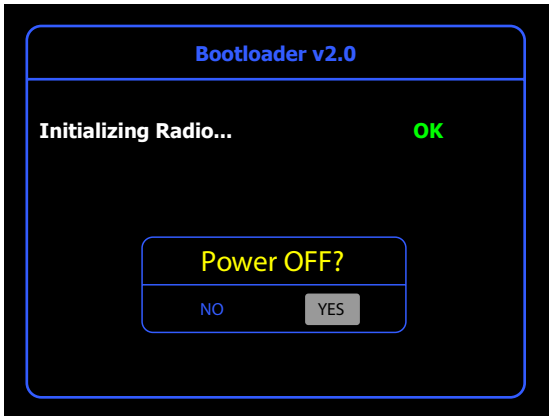


The current version of the software is visible on the main surface display. In this example, the software version shown is 1.7.

To switch to bootloader mode, select SET HARDWARE on the surface configuration screen, then select Software upgrade and confirm with „YES" No Yes

The device will switch to bootloader mode and start and configure the radio module for communication with the computer.





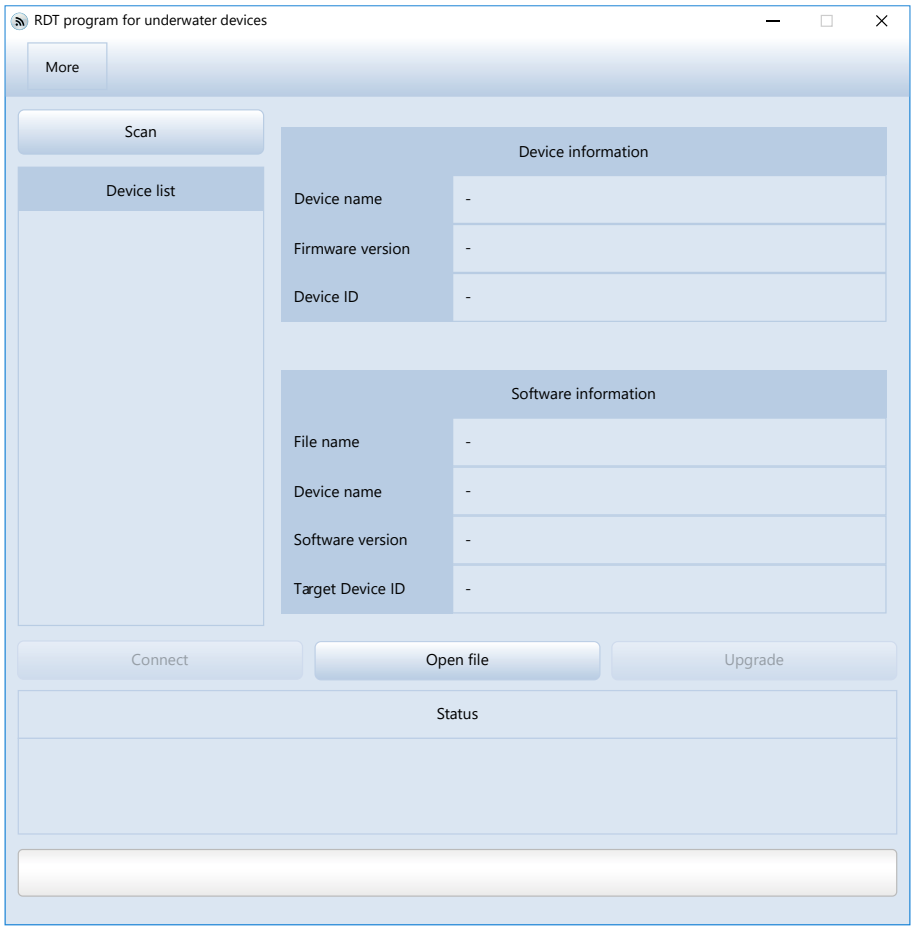
To exit the bootloader mode without making any changes to the firmware, press both buttons simultaneously and then confirm by selecting „YES".

It is not possible to leave the bootloader after the firmware update process has started.

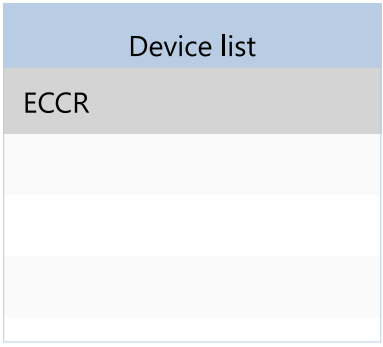
After each startup, the device checks the installed software (CRC checksum) to ensure fault-free operation. In the event of a software error (non-compliant CRC checksum), it is deleted to prevent loading the damaged firmware and the device goes into UPGRADE mode. In this case, new software is required to be uploaded.
After fifth failed attempt of booting the device, BOOTLOADER mode is loaded to allow upload of the proper software.

A further process of software upgrades runs from the computer side, using the included PC / MAC / LINUX software:

1) Open the RDT program

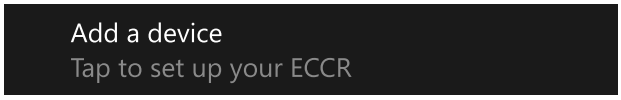


2) Press Scan to search for the device. Scanning lasts up to 30 seconds. If your device is in BOOTLOADER mode, its name (ECCR controller) will be listed:

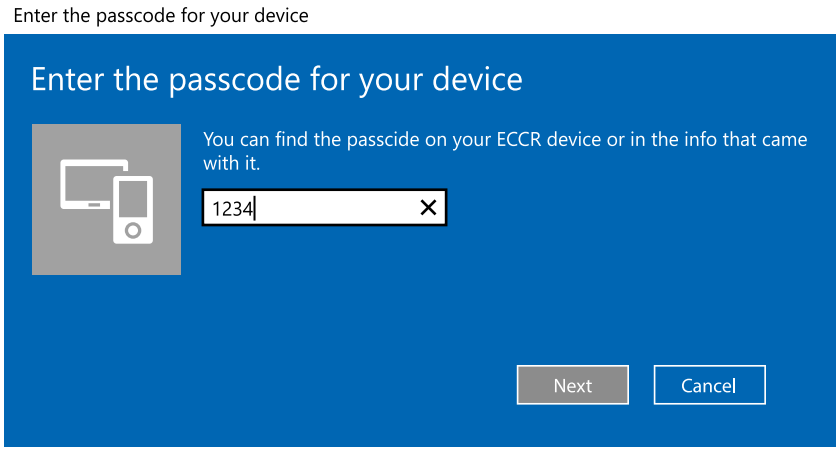


Choose the device and press:

If this is a first connection to your computer, the operating system will prompt you to „pair":



After clicking, you will be prompted to enter the device password. Type „1234".



The device information will be displayed in the application window:

Device information	
Device name	ECCR
Firmware version	v1.7
Device ID	00460028-30345119-38353334

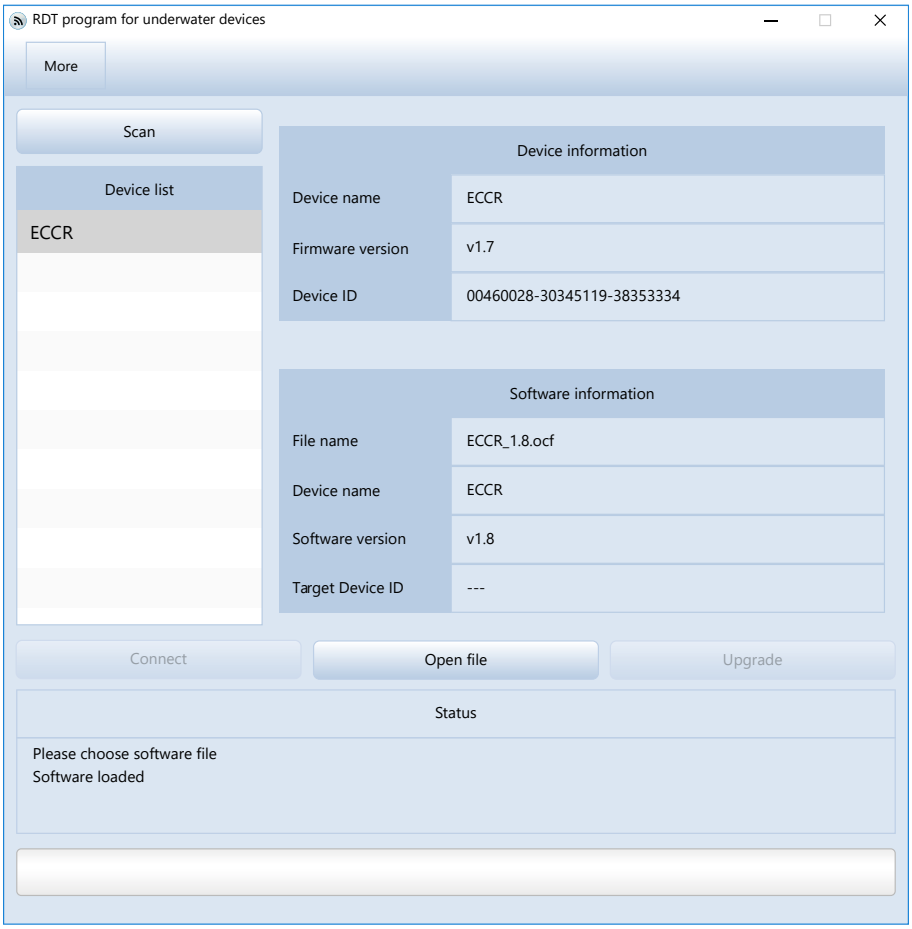
- **Device name** – name of the device
- **Firmware version** – the firmware version currently installed on your device
- **Device ID** – device identification / serial number

3) Load the file with new firmware version.
   - Click Open file
   - Specify the location of the firmware file ECCR_1.8.ocf - only the .ocf file containing the device firmware can be loaded.
   - Click **Open** (in the file list window).
     The file will be loaded and the firmware information displayed in the application window:

Software information	
File name	ECCR_1.8.ocf
Device name	ECCR
Software version	1.8
Target Device ID	---

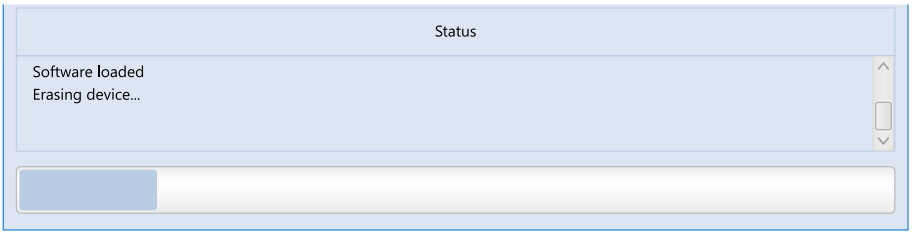
- **File name** – name of uploaded file
- **Device name** – name of the device for which the firmware is intended
- **Software version** – firmware version loaded from the file
- **Target device ID** – ID / serial number of the device for which the firmware file is loaded. For dashes „---" - for all devices given in the „Device name" field.

If the information contained in the file matches the information loaded from the connected device, the Upgrade button becomes active and the application window looks like this:

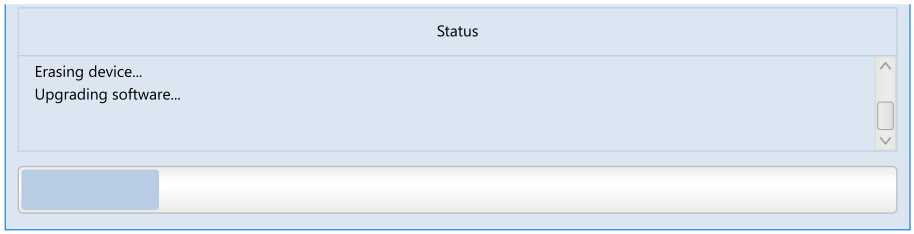


4) Click Upgrade button. The update process will start and its progress will appear in the progress bar:

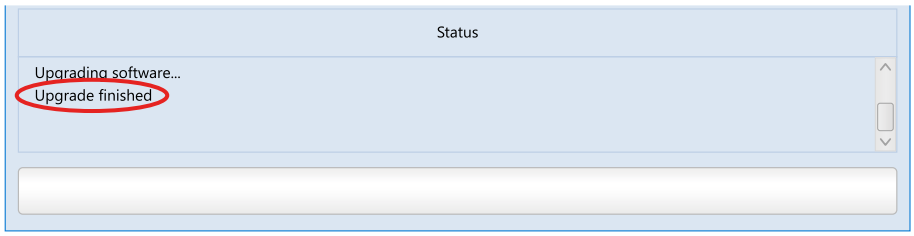
- Deleting the current version of the firmware



- Saving the new firmware version



5) The process is terminated by the message **„Upgrade finished"** in the Status field:



If an error occurs while updating the firmware, the entire process must be repeated from the beginning.

It is forbidden to change the firmware of the device to non-original, modified or derived from unauthorized sources! This is a direct threat to your life!

13. APPENDIX

The intended use of the ECCR controller Electronics is to measure, calculate and display relevant dive information for divers, and control the oxygen partial pressure in the breathing loop by injecting oxygen via an oxygen injection solenoid. It has a built in temperature and ambient
pressure sensor. The values are calculated from a microprocessor and all information is displayed for the user on the primary handset. Limited PO_2 information is also displayed on a head-up display; it cannot be used as a standalone depth gauge or watch.

13.1 Operating conditions

- **Operating altitude range:** 0 to 2,000 metres above sea level provided the oxygen sensors can read 37mVs or higher at ambient pressure.
- **Diving temperature range:** 0°C/32°F to 40°C/104°F
- **Storage temperature:** -20°C/-4°F to 40°C/104°F (it is recommended to store the device in a dry place at room temperature)
- **Maximum depth:** 100M/330FT
- **Depth resolution:** 0.1M
- **Operating temperature range:** -10°C/14°F to 50°C/122°F

13.2 Depth gauge

- **Maximum depth of operation:** 100M/330FT (complying with EN 13319)
- **Accuracy:** ± 1% of full scale at 20°C/68°F (complying with EN 13319)
- **Resolution:** 0.1M from 0 to 100M/300FT

13.3 Temperature measurement

- **Measurement range:** -10°C/14°F to 50°C/122°F
- **Temperature display:** Celsius (°C) or Fahrenheit (°F)
- **Temperature sensor resolution:** 1°C

13.4 Memory

- **Internal memory:** 2 Megabytes
- **External Memory:** 8 Megabytes
- **Maximum total dive time:** 999 minutes

13.5 PC interface

- **Radio Data Transmission**

13.6 Battery

- **Type:** rechargeable Lithium-ion battery
- **Rechargeable:** via the USB charger
- **Charging time:** 10 hours
- **Battery lifetime in operational mode:** approximately 15 hours
- **Battery life in standby mode:** approximately 2 years
- **Note:** operating temperature affects the battery life: at lower temperatures the battery life can decrease.
- The user cannot replace the battery. Only an authorized Tecdiving service provider can replace the battery.
- Failure to observe this leads to loss of warranty and any product related liability of Tecdiving.

13.7 User interface

- **Buttons:** two integrated aluminum piezo switches
- **Audible alarms:** there are no audible alarms
- **Display:** full colour TFT dispaly with 320X240 pixels

13.8 Handset mechanical and material characteristics

- **Weight:** approximately 405g (including SS head plug)
- **Approximate Dimensions:** 83mm length, 63mm width, 48mm height (excluding cable)
- **Material of the housing:** black polyoxymethylene (POM)

13.9 Head-up display mechanical and material characteristics

- **Weight:** approximately 70g (including cable and SS head plug)
- **Approximate Dimensions:** 46mm length, 15mm diameter (excluding cable and SS head plug)
- **Material of the housing:** stainless steel and clear polycarbonate
- **Material of the HUD holder:** black polyoxymethylene (POM)

13.10 General Warnings, Cautions, and Notices

As a reminder, scuba diving holds certain inherant risks that cannot be eliminated entirely. The best way to mitigate those risks is to seek proper training with a qualified instructor, dive within the limits of your training and experience and dive within equipment manufacturer guidelines. Special note should be made of the following warnings, cautions, and notices prior to diving the ECCR controller electronics.

Before using the ECCR controller electronics, read the manual and become familiar with all the functions of the device.

This manual is not intended to replace a proper CCR diving manual or training, from an approved training agency.

No person should breath from, dive, or attempt to operate in any way a rebreather equipped with ECCR Controller, or any component/ part thereof without first completing an appropriate certified user-training course.

The risk of decompression sickness (DSC) or Oxygen toxicity for any dive profile, even if you follow dive tables, or a dive computer, cannot be totally eliminated. This risk also depends on the individual diver's physiological condition, which can vary from day to day. The ECCR controller electronics cannot account for these variations. We strongly advise you to stay within the exposure limits provided by the instrument to minimize the risk of DCS.

Before diving you should consult a physician regarding your fitness to dive.

We strongly recommend diving within the recreational limits, to limit your maximum depth to 40M and to limit the PO_2 to a maximum of 1.2 bar. Exposure to greater depths or PO_2 increases the risk of oxygen toxicity and/or decompression sickness. Diving beyond the recreational limits may greatly increase your risk of decompression sickness.

Do not ignore warning signs and indicators on the ECCR controller handset and HUD, as this may result in death or serious injury.

Be aware of inert gas narcosis, this cannot be indicated on the ECCR controller, there are no warnings.

The ECCR controller does not indicate any safety stops. Safety stops must be performed according to your own dive planning and at your own risk. Safety stops shall be made between 6 and 3 meters. It is strongly recommended to perform safety stops as a standard procedure before completing your dive.

The ECCR controller should never be shared between differed divers. Always use the same ECCR controller for repetitive dives. There is an in-built memory that keeps track of a diver's diving history. Changing the ECCR controller in between a series of repetitive dives may result in incorrect decompression calculations.

Should the ECCR controller fail, you should immediately abort the dive by bailing out to open circuit and ascending in the appropriate manner.

Do not fly, or travel to high altitudes while the NO-FLY indication remains active. Flying while the ECCR controller displays NO FLY can result in serious injury or death.

If a reset of the ECCR controller occurs, for instance after a software update, information about tissue tensions from previous dives will be lost. When this situation happens in between a series of repetitive dives, the decompression schedule and the remaining no decompression time for the following dives may be incorrect.

If you do not perform the proposed decompression stops, a flashing sign will indicate a ceiling to which you should ascend. If you still ignore these warnings, there is NO additional ERROR OR LOCKOUT. Do not ignore these warnings, decompression stops must be done for your own safety and on your own responsibility.

For safety reasons you should always dive with backup instruments, including a depth gauge, pressure gauge, dive watch, or a backup dive computer and have access to decompression tables while planning your dive with the ECCR controller. In addition, you should ALWAYS carry an independent bailout gas cylinder.

If you do not fully understand how to use the ECCR controller, or if you have any questions, contact your instructor, or your authorized ECCR controller dealer before diving with it.

Never lift or carry your rebreather's head by the attached cables. This will result in damage to the cables and/or connectors.

Do not disassemble or remodel any cable or connectors. Use only the original charger. Check compatibility before use.

Ensure that there is no water or moisture inside the cable connectors. This may seriously damage the unit.

13.11 Tecdiving Limitation of Liability

WITH THE PURCHASE AND OR USE OF THE ECCR controller YOU HEREBY AGREE TO THE FOLLOWING exclusions and limitations of Tecdiving's liability to you.

YOU AGREE AND UNDERSTAND THAT REBREATHER DIVING IS A HIGH RISK, POSSIBLY LIFE-THREATENING ACTIVITY AND THE USE OF THE ECCR controller IS IN NO WAY A SUBSTITUTE FOR PROPER REBREATHER TRAINING AND CERTIFICATION AND THE USE OF COMMON SENSE WHILE DIVING.

Because of the number of variables and the varying degrees to which they may affect individuals engaged in rebreather diving, Tecdiving DOES NOT GUARANTEE THAT USE OF THIS PRODUCT WILL PREVENT DECOMPRESSION SICKNESS, HYPOXIA, HYPEROXIA, HYPERCAPNIA, NARCOSIS, OTHER HYPERBARIC INJURIES, DROWNING, BAROTRAUMA OR ANY OTHER CONDITION OR INJURY INCURRED WHILE USING THIS PRODUCT.

These influencing variables may include, but are not limited to, dehydration, obesity, age, old injuries, or other physical conditions on the part of the diver, or environmental extremes of heat or cold, or poor training, or diving practices, any of which may promote the onset of decompression sickness or other harmful effects.

The ECCR Controller was tested according to relevant normatives EN13319 and EN250 and was EVALUATED in numerous test dives. However, THERE MAY still BE ERRORS in the Software, THAT WERE NOT IDENTIFIED yet and that may lead to malfunctions of the ECCR controller. THEREFORE, Tecdiving REQUIRES users always carry and use a secondary PO_2 monitor and decompression computer.

Additionally, Tecdiving also DOES NOT GUARANTEE the function of consumables used in the Rebreather including the oxygen cells and CO_2 scrubber even when used within the manufacturer's recommendations.

YOU AGREE THAT YOU UNDERSTAND AND ACCEPT ALL RISKS ASSOCIATED WITH DIVING, AND THAT Tecdiving, its elected and appointed officials, employees, volunteers or others working on behalf of Tecdiving are NOT LIABLE TO YOU OR ANY OTHER PERSON, INCLUDING YOUR HEIRS, EXECUTORS OR PERSONAL REPRESENTATIVES, FOR ANY LOSS, DAMAGE, COST, EXPENSE OR CLAIM ARISING OUT OF, CAUSED BY OR RELATING TO YOUR PERSONAL INJURY OR DEATH WHILE DIVING, EVEN IF YOUR PERSONAL INJURY OR DEATH IS CAUSED, IN WHOLE OR IN PART AND DIRECTLY OR INDIRECTLY, BY THE PURCHASE OF THE ECCR controller OR YOUR USE THEREOF, OR ARISING FROM BREACH OF THE WARRANTY, BREACH OF CONTRACT, NEGLIGENCE, STRICT TORT, OR ANY OTHER LEGAL OR EQUITABLE THEORY, EVEN IF Tecdiving KNEW, OR SHOULD HAVE KNOWN OF THE LIKELIHOOD OF SUCH DAMAGES, AND REGARDLESS OF WHETHER OR NOT THE ECCR controller FUNCTIONED PROPERLY OR WAS DEFECTIVE IN ANY WAY. Tecdiving SHALL NOT BE LIABLE FOR DELAY IN RENDERING SERVICE UNDER THE LIMITED WARRANTY, OR LOSS OF USE DURING THE TIME THE PRODUCT IS BEING REPAIRED.

YOU HEREBY IRREVOCABLY WAIVE AND RELEASE Tecdiving, its elected and appointed officials, employees, volunteers or others working on behalf of Tecdiving FROM ANY LIABILITY OR OBLIGATION TO YOU OR YOUR HEIRS, EXECUTORS OR PERSONAL REPRESENTATIVES FOR ANY LOSS, DAMAGE, COST, EXPENSE OR CLAIM ARISING OUT OF, CAUSED BY OR RELATING TO YOUR PERSONAL INJURY OR DEATH WHILE DIVING, EVEN IF YOUR PERSONAL INJURY OR DEATH IS CAUSED, IN WHOLE OR IN PART AND DIRECTLY OR INDIRECTLY, BY THE ECCR Controller OR YOUR USE OF THE ECCR Controller, OR ARISING FROM BREACH OF THE WARRANTY, BREACH OF CONTRACT, NEGLIGENCE, STRICT TORT, OR ANY OTHER LEGAL OR EQUITABLE THEORY, EVEN IF Tecdiving KNEW, OR SHOULD HAVE KNOWN OF THE LIKELIHOOD OF SUCH DAMAGES, AND REGARDLESS OF WHETHER OR NOT THE ECCR controller FUNCTIONED PROPERLY OR WAS DEFECTIVE IN ANY WAY.

You must read AND ACCEPT the Agreement for all limitations and exclusions of Tecdiving's liability to you.