APECS 4™ ISCAN OPERATIONAL INSTRUCTIONS

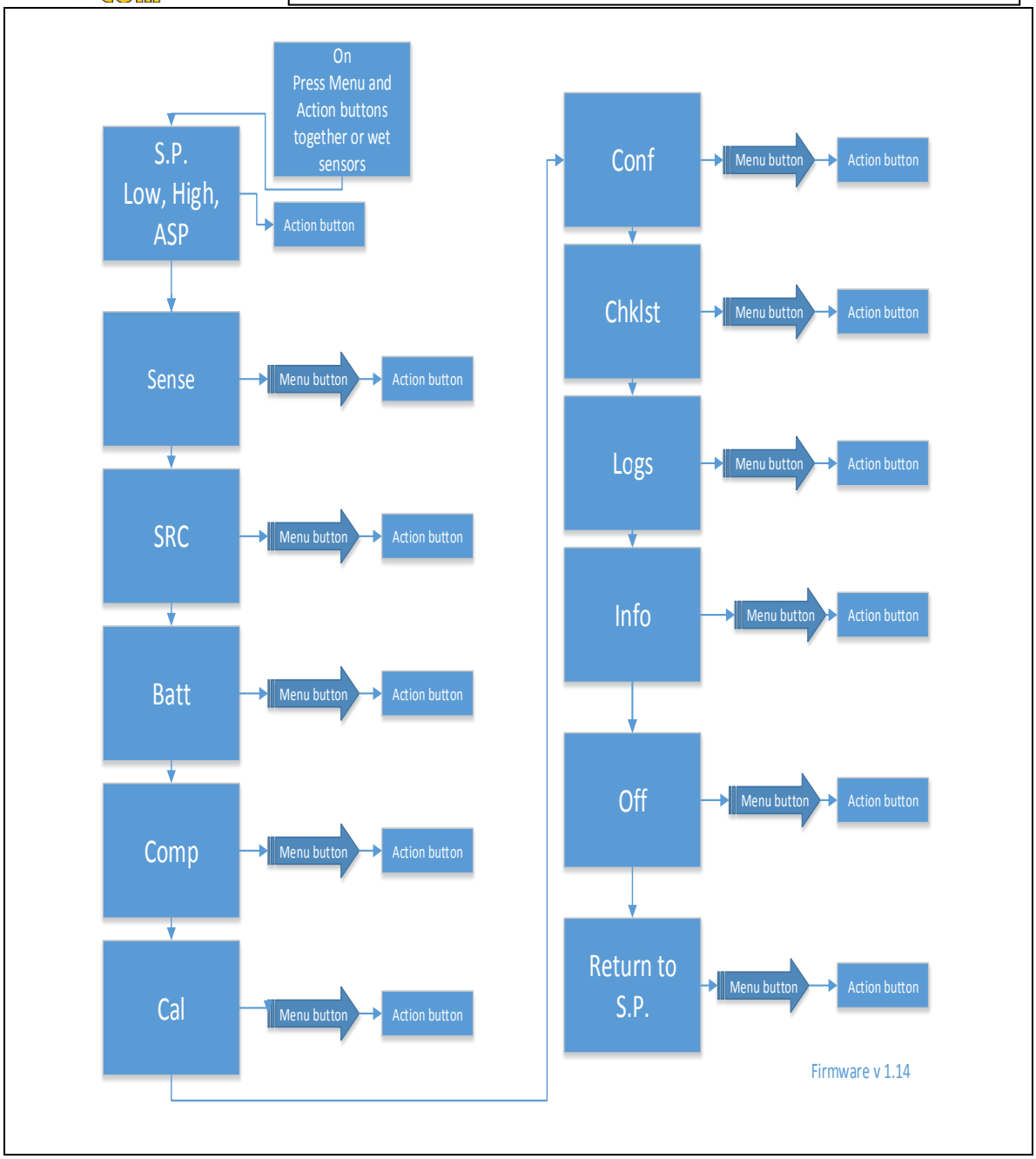
V1

01 Nov 2014

APECS 4™ OPERATIONAL

INSTRUCTIONS (v.)

DOCUMENT REPRODUCTION AND LICENSING


On
Press Menu and Action buttons together or wet sensors
S.P. Low, High, ASP
Action button
Sense
Menu button
Action button
SRC
Menu button
Action button
Batt
Menu button
Action button
Comp
Menu button
Action button
Cal
Menu button
Action button
Conf
Menu button
Action button
Chklst
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Logs
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Return to S.P.
Menu button
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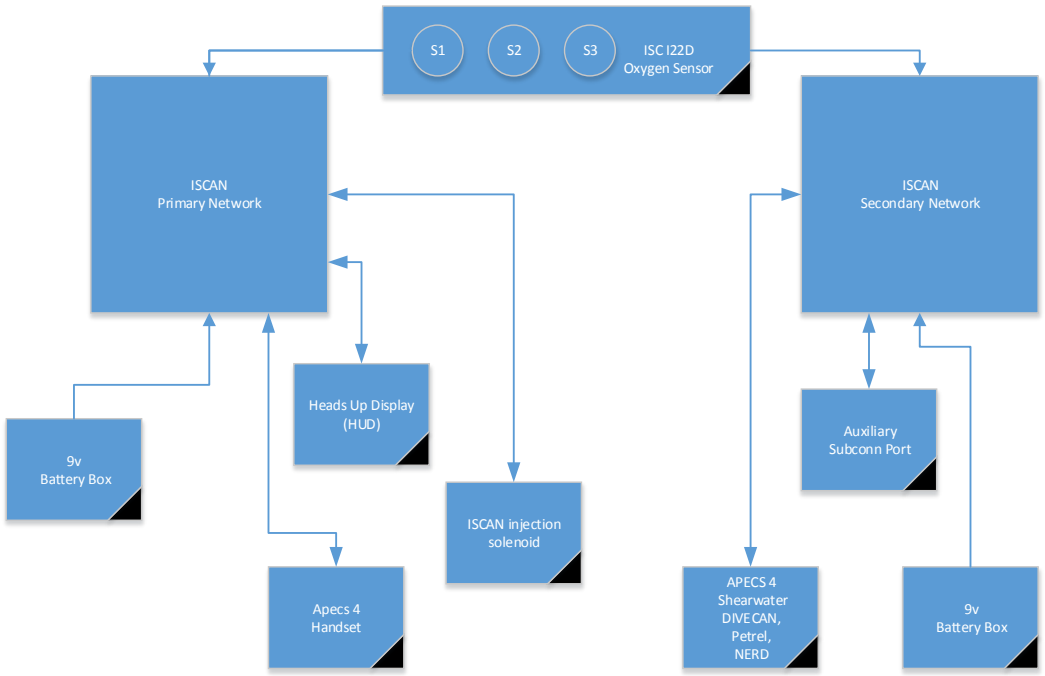
Firmware v 1.14


S1
S2
S3
ISC I22D
Oxygen Sensor
ISCAN
Primary Network
ISCAN
Secondary Network
Heads Up Display
(HUD)
9v
Battery Box
ISCAN injection
solenoid
Auxiliary
Subconn Port
Apecs 4
Handset
APECS 4
Shearwater
DIVECAN,
Petrel,
NERD
9v
Battery Box

Conventions

The various menus, commands and other screen information described in this manual are **CAPS BOLD** and truncated just as they appear on the actual menu screens for the sake of clarity. Conditions that could affect the **safety** of the diver are **called out** in **RED BOLD** to facilitate proper warning of potentially hazardous conditions. Closed Circuit Rebreathers artificially manipulate the divers breathing environment, which creates the **potential** for i**njury** and **death** if the apparatus is not properly assembled, tested, calibrated, and operated. Divers certified on previous releases of APECS™ are strongly advised to study this manual carefully and consult with an ISC approved instructor prior to using this release.

Introduction

The ISC **A**dvanced **P**ersonal **E**nvironmental **C**ontroller **S**ystem 4 (APECS 4™) is a family of CCR electronics designed to be used in a variety of diving roles to fit the operational needs of the end user. The APECS 4™ family is designed to be used in saturation, military, commercial and recreational roles providing reliable, user-friendly operation with room for ISC factory/end user customization to further meet the end users needs. The APECS 4™ has a simple self intuitive Menu and Action/Confirm system and essential information dive screen that minimizes the task loading of the diver by providing a “quick look” ability of essential information and the ability to quickly change on the fly operational characteristics to the breathing media. APECS 4™ is the latest general release of the software and hardware and consolidates the tested features of APECS 2.5 into APECS 4™, a common core with unique configurations to simplify software and hardware maintenance. APECS 4™ is also designed to accommodate the Shearwater DiveCAN system, which facilitates integration of third party decompression computers or CAN based components onto the ISC breathing loop.

What is CAN?

Controller Area Network is a series of microcontrollers and devices that shares a specialized internal communications network without a single host computer used in conventional electronics. CAN is a proven ISO multi master priority aberration message based protocol serial standard that allows up to any number of devices or independent control units to communicate with each other on a BUS/network system.

Prominent system features: Designed to work in the harshest environments imaginable, fault tolerant and fault confinement, error detection, deterministic redundant routing, high data speeds, device replacement units that can be

installed within minutes by the end user and inexpensively restores electronics to service, and CAN systems has been proven everyday the world over.

The ISC ISCAN (intelligent systems controller area network) is a new breed of electronics that will support ISC far into the future of life support electronics.

The ISC ISCAN is based off a historically proven system used in aerospace, military, and commercial arenas and supported by elite commercial entity's that wrote the book on controller area network i.e. CANBUS systems.

The ISC ISCAN can support up to 15 independent devices on each network, the Meg 15 and Pathfinder CCR systems each have two independently powered networks supported by Wi-Fi communications for ease of user upgrades and water/pressure proof Subconn connectors for fast replacement and user custom set ups.

Feature/Function list for APECS 4 handset

- InnerSpace Systems Controller Area Network (ISCAN) compatible messaging system. Compatible with Shearwater Dive Can system.
- 3000mAh rechargeable battery. No more specialized replacement batteries. System can stay nearly fully charged up to a year and operate the handset over 24 hours of continuous dive time, depending on usage, power saving settings and ambient temperature. Quickly recharged using micro USB/USB wall plug or PC.
- TFT Brilliant full color display. Highest contrast, sharpness, and brightness. No backlighting needed and can be seen from almost any angle. Low power consumption, large font and colored alarm indicators.
- Rotatable screen for left arm or right arm viewing.
- 96kB of RAM memory.
- 8GB SD card for operational log memory. System can log all data up to 500 dives.
- Integrated system black box.
- Dive computer compatible. System can support the integration of decompression computational algorithms.
- Wi-Fi capable. System can communicate over a local network as a simple, integrated web server for configuration and downloading dive logs, and system upgrades.

- Integrated compass showing all 4 points of the compass rose for easy positional orientation with concurrent displayed PO2. Displayed Depth, Time and decompression, window with the compass a future option.
- APECS 4 is part of the independent pressure/water proofed primary and secondary electronics and power supply's.
- Independent isolated display system with pressure/gas and water resistant cabling.
- SubConn connectors. Connectors allow for plug and play features and are rated for depth of ocean.
- Leak proof, soft touch activation buttons.
- Two button self-intuitive menu navigation and action/confirm system with 10 standard selectable menu options.
- Auto safety-wet sensor or soft touch button system activation.
- Pre-breathe 5-minute countdown timer.
- Pre-dive 8-question checklist.
- Optional operator depth sensor integration or replacement.
- Anti-hypoxia .21 PO2 setting.
- Danger high 1.6 set point setting for expedited in water decompression or emergency recompression treatment.
- Automatic set point setting (ASP). Pressure sensor independent (failure point) hands free set point adjustment.
- On the fly set point adjustment and indicator.
- Low battery indicators for head and handset systems.
- Set point quick select up to 3 user pre-select set points.
- Average millivolt and PO2 displayed on main screen.
- Displayed 3 sensor mV and corresponding sensor PO2.
- Voting logic indicator. Indicates a sensor is out of tolerance and removed from the sensor group.
- System Status Indicator. System heart beat indicating the electronics are not locked up and are functioning.
- Selectable oxygen dosage. May be adjusted on the fly to allow user to set the personal settings according to work effort and depth of dive, this may be used to minimize oxygen spikes. This is accomplished in two ways, by the ISC adaptive algorithm which controls the amount of time the solenoid is open, and by the user selectable oxygen off dwell time menu which increments in intervals of 4,5,6, 7, and 8 seconds off period.
- Air or 100% single point calibration for all independent oxygen monitoring devices. Fastest calibration method in the world. Less than 3 seconds.

- Full mixed gas capable.
- System may be used with any mix of Oxygen.
- High altitude oxygen sensor calibration. 14,700ft/4700m.
- No system lockouts.
- Handset can independently power main network for back up to main system power supply.
- System is independent of other network devices for true independent system monitoring.

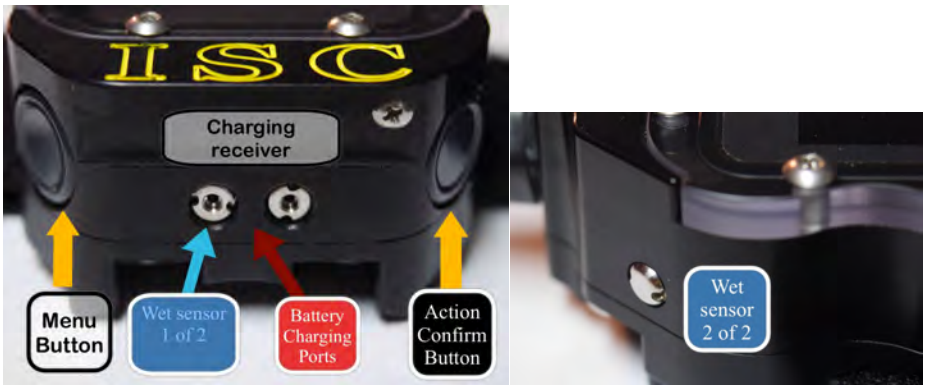
The APECS and ISCAN systems strengths come from a practical approach based off of designer experience and the application of design principles that closely follows function leading to form and built fit for purpose. Regarding the functions of the APECS 4™ electronics, it is encouraged that the diver feels free to push the buttons on the handsets to see what they do, starting with the **Menu and Action/Confirm** buttons.

DANGER! The ISC rebreathers and electronics operates by using batteries, the diver must insure that the batteries are fresh or recharged enough to conduct the planned diving operation or the batteries must be serviced if they are in question. Also, the power must be turned on prior to conducting the diving operation. The Maximum allowed supply voltage is 10.0 volts in the head batteries, and minimum voltage is 6.0. The APECS 4 handset battery maximum is 100%. Minimal is 20% or 1/3 of time needed for decent, 1/3 for ascent or exit, leaving 1/3 for unforeseen circumstances.

APECS 4™ Operating Instructions

Navigation through Menu:

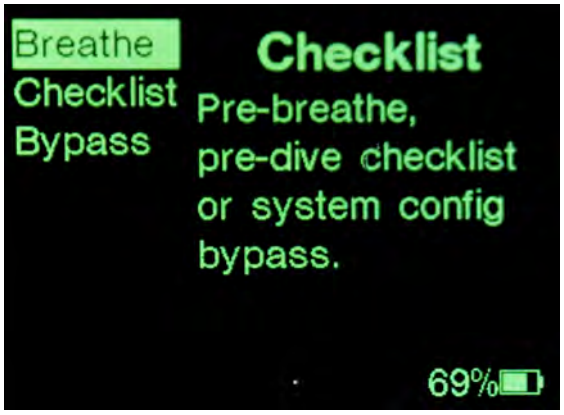
The APECS 4™ handset has two buttons. The top button is the **Action/Confirm** button and it either **unlocks** access to the set point system if the system is placed in **low power** mode, or it can **rapidly** change from the Low, High or ASP set points if it is **not** in a **power saving** mode. **Beware** that if the setting is in a non-power saving setting you could **bump** the button by accident and change the set point setting to a lower or higher set point. **Always watch your PO2!**



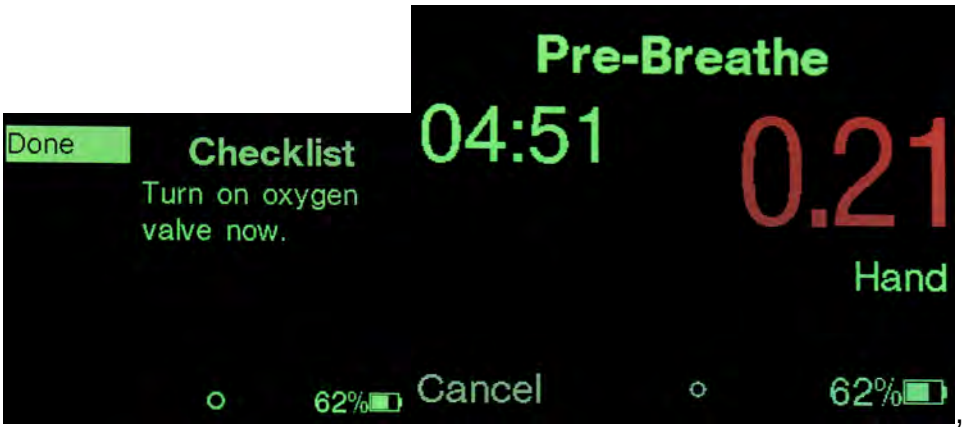
ACTIVATION:

There are **4** ways to **turn on** the APECS 4™ system. First by gently **pushing** the **Menu and Action/Confirm button** on the side of the handset, 2nd by **wetting** your fingers and touching the **wet sensors**. If you touch the wet sensors, the APECS 4 will **go strait to the dive screen and low Set point**. 3rd, the replacement of batteries and power supplies, 4th the plugging in of certain devices. Notice on the handset the opening screen on the APECS 4™. The **opening screen** is the ISC helmet logo and then you will see the colors Red, Green, Blue and White. This is a display color check. The **HUD** also will go through its **color check** of 3 Greens, 3 Reds, 3 Amber, and flash the current PO2 or warning. The **solenoid** will **activate 3 times** and you will hear an audible "click" sound to show the **actuator releasing the oxygen is not frozen**.

After the colored screen testing is done the Handset will settle on **three options; Breathe, Checklist, and Bypass.**



- **Breathe** means “Pre-breathe”. This selection is the first thing the diver will do prior to diving. The diver selecting the Pre-breathe option by pushing the **Action/Confirm** button will display **“Turn Oxygen on now”** The diver if they have not already done so, will turn on both gas cylinders. The diver will then push the “done” button and a 5 min countdown will start, and the diver will start the pre-breathe sequence. After the countdown is done the device will go to the dive screen and set itself to the Low Set Point. At anytime the diver can **cancel** the countdown by pushing the **Action** button the display will go back to the Pre-dive menu showing “Breathe”, “Checklist”, and “Bypass”.

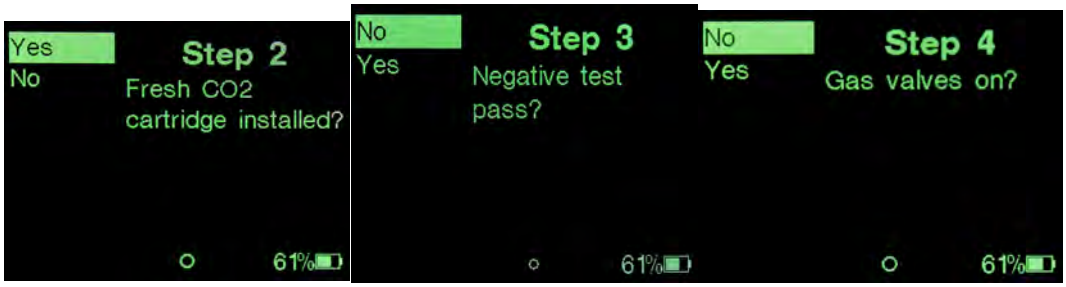


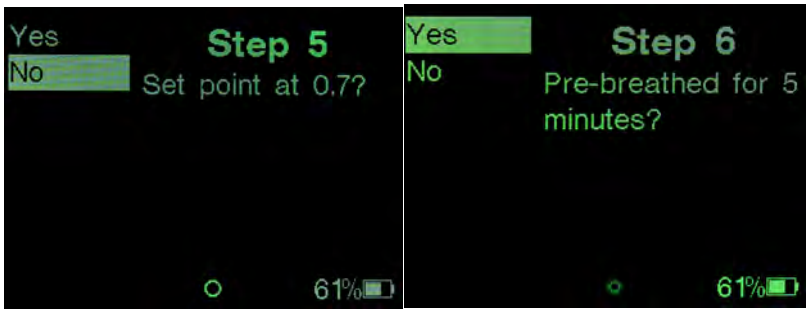
- **Checklist** is the next action taken by the diver **prior** to diving. The diver will answer 8 questions that help ensure the rebreather is starting in a safe condition. All questions are logged so please insure you answer them properly. Once you are in the question and answer mode you must **answer to exit** the checklist.

- Yes or No, Execute checklist?

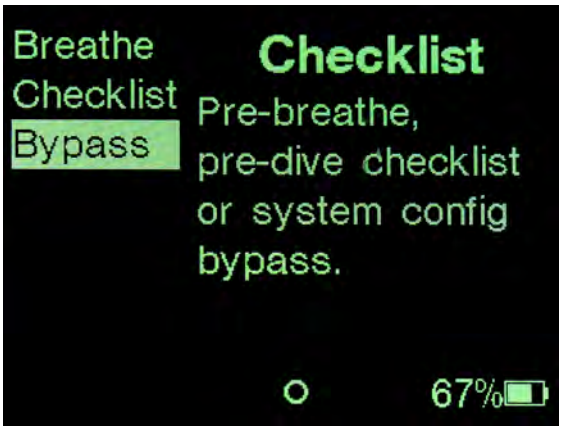
1. Yes or No, Calibrate today?
2. Yes or No, Fresh CO2 cartridge installed?
3. Yes or No, Negative test pass?
4. Yes or No, Gas valves on?
5. Yes or No, Set point at 0.7?
6. Yes or No, Pre-breathed for 5 min?
7. Yes or No, Do displays agree@ set point?
8. Yes or No Any displayed warnings?

NOTE: Any critical question’s not answered correctly will kick you back to Step 1, and your answer will be logged.





- **Bypass** will bypass all the above and take the diver straight to the dive screen and menu options will be available.



NOTE: At anytime before the dive the diver can access the 3 pre-dive options by scrolling down the menu to the "Checklist" option.

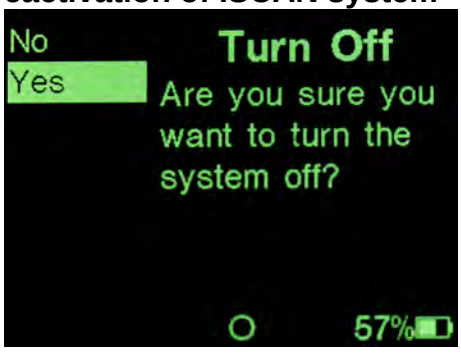
NOTE: The ISCAN system is designed to be "ON" and monitoring relevant oxygen levels surrounding the diver.

4 activation possibilities:

1. **Normal power on by pushing the Menu and Action button.**
2. **Wet sensors.**
3. **Replacing batteries or power supply.**
4. **Installing devices into Primary and Secondary networks.**

NOTE: The system is programed to want to stay on, and failure of the user to insure the system is in an "Off" status can drain batteries if it is not turned off by the APECS 4 or other ISCAN/DiveCAN handsets.

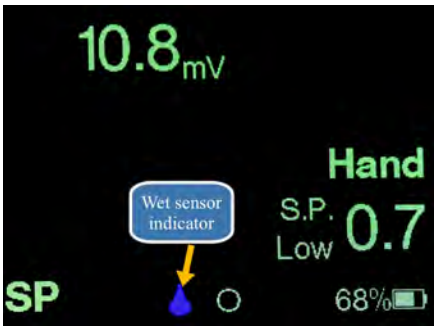
Deactivation of ISCAN system



DEACTIVATON:

To turn system off, simply **Bypass** the pre-dive options and the diver will be in the dive screen, push the menu button and scroll through the menu items on the bottom left corner until “Off” is seen. Push the Menu button until “Yes” is annotated and push the **Action/Confirm button**.

The **only time the diver cannot turn off** the system is if the wet sensor is activated. The diver will not be able to turn off, and adjust calibration settings.



Wet sensor in “On mode.

Primary Handset

The main operational screen will be the diver’s primary diving information on the current status based on operational priorities. In bold numbers in red <0.5 PO2, or green >0.5 PO2, will be the **Average PO2** based off of the 3 sensors and the voting logic system.

The **Average PO2** is what you want to observe primarily for decompression reasons and to see how close you are to your desired set point. To the left of the displayed average PO2 is the **average displayed millivolts (mV)** for all 3 sensors. The diver at any time may observe a color change or blinking of the displayed sensor mV and that is an indicator of a sensor being voted out. The diver at that time may menu to the **sensor page** to see which sensor is voted out. If this is observed, the voting logic is voting out the sensor and continuing the averaging of the two remaining sensors. The APECS 4™ and ISCAN system will self correct if the problem is temporary, if the sensor has failed or connection is broken the diver must abort the dive and exit the water as soon as possible observing all displays and being prepared to conduct an immediate action procedure (IAP). If in **doubt** of what the diver is breathing, the diver should **bailout to another breathing system**.

System Status Indicator: The **SSI** is the **"heart beat**" of the APECS™ and is indicating the operational status of the electronics; the heartbeat is a **continuous growing circle** and on the bottom of the screen. The dive page (PO2 Display) has an additional indicator (*) which when present indicates the **solenoid is attempting to fire (the diver should also be able to hear the solenoid fire and oxygen being injected).**

WARNING! If for any reason the diver observes one frozen single character instead of changing, the APECS 4™ has "Locked up" and the primary system operating the solenoid may be affected. The diver will have to use the other displays to operate the CCR manually and the diver must exit the water as soon as possible and use IAP when necessary.

Menu and Action/Confirm button: Press the Menu button of the primary hand set and scroll through the menu options, the diver will see the following; **S.P (Set Point), Sense (Sensors) SRC (Source) Batt (Battery's), Comp (Compass), Cal(Calibration),Conf(Configuration) Chekist (Checklist), Log, Info (information), Off.** The diver may select an option from the menu and press the **Action/CONFIRM** button and see the option lock into place into a submenu or some operational information the diver may want to see.

WARNING! It is imperative that the diver does NOT enter the water with a PO2 and set point of less than 0.5 PO2 in the breathing loop and/or oxygen cylinder off!!!

DANGER! Do not dive with oxygen sensors older than 1 year.

The Diver at any time may leave the selected option by making a selected menu change to the APECS 4™ or the system will time out in 5 seconds and go back to the main diving informational screen unless the diver selects **Sens** (Sense) or **Comp** (Compass) and those two menu items will stay on for the diver to observe and only be deactivated by the diver by using the **Action** button.

WARNING! Always insure that you have a breathable P02 in the loop, and set point that will also support your planned decompression.

The 0.2 set point is an artificial set point of 0.20 and attempts to maintain a loop PO2 of .20 (Air) at all times. It is **not** for **surface swimming, or diving!!** Assuming the oxygen cylinder is on, the 0.2 is a failsafe set point to avoid hypoxia, and for pre-diving the CCR to avoid wasting oxygen and battery power through solenoid injection. The **0.2 set point** is **only accessed** in the **Conf/Solenoid** menu items. To turn **on** or **off** the 0.2 feature, simply **menu** to **Conf** and press the **Action** button and you will see **Solenoid** highlighted and

press the **Action** button again and you will see the main dive screen with the 0.2 PO2 displayed or if turned off, one of the three set points.

NOTE: If the **0.2** is displayed, then the diver **cannot use** the diving set point options (LOW, HIGH, and ASP) and the diver must turn off the 0.2 option in the **Conf/Solenoid** menu.

WARNING! NEVER USE THE 0.2 SET POINT FOR SURFACE SWIMMING, OR DIVING OR WHEN GEARING UP!

WARNING! INSURE THE OXYGEN VALVE IS TURNED ON WHEN GEARING UP AND THE BREATHING LOOP PO2 SET POINT IS SET FOR AT LEAST 0.7.

S.P: Set point selection is the first menu item on the dive screen and if it not, then the diver may push the **Menu button** until **S.P.** observed. **S.P**. may be accessed by pushing the **Action/Confirm** button. The diver will see one of three pre-set S.P items, **LOW**, **HIGH,** and **ASP**. The first set point is **LOW** usually that is a 0.7 PO2, **HIGH** is usually 1.3 PO2, and **ASP. ASP** stands for Auto Set Point. Auto Set Point is to be used during rapid descents. **ASP** is

Set point set for ASP.

S.P. Set on Low (0.7).

Set point set on High (1.3).normally selected immediately prior to descent; as the diver descends and PO2 rises in the breathing loop, **ASP** ensures that the PO2 does not fall below current displayed PO2 at any point. Once the descent is complete the diver should verify they are factually at the desired HIGH set point. The ASP starting PO2 is 0.5, and the normal high is 1.3. The diver can select the **maximum** PO2 that ASP will maintain on the **SET MAX SET POINT** in the **Config/Manual** menu.

To **reconfigure** the Low, High and the ASP set points to other fixed PO2's, the diver will go to the Conf.- Menu and then Solenoid submenu and Set point.

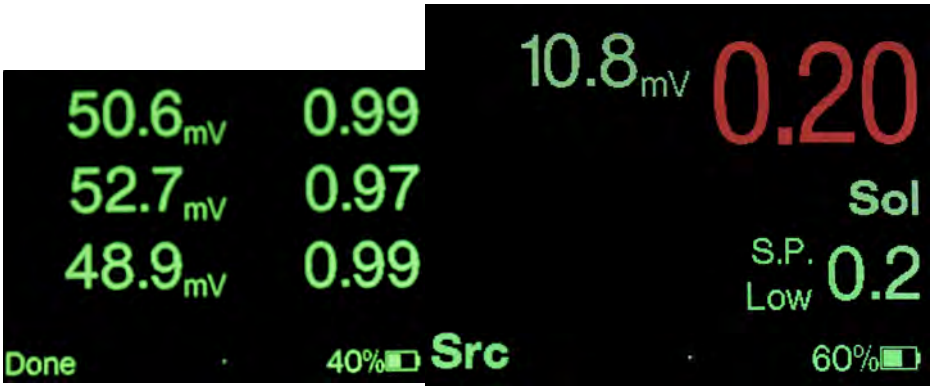
Set point settings:

- **0.2 (Manual) mode. (None adjustable) Found in Conf-Solenoid menu.**
- **Low 0.3 to 1.4 (Normal 0.7) S.P. menu: Action button.**
- **High 0.3 to 1.4 (Normal 1.3) S.P. menu: Action button.**
- **ASP 0.5 to 1.4 (Normal 1.3) S.P. menu: Action button.**
- **Danger High 1.6 (None adjustable) Found in Conf-Solenoid menu.**

WARNING! The diver must ensure that they have a breathable PO2 at all times and maintain the planned PO2 to support the planned decompression.

DANGER! THE DIVER MUST CHECK THE PO2 IN THE BREATHING LOOP EVERY 1-4 MINUTES.

Other considerations for set point selection are **Oxygen CNS toxicity** and **Whole body Oxygen toxicity**, the planned PO2 must insure that all oxygen hazards are avoided by prudent CCR diving practices. So use the oxygen set points wisely.



Sense (Sensors): The Sensor menu item is the displayed data from all three oxygen sensors. The displayed data is reflected in individual sensor mV (millivolts) and PO2. The top sensor displayed is sensor one, then sensor two and followed by sensor three. The diver can use this data to determine what sensor has been voted out, when a sensor is out of range (9.0-13mV, sea level, ambient air)(43mv-62.2mv, sea level, 100% oxygen) and relative speed of response of each sensor. (Fast response sensors are best). When the sensor page is selected it will not automatically shift back to the main diving page, the diver must use the **Action button**.

The sensor mv is an indicator of sensor degradation (health), the diver may see how the sensor is performing at all times during the pre-dive, dive, and post-dive, operations. The diver should record the information on the pre-dive/post-dive check sheet to monitor sensor life and performance over time. **Normal** sensor mv is **9 to 13.0** in air at sea level, 25°c**.** Sensor mv output will be less at higher elevations and or lower temperatures. It is a prudent habit to record the sensor mv at various set points during the dive and to do comparison check on later dives, or to do the mv calculation and compare results with desired set point to insure the diver is at the desired PO2.

NOTE: SEE mV calculation at the end of this document.

Sensor 1 is voted out.

Sensor 1 is voted out. Sensor 2 and 3 are below 0.5 but are still averaging the set point.

DANGER! IF THE DIVER SEES A SENSOR CONTINOUSLY VOTED OUT AND HEARS THE SOLENOID CONTINOUSLY INJECTING OR THE DIVER IS

CONTINOUSLY INJECTING OXYGEN MANUALLY WITHOUT THE CHANGING OF DEPTH, THE DIVER SHOULD SUSPECT THE GOOD SENSOR IS VOTED OUT AND DIVER SHOULD FLUSH THE BREATHING LOOP WITH DILUENT AND SET THE SET POINT BELOW 1.0 PO2 OR SIMPLY BAILOUT!!

WHEN IN DOUBT, BAILOUT!!

SRC (Source) The ISCAN system are controller area networked (CAN) based electronics and each device such as your HUD, APECS 4 handset, and even the Solenoid O2 network system are considered individual devices that monitor the oxygen levels individually and that's why they calibrate with the oxygen sensors independently. It would stand to reason that the diver should be able to see what **each device** is seeing in regards to the oxygen sensors PO2 and mV. On the main dive screen you will see one the device names under the displayed PO2 and that is the device that is reading the current PO2. If diver sees "Hand", that is the APECS 4, if the diver sees "HUD" or "Sol"(Solenoid) then they are viewing the displayed PO2 of that device.

It is standard for the diver to have the main dive screen show the Handset so the diver can know what PO2 it sees. The HUD PO2 will be reflected by the blinking colored LED on the HUD, and the diver can tell if the solenoid is maintaining the proper set point by the way it maintains the desired selected set point by injecting oxygen. Where the SRC feature comes in, is if one of the devices does not match the other devices for the calibrated PO2 and set point, and then the diver can use the SRC to compare and trouble shoot the problem which is normally a bad calibration done by the diver.

Note: PO2 is displayed.

NOTE: No displayed PO2 or mV.

NOTE: The bottom picture is showing no displayed PO2 or mV. The oxygen sensors were disconnected from the ISCAN network system in the Meg 15 or Pathfinder head. Also notice that the battery indicator is still showing green for OK on both head and APECS 4 handset.

NOTE: Calibrate each device at the same time using only ambient air or 100% oxygen at the proper barometric pressure (Altitude) to avoid confusing readings.

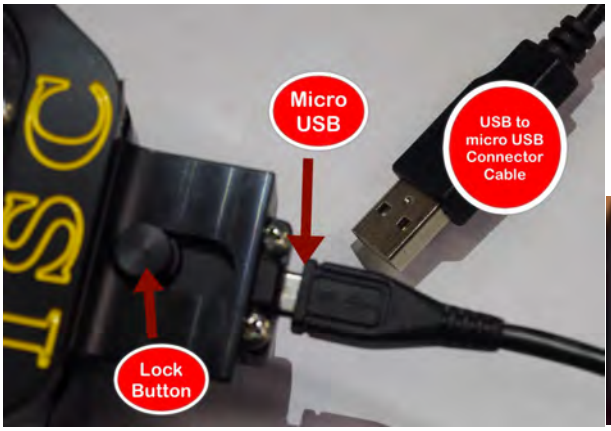
BATTERY: The APECS 4 uses a rechargeable battery that the user can recharge using a micro USB/USB cable and APECS 4 connector plug. The diver should always insure that they have adequate battery % for the length of the dive, and fully charged is a prudent practice if the diver is not sure. The APECS 4 can be charged from a USB wall charger, PC, or in some cases a solar charger.

Depending on the use of the power save feature, brightness of display, and temperature, and turning off when not in use, it is not unheard of to dive for almost two weeks with no recharging when diving 4 hours a day and still have 20% or more left on the battery.

To recharge the APECS 4 handset, slide the recharging plug inside the recessed track on to the side of the handset in between the Action/Confirm button and Menu button, and gently engage the pins by pushing down on the lock button to slide into the receiver. The handset will wake up and the diver can see on the main dive screen the lightning mark over the battery indicator indicating charging. The battery is fully charged at 100%. To speed up charging, turn off the handset and check periodically for complete charging.

To remove charging plug from handset, simply push the lock button down on the plug and slide the plug off the track and disconnect the micro USB and store both components in a dry and protected container to prevent corrosion and damage.

WARNING! The APECS 4 battery must be recharged for the APECS 4 to operate! It is recommended that 1/3 of the charge is used for decent or penetration, 1/3 charge for ascent or exit, and 1/3 for in-water unexpected circumstances.



ISCAN BATTERY:

The ISCAN battery primarily powers the CAN network, solenoid and HUD. The ISCAN system can be a single 9V battery or two 9V batteries, and each CAN network is powered by its own power supply, so in the Meg 15 head you could have 4 9V batteries for extended diving capability and each network has its own pressure proof box. The Pathfinder CCR uses one 9v battery per CAN network and both of the 9v are sealed together inside a single pressure proof box.

The ISCAN system and the APECS 4 have a partitioned power supply feature that gives the diver options in extreme circumstances. If the diver fails to replace a battery, the ISCAN handset, assuming it is adequately charged, will power the CAN network but **NOT** the solenoid, and the diver will have to maintain the oxygen set point manually. The HUD will be powered by the APECS handset.

If the diver has batteries powering the secondary ISCAN network, then the diver will have another independent network to manually operate the rebreather.

The Shearwater NERD and Petrel systems are CAN based devices and are compatible with the ISCAN system and will operate on the same principles explained above, but at no time will they control the solenoid, that is specific to

the APECS systems only. Consult Shearwater manual for battery data and usage/replacement.

WARNING! The lower 9 Volt limit is 6.0 to 5.5 volts; the diver must replace the battery!

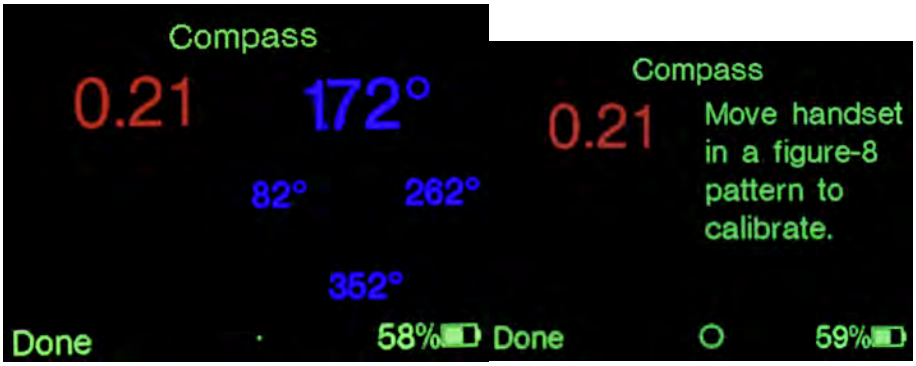
DANGER! Terminate the dive as soon as practical considering decompression and other operational factors. Both conditions warrant the battery to be replaced prior to the next dive!

In most diving scenarios, the diver has adequate time to exit the water without sacrificing safety.

NOTE: Whenever a device or battery is installed, such as a handset, HUD, and of course battery, the ISCAN system in the head may turn itself on. It is the divers responsibility to check the system and insure it is off when not in use. Failure to check may result in a dead power supply.

COMPASS: To activate the compass, simply **Menu to Comp and push the Action button**, and the display will lock on displaying the compass. The compass will show the current direction if held parallel to the diver and the other 3 points of the compass rose will be relative to the direction the diver is facing. The displayed compass rose will give the diver the ability to box around objects or do a 180 without having to do any calculations. The compass rose is displayed in blue and the current average PO2 will be displayed off to the left in Red <0.5 or Green >0.5. To deactivate the compass, push the Action button.

The compass is reasonably accurate, however to do not use for plotting courses or plotted courses on charts or over horizon navigation and where life and limb could be effected. The compass shares the same critical characteristic of all magnetic compasses, so exercise care when using it.



Calibration of the compass is only when the device requests to be calibrated. The device will ask to be rotated in a figure 8, so the diver just needs to hold the APECS 4 handset out in front of them and move the handset in an arcing figure 8.

NOTE: The compass calibration can only be done before the dive out of the water.

Future features on the compass will display depth, time, and decompression data.

CALIBRATION OF ELECTRONICS: Calibration is matching the independent mV output of the oxygen sensors to the electronics and essentially showing the electronics the characteristics of each sensor. By definition, calibration is taking a measurement of a device and comparing to a known reference, and in this case it's the electronics plus sensors and comparing them to Air or 100% oxygen gas at a fixed barometric pressure.

When does the diver calibrate?

- When a sensor get replaced.
- Change in reference gas.
- Change in altitude or barometric pressure.
- When using the Pre-dive assembly checklist.
- When the diver has not used the rebreather over several days.
- When in doubt of sensor performance, such as the voting logic is appearing on a specific oxygen sensor during the course of the dive and the sensor is less than a year old.
- A good rule of thumb is to calibrate when changing the CO2 scrubber canister assuming the above is consulted first.

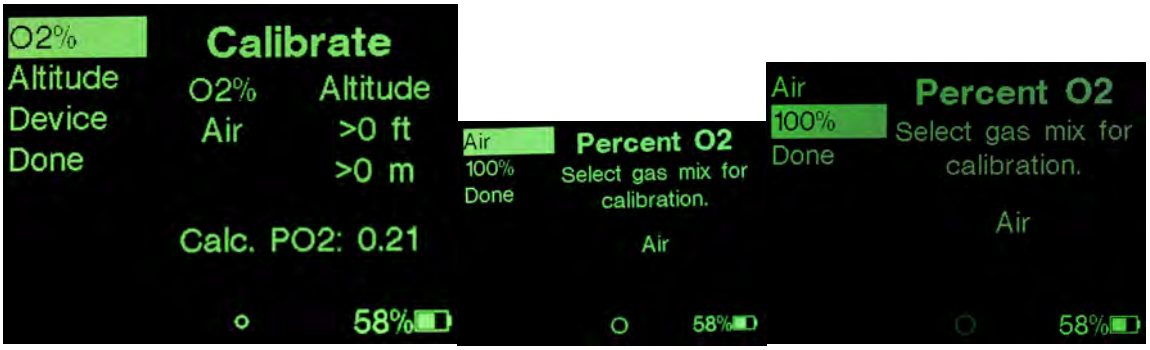
The APECS 4 and the ISCAN system is a single point 2 optional gas calibration system with high altitude oxygen sensor adjustment. The diver can calibrate the electronics to the oxygen sensors using one of two gas references, one being ambient air (0.21) and the other being 100% oxygen and physically adjust the calibration parameters for altitude up to 14,700 feet (4,454 m) at a PO2 of 0.12.

To best perform the calibration procedure follow the Pre dive assembly check sheet and these instructions. When you select the calibration menu, the screen displays the Percentage of oxygen used for calibration and the altitude used for calibrations. This will normally be Air (0.21) or 100% oxygen, and 000 ft or meters sea level. Ensure the calibration reference gas and the altitude are set properly before calibration.

WARNING! IF THE OXYGEN PERCENTAGE AND ALTITUDE IS SET INCORRECTLY THE UNIT WILL NOT CALIBRATE CORRECTLY RESULTING IN A POTENTIALLY LETHAL CONDITION!

DANGER!: Failure to calibrate the sensors to the correct reference gas and altitude will affect the desired breathing mixture in the CCR breathing loop that can lead to decompression illness or death from hypoxia or hyperoxia. Bad Data in is Bad DATA out!!

Warning! Know your reference gas and altitude! Always analyze the oxygen in the cylinder if 100% oxygen is selected for calibration. If reference gas is not 100% oxygen, then select Air for the calibration reference gas.



To start the calibration process, push the **Menu** button until **CAL** is **displayed** and push the **Action** button and the calibration page will be displayed. The diver will see on the left of the screen O2%, Altitude, Device and Done. To the right and under the word calibrate the diver will see O2% and under that will be either the reference gas “AIR or 100%. The diver can select either gas by using the Me**nu, Action** button on the highlighted character. When done the diver can select “Done” and push the **Action** button to exit the Oxygen %.

Altitude selection is done the same way as selecting the Oxygen %. Menu to “Altitude” and push the Action button and the diver can select Alt up or Alt down until the proper altitude zone is selected.

The following table illustrates the permissible altitude zones.

Altitude Zone in FEET (Meters)	LoPO2 in AIR	HiPO2 at 100% Oxygen
> 0 (0)	0.21	0.99
> 1,200 (327)	0.20	0.96
> 2,700 (818)	0.19	0.90
> 4,200 (1272)	0.18	0.86
> 5,700 (1727)	0.17	0.81
> 7,200 (2181)	0.16	0.76
> 9,000 (2727)	0.15	0.71
> 10,700 (3242)	0.14	0.67
> 12,700 (3848)	0.13	0.62
> 14,700 (4454)	0.12	0.57

NOTE: Once the Altitude zone is selected, the Calc. PO2 will be displayed at the bottom of the Calibrate page confirming to the diver the reference PO2 for that altitude.

1. Initial display shows "**Current PO2 = .21**". This is the current setting as last calibrated.

2. Prompt line initially asks > 000 FT and shows = (the current PO2)(current **MAX OXYGEN** setting) i.e. .21 ….100.

3. The **Action** button in this submenu adjusts the Alt. Up or Alt. down. The bottom point in the zone represents the HiPO2 result as just described.

Example, 21%O2, altitude is 6,500 feet (1,969 meters). LoPO2=0.17, HiPO2=0.81.

The altitude menu calculates the high point PO2 to be the HiPo2 at 100% oxygen times the oxygen percentage currently set in the **MAX OXYGEN** menu and displays the result as the HiPo2 as the diver selects the appropriate altitude zone.

HEAD ONLY METHOD CALIBRATION:

To calibrate the independent ISCAN devices such as the APECS 4, HUD, and Solenoid, using the **head only method using AIR**. The diver Menu's down to the

Device option and pushes the Action button and the Device Icon will be highlighted. The devices that are physically linked up on the primary network will be displayed. Assuming the APECS 4, HUD are connected to the primary network you will see their name. Simply push the Action button and for the first device and you will see a message stating; **"Primary Handset Primary O2 Calibration successful"** If you see any other message you have not calibrated the device and you need to trouble shoot the system.

Calibrating the HUD and the Solenoid is conducted the same as above. Calibration should take less than 3 seconds for all three devices.

NOTE: If the diver does not see the Device annotated for calibration, the device may not be connected or has a bad battery.

When done with calibration, simply menu out of the calibration page by pushing the Action button on "Done" and the diver will go back to the main diving page.

Warning! After calibration, all displays must be within 0.05 ATA/Bar of each other.

To CALIBRATE USING 100% OXYGEN:

NOTE: Insure the reference gas cylinder has been analyzed prior to calibration of the ISCAN electronics.

Loop Flush High Point Calibration

1. Perform all Pre-dive check procedures up to the step "Complete calibration if necessary". To complete calibration, all performance checks prior to this need to be completed. Insure that negative pressure check step was good and apply another vacuum to the loop sucking all the ambient air out of the loop. Next, close the vent valve on the exhaust counter lung and fill the loop with 100% Oxygen until the vent valve vents gas. Let set for 10 seconds.

2. Tightly pinch the inhale breathing hose to isolate the exhaust counter lung from the oxygen bypass on the inhalation counter lung.

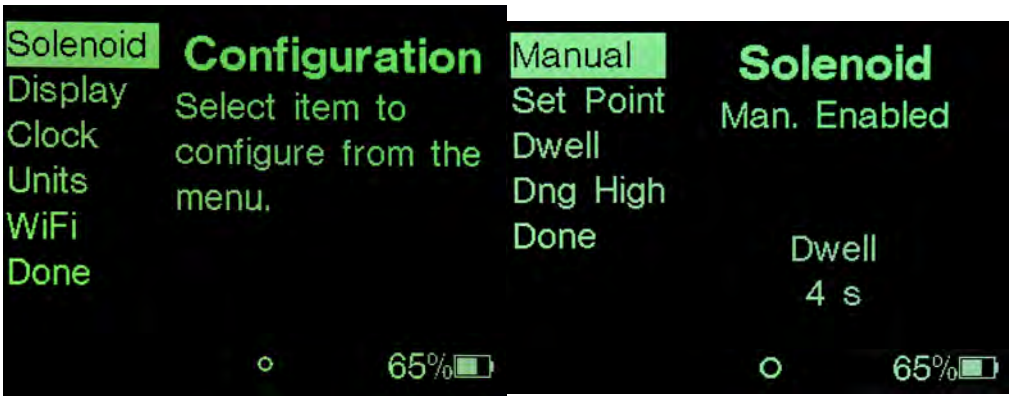
3. Push the oxygen manual bypass for 3-6 seconds; this will blow 100% oxygen over the sensors.

4. You now have a purged loop with 100% Oxygen. You will observe the sensor millivolt output in the APECS 4 display and the normal output is in the **zone of 43 to 62.2 millivolts. Any lower than 43mV, discard.**

Note: The lower the sensor mv output at both points of calibration the lower the sensor mv reading. Beware that the sensor is reaching its end of useful life.

Warning! After calibration, both displays must be within 0.05 ATA/Bar of each other.

CONFIGURATION MENU: The configuration menu gives the diver access to the solenoid functions, Display functions, Clock settings, Units for Imperial and Metric, and Wi-Fi communication.



To access the **Config** menu, push the menu button until the diver sees **Config** and push the **Action** button to enter the menu. The diver will see a list of submenu's, Solenoid, Display, Clock, Units Wifi, and Done.

The diver can simply **selec**t one of the submenu's by highlighting it with the **Menu** button and push the **Action** button.

Solenoid: The solenoid submenu allows the diver to access solenoid control.

Manual: The 0.2 set point is an artificial set point of 0.20 and attempts to maintain a loop PO2 of .20 (Air) at all times. It is not for surface swimming, or

diving!! Assuming the oxygen cylinder is on, the 0.2 is a failsafe set point to avoid hypoxia, and for pre-diving the CCR to avoid wasting oxygen and battery power through solenoid injection. The **0.2 set point** is only accessed in the **Conf/Solenoid** menu items.

To turn **on** or **off** the 0.2 feature, simply menu to **Conf** and press the **Action** button and you will see **Solenoid** highlighted and press the **Action** button again and you will see the main dive screen with the 0.2 PO2 displayed or if turned off, one of the three set points.

NOTE: If the **0.2** is displayed, then the diver cannot use the diving set point options (LOW, HIGH, and ASP) and the diver must turn off the 0.2 option in the **Conf/Solenoid** menu.

Set point: The Set point sub menu allows the diver to pre-set the Low, High, and ASP set points from Low to High. The diver can do this at any time even during the dive. The Set point pre-set allows the diver to customize the oxygen level in the breathing loop instead of the standard 0.7, 1.3, and ASP. Never use any higher PO2 Set point than necessary. Remember to consider when selecting new set points the oxygen exposure limits and age and condition of oxygen sensors.

Set point settings:

- **0.2 (Manual) mode. (None adjustable)**
- **Low 0.3 to 1.4 (Normal 0.7)**
- **High 0.3 to 1.4 (Normal 1.3)**
- **ASP 0.5 to 1.4 (Normal 1.3)**
- **Danger High 1.6 (None adjustable)**

Dwell: Dwell is the off period in between the solenoid injections. **Normal** dwell time is **6** seconds but the diver can set the dwell from 4, 5, 6, 7, and 8 seconds. The diver may elect to select a lower dwell time for divers that are large and are heavy breathers and have a high VO2 and the oxygen injections are undershooting the set point. The higher dwell times are for smaller divers or divers that do not have high VO2's and the oxygen injections are over shooting the set point. Selecting the correct dwell time will also save battery power and over use of oxygen. The purpose of controlling the required off time between solenoid "firing" is to allow time for the oxygen in the loop to homogenize to help avoid spikes in PO2 and to facilitate the operation of the Adaptive Injection Algorithm. The duration of time the solenoid is permitted to "fire" is controlled by the Adaptive Injection Algorithm (AIA). The Adaptive

Injection Algorithm monitors the current PO2 and adjusts the permitted "firing" time to maintain the desired set point as determined by ASP(current set point on descent) or set via the **SP** menu. The permitted solenoid "firing" durations range between a .25 second and 4 seconds depending on the rate of response of current PO2 vs. desired PO2. To access the Dwell time, simply use the Menu and Action buttons on the highlighted submenu.

- **WARNING! It is the diver's responsibility to monitor and maintain a safe PO2 at all times, and to monitor the rate of change of PO2 especially during times of high workload, descents and ascents! COMPLANCY KILLS!**

Dng High: Danger high is an optional 1.6 PO2 set point used for expediting decompression at 20 fsw (6 msw). Traditionally the diver has to manually add oxygen to exceed the programed set point to reach 1.6, now the diver can set the electronics to Dng high. To access the sub menu, simply use the Menu and Action buttons on the highlighted submenu. Upon programming Dng high, the main dive screen will be displayed and

1.6 will replace the last known set point. To quickly exit the 1.6 set point, simply push the Action button and it will take you to the last set point.

- **Done:** (Exit) To access the sub menu, simply use the Menu and Action buttons on the highlighted submenu and the diver will exit.

Display: The display menu allows the diver to enter the submenu's controlling the brightness, rotation and power saving features. To access the sub menu, simply use the **Menu** and **Action** buttons on the highlighted submenu.

- **Bright:** Bright is recommended for high ambient light on land or underwater.
- **Med:** Medium is the normal brightness mode.
- **Dim:** Is very low light and power saving, but very hard to see in high ambient light.
- **Pwr save**: The power save feature is used for two functions, one is power saving and the other is Locking out the Action and Menu buttons. The diver may select one of the above brightness functions and set the Power saving function and the handset will dim in about 8 seconds and save power. To "wake" up the display the diver can push the **Action** button and take a look at the display. The other function is to **"Lock"** the display from **accidental changing** of the set point by the **Action or Menu** buttons. To
-

unlock the function, the diver **pushes** the **Action** button once to wake up the display and again to change set points or use the Menu button.

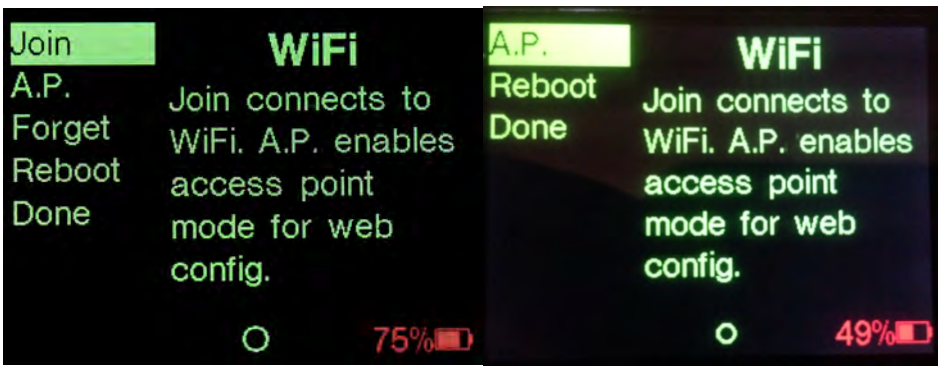
- **Rotate:** This feature allows the diver to rotate the screen if desired to use the APECS 4 handset on either arm or ISCAN primary or secondary network.
- **Done: (**Exit) To exit submenu's, high light Done using the Menu button and press the Action button and the diver will be returned to the dive screen.

NOTE: With the above three options the diver has great flexibility with which to manage power and handset readability.

CLOCK: The clock allows the diver to set relative time in 24hour time increments and the current date. This is important for logging purposes. To set the time and date the diver just has to use the Menu and Action button and highlight the desired function and press Action to move to the next function or use menu to add or subtract a character. The date is displayed as Month/Day/Year.

UNITS: The Units menu allows the diver to choose between metric and imperial units of measurement and Fresh and Salt water. Care should be taken that both the primary and secondary systems are set to the same setting to avoid calibration problems.

Wi-Fi: The Wi-Fi communications system is a feature that allows the user to upgrade or enter feature sets in the APECS 4 and the ISCAN system.
To access Wi-Fi mode, Menu and press Action button to enter Conf, highlight using the Menu and Action buttons on Wi-Fi. Enter the Wi-Fi and the diver will see one of two modes; Join or A.P.



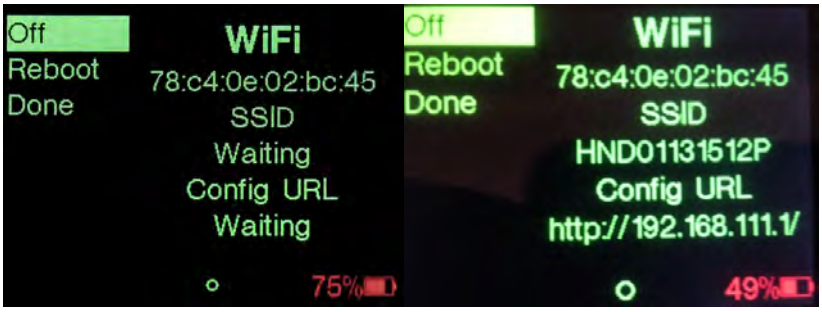
A.P. (Access Point) A.P. initially enables Wi-Fi network configuration. A.P. is the first thing the diver will set up to the diver will enter information needed so the APECS 4 and ISCAN systems can join the divers existing network.

A.P. also provides user information and access to diving logs.

A.P. will not allow the user to perform firmware updates.

JOIN: Join mode is used when the user has already programmed through A.P. a current user network and is used to rejoin that existing network.

A.P. OPERATION: Enable the highlighted A.P. mode using the Menu/Action buttons. The system will activate A.P. and it will take about 30 seconds. The diver will see “Trying”. Once the APECS 4 fully enters A.P. mode, it will display the name of the network it created (SSID). The APECS 4 will also display a URL that the diver can enter into a web browser and connect to the handsets integral webserver.



Once the APECS 4 A.P. mode, the diver can use their phone, laptop, desktop, or other devices that has Wi-Fi to connect to the APECS 4 SSID number.

Example: iPhone, go to the phone settings, access Wi-Fi and look for “Choose network” and look for the APECS 4 SSID number, and push the option. The phone should now see and checkmark the APECS 4 SSID number. (HNDO1131512P) and your phone or device is now connected.

NOTE: If the APECS 4 does not have an SSID number, it will be A4.1CE.

NOTE: APECS 4 handset may be connected or disconnected to the ISCAN system (Meg 15 head, Pathfinder head, or other ISCAN electronics) for it to connect. But for total system firmware updates, all devices need to be connected.

Next is to use the connected device web browser to connect to the APECS 4 integrated web server. When in A.P. mode the URL will be http://192.168.111.1/

iPhone photo.

The above screen may be used to enter information that will allow the APECS 4 to connect to your home or hotel's Wi-Fi network.

At this time the diver may enter the Wi-Fi network name into the SSID field and enter the passcode into the security field. The diver may enter authentication options on how the APECS 4 gets it's IP address.

Owner information filed is for the owner to program the APECS 4 with their name and contact information such as email. This information will be present on the Menu item "Info" screen.

Viewing dive logs link: This option will give a diver a list of all available dive logs. The diver can click on them to download the diver log data as a CSV file that can be imported into an Excel or some other spreadsheet application. The dive logs link is best used with a computer.

After the data has been filled in, push the submit button at the bottom of the page. Next is to go back to the APECS 4 handset and select **"Off" (NOT DONE!!)** Off is the highlighted "Off" icon. Selecting off turns off the Wi-Fi and the screen will go back to the initial Wi-Fi screen. If you did push **"Done"** instead of "Off" you may return to the screen and select "Off".

Once the Wi-Fi has been turned off, **and** the diver has programmed the new SSID and pass code **and** applied the "Submit" button, the diver will see two new Wi-Fi menu options: **Join and Forget**. If the diver does not see the additional options then the diver did not program the SSID or push the "Submit" button.

Join enables the user to access the users programmed Wi-Fi network, and will appear with **A.P**. menu option on Wi-Fi start up.

Forget enables the user to erase the SSID and passcode from the APECS 4 and will remove **"Join"** from the initial Wi-Fi start up.

Once the APECS 4 has been successful in joining the Wi-Fi network, the screen will again display an SSID and URL. The SSID will be the new programmed one. The URL will show the IP address of the local router assigned to the handset.

If the diver uses a laptop or phone and connects to the same SSID, the diver can enter the URL into the browser to get to the APECS 4 internal web server.

Upload feature: The upload feature can transfer log files to the ISC server. This is not useful for the diver unless the diver is experiencing strange behavior, or the log files need to be reviewed by ISC. This is a diver option not generally accessible by ISC.

Update feature: The update feature allows the APECS 4 and any connected devices to connect to the ISC server to see if there are any firmware updates available for the system. The system will either say everything is up-to-date, or give the diver the option of updating devices. The system will tell the diver how many items to down load such as 5 and tell the diver what items of that 5 have been downloaded. While updating, a progress percentage will be displayed until 100% is reached.

All system devices after the upload of new firmware will automatically reboot with the exception of the APECS 4 handset. The APECS 4 waits until it is done updating all the devices and then asks the diver to "Reboot" the diver should say "Yes".

In the future, ISC will provide other features such as Decompression computer with a removable depth sensor system, and other firmware/hardware that will add more advanced features for the divers enjoyment. ISC will post upgrades on the web site www.megccr.com and on social medial sites.

To program future features, the diver will need to use a special log in and use the serial number on the APECS 4. When the diver performs the "Update" the APECS 4 will see the new feature and ask the diver to "Enable" to turn it on.

STEPS IN ORDER:

1. **Enter A.P. mode.**
2. **Connect to the APECS 4 web server using the specified Wi-Fi network name (SSID) and URL.**
3. **Enter Wi-Fi network information.**
4. **Turn Wi-Fi off on the APECS 4.**
5. **Select Join to connect to programmed Wi-Fi network.**
6. **Once connected, select "Update" to get the latest firmware. If there is an update for the APECS 4 handset, select "Reboot" when it asks. If no update available, select, "Off" to turn off Wi-Fi.**
7. **To down load dive logs, use "Join" or "A.P." and connect to a computer.**

Secondary Network

The secondary ISCAN network is an optional CAN based network that the diver can use with any APECS handset or a Shearwater dive computer system that is Dive CAN based. All the diver has to do is connect a device into the Secondary network and install the battery into the power supply. The secondary network is totally isolated from the primary system in regards to information, power supplies, and calibration, the secondary network does not control the solenoid in any way. The secondary network is a monitor system only. The only commonality between the primary handset and the secondary handset are the sensors, each displaying the sensor output. The secondary and the primary handsets are truly isolated and independent from each other. It has been shown that a severed hand set cable (bare wires in salt water) does not affect the independent systems

HUD Operation

The HUD is only available on the secondary handset system of a dual APECS system or on the Primary handset on a Shearwater configuration; it displays the 3 individual sensors by color and number of blinks. The diver may at any time

turn off the HUD especially after the dive to save battery power and may turn it back on at any time.

Note: If the HUD is disabled and the PO2 falls below 0.5 the HUD will automatically enable until such time as the PO2 rises above 0.5 at which time it will automatically disable.

The HUD brightness may also be adjusted to bright and dim. The dim may be used when there is no ambient light and the bright may be too bright. The dim does not save any more power as the bright; in fact it uses more power.

The HUD is a powerful indicator to you and your buddy or student, at any time the buddy/instructor can see what you/buddy/student are breathing and the condition of each sensor by looking at the color and number of blinks.

The following is a brief explanation of the HUD color and number system (single LED HUD).

Color	*PO2*	*Blinks*	*Condition*
Red	*<0.50*	*Rapid Blink*	*Preliminary alert to a HYPOXIC loop.*
Red	*0.5*	*5 Short*	*Ambient air.*
Red	*0.6*	*4 Short*	
Red	*0.7*	*3 Short*	
Red	*0.9*	*1 Short*	
Orange	*1.0*	*1 Short*	*Post calibration on O2*
Green	*1.1*	*1 Short*	
Green	*1.2*	*2 Short*	
Green	*1.3*	*3 Short*	
Green	*1.4*	*4 Short*	
Green	*>1.5*	*Rapid Blink*	*Preliminary alert to HYPEROXIC loop.*

Example: During the dive the diver has a set point of 1.2, the diver will observe the following on the HUD, Sensor 1, green blink blink, pause, Sensor 2, green blink, blink, pause, Sensor 3, green blink blink, long pause and back to Sensor one again.

Note: The system is very simple and is more complex to explain then to interpret.

NOTE: ALTERNATING RED/GREEN FLASHING IS AN INDICATOR THAT THE HUD IS OUT OF CALIBRATION.

DUAL LED HUD: The dual LED configuration features two LEDs oriented approximately 90 degrees apart to facilitate divers with various degrees of color blindness. The upper LED is dedicated green and the lower LED is dedicated Red. The blinking pattern is identical to the table above with the exception of a PO2 of 1.0 will cause both the red and green LEDs to blink instead of one LED blinking orange.

DANGER! The diver at all times must be aware of the proper operation of the primary and secondary systems. If the primary network at anytime fails to activate and display the PO2 on the APECS 4 or HUD, your solenoid may not activate due to the failure.

DANGER! If the secondary network fails and assuming you are using an ISC approved decompression computer, you may not be able to use the decompression computer. The diver must insure that they carry an independent decompression calculating system.

APECS / SHEARWATER PURSUIT CONFIGURATION

ISCAN hardware, in combination with APECS 4, permits safe integration of third party decompression solutions. At present only one product has met the stringent criteria and testing for integration with ISC CCR's and that is the Shearwater Dive Computers with Dive CAN. Integration is achieved by Plugging in the secondary network. The Shearwater is powered by it's own internal battery. The ISCAN secondary network provides information to the Shearwater device and provides real time decompression data to the diver.

The ISC I22D oxygen sensor cells are connected to the Primary and secondary networks via isolations system. A fault with either the Isolation board or the Shearwater system or cable will not affect the APECS/ISCAN network and vice versa.

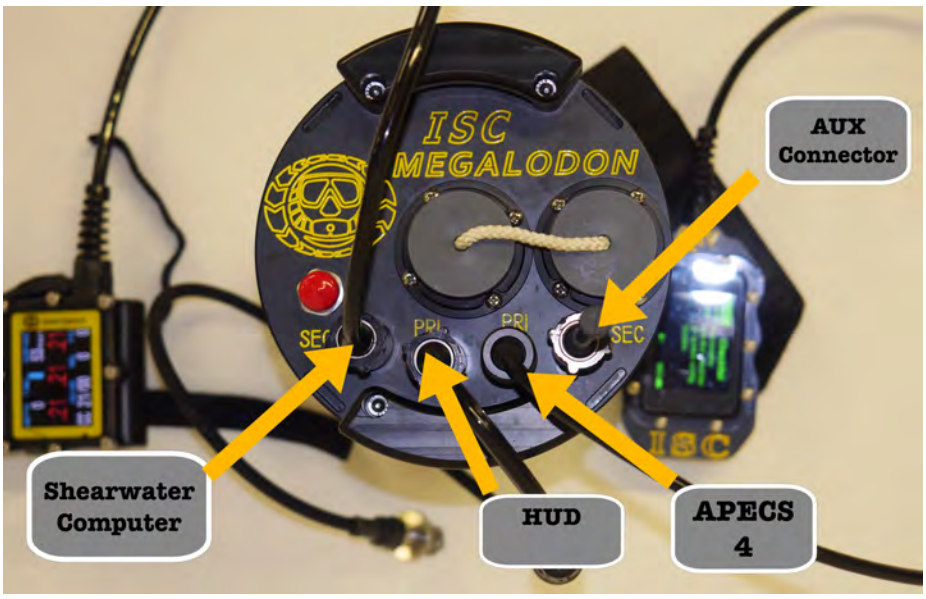
Operational instructions and operating procedures and limitations as well as software updates and support are available directly from Shearwater Research Inc. (www.rebreather.ca).

DESCRIPTION AND MAINTEANCE OF THE MEG 15 HEAD ASSEMBLY

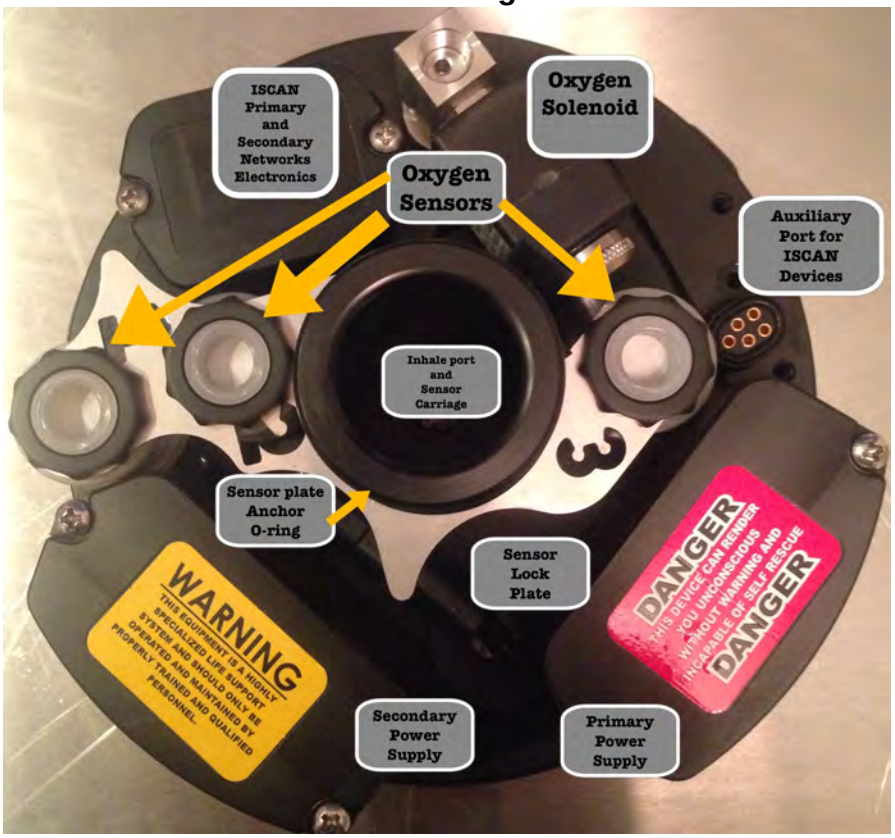
The Meg 15 head assembly is a generation change to the time tested Megalodon head assembly that use the APECS 2.5/2.7 and the U.S. Navy MK-28.

MEG 15 head assembly, with APECS 4

Item description on top of Meg 15 head



Underside of Meg 15 head



SubConn Waterproof connectors.

ISC is fundamentally against connectors as they decrease reliability by the overuse or incorrect use by the user. ISC has identified a waterproof connector that used wisely and correctly will offer years of reliable performance.

The SubConn Connector is a water/pressure proof connector that is rated for depth of ocean. It has 5 gold contact conductors encapsulated in EPDM rubber and the connector is designed to be a dry or wet plug.

The ISC Meg 15 and Pathfinder CCR systems use the SubConn connectors to provide the diver with options of easily replacing a damaged or failed device, or making custom configurations by easily switching positions of ISCAN devices.

Each ISCAN network on the Meg 15 head assembly has two SubConn connectors; 2 Primary and 2 Secondary. The APECS 4 is connected to the Primary network on the left shoulder connector and issues user commands to the Solenoid. The HUD is connected to the Right shoulder Primary connector.

If the diver wishes to use the Secondary network, then they must install the battery and connect another device on the Right SubConn connector. The device may be another APECS 4 or a Shearwater DiveCAN computer. The remaining secondary connector **MUST have a blank SubConn installed to prevent damaging the connector.**

The Pathfinder head SubConn connectors is the same with the exception of having one less Secondary connector.

WARNING: Do not dive with any disconnected SubConn connectors!

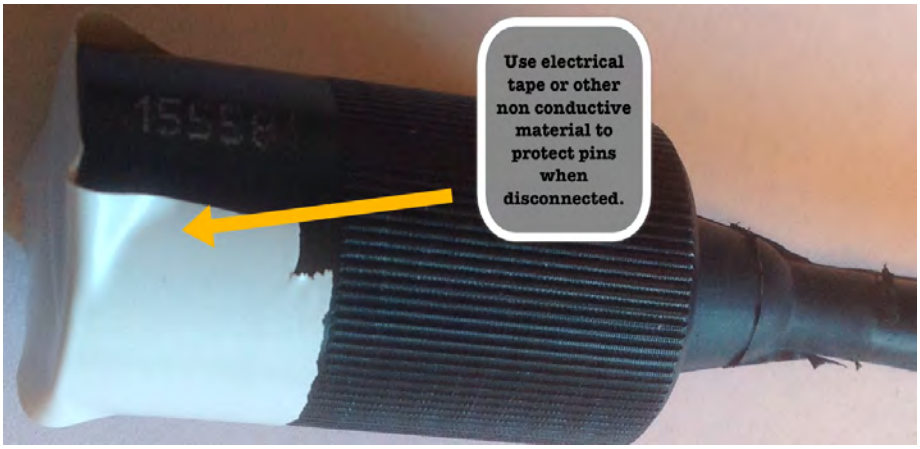
Handling:

- Always protect SubConn connectors when not connected to head assembly.
- Always leave connector installed, unless for maintenance or travel.
- Inspect for corrosion on connectors after long storage, every month, or before a diving trip.
- Lightly grease connectors with approved grease.
- Disconnect by gently gripping the plug and not the wire and pulling straight out not at an angle.
- Install connectors by gently pushing straight into female connector port and lock down with locking sleeve.

Cleaning:

- It is best to clean all electrical connectors with 100% isopropyl alcohol but only if corrosion is observed. Only use other contact cleaners on the outside of the breathing loop.
- Use a soft toothbrush for gently cleaning the conductors on the SubConns.
- **New grease must be applied after cleaning!**

SubConn connector for APECS 4/Aux Devices



Alcohol can clean all electrical contacts and displace water from a flood!

Corroded SubConn and damaged EPDM seal from lack of grease.

Connector cleaning kit

WARNING!

Do not use electrical solvents or cleaners on electrical connectors inside the breathing loop. Only use 100% Alcohol.

See YouTube video on SubConn care.

OXYGEN SENSORS

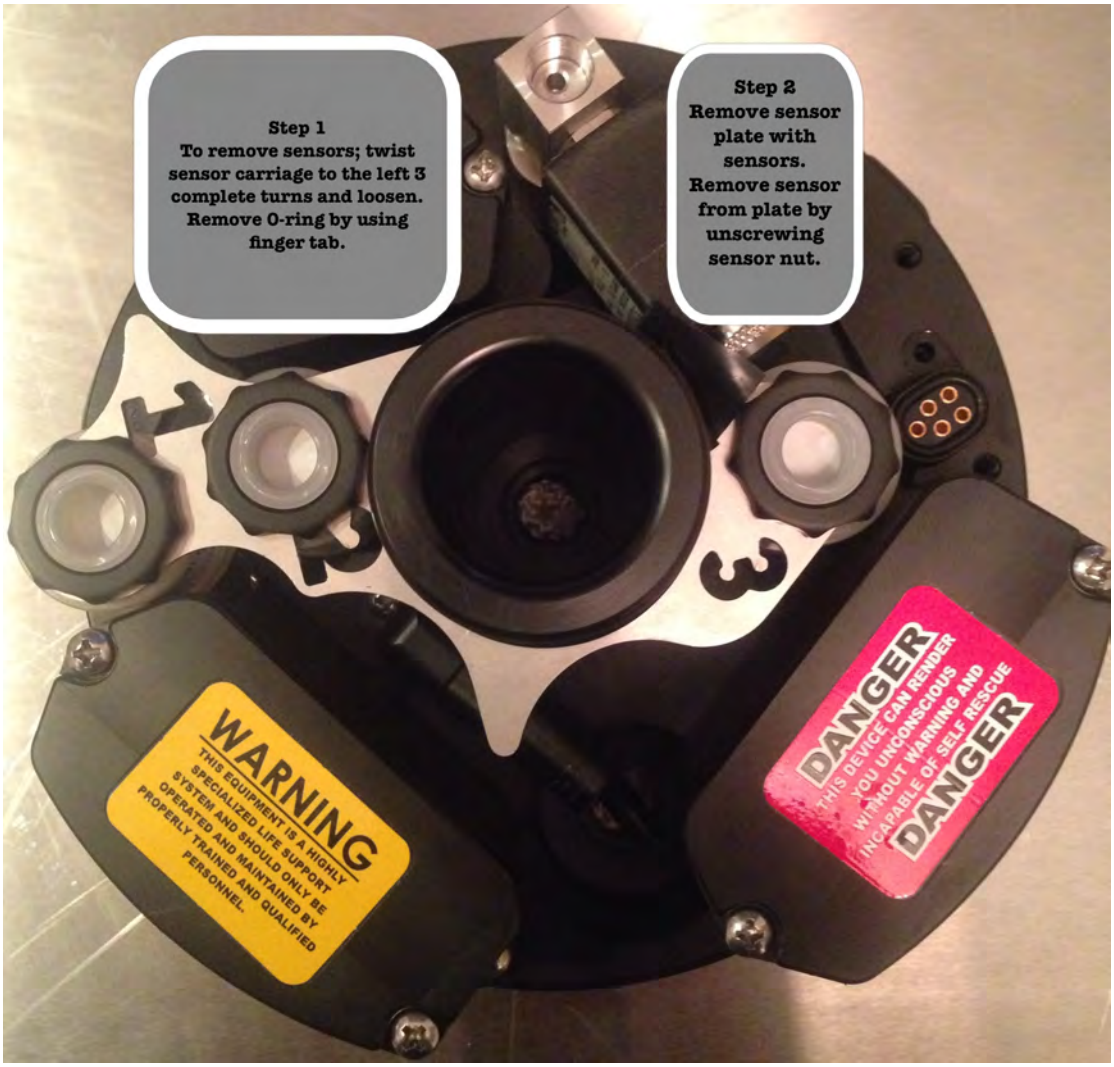
- Use only the approved ISC I22D oxygen sensors. They are the only sensors tested with the Meg-15 and ISC rebreathers.
- Replace oxygen sensors once a year or from the date of receiving in the mail. Check the manufacture date and insure the sensors are not over 6 months old first. If they are contact ISC.
- **Do not use oxygen sensors in CCR if they are not acting perfectly from when they were new!**
- **See System requirements page for more information.**

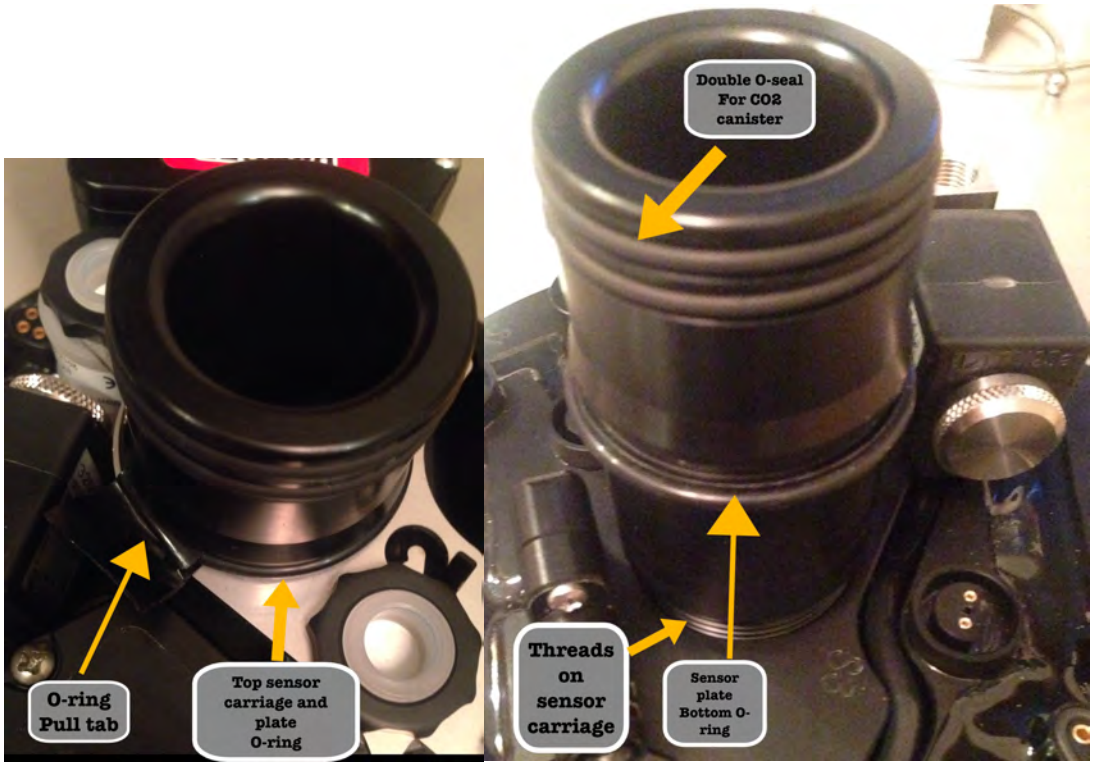
Removal of Oxygen Sensors:

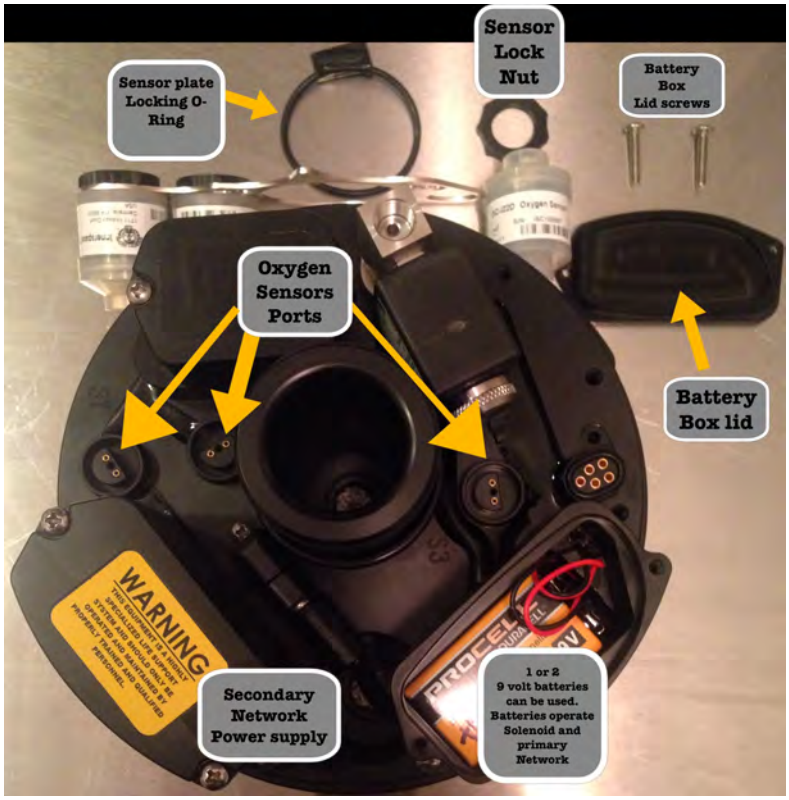
- Unscrew sensor carriage 3 complete turns to loosen sensor plate.
- Remove O-ring locking down the sensor plate by pulling on the finger tab.
- Gently remove sensor plate with all three oxygen sensors.
- **Do not drop sensor plate or sensors!!!**
- Remove one or all oxygen sensors from plate by unscrewing sensor lock nut.

Reinstallation of oxygen sensors:

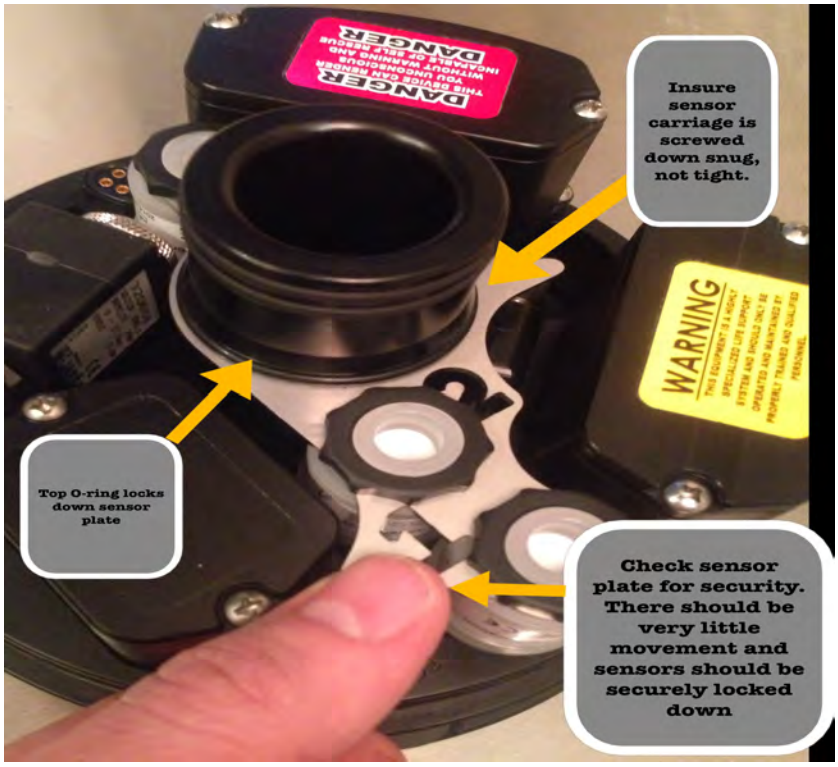
- Label oxygen sensor before installing with date and position of sensor in docking port.
- Install oxygen sensor into their respective docking port.
- Place the sensor plate on top of the sensors and secure the sensor locking nuts.
- Replace the sensor plate O-ring and insure the tab is sticking out the side.
- Twist the sensor carriage back down snug and not tight! Sensor plate should be secure and not move. The sensors must be tight in the docking port and not loose.
- Check plate for movement.


Step 1
To remove sensors; twist sensor carriage to the left 3 complete turns and loosen. Remove O-ring by using finger tab.
Step 2
Remove sensor plate with sensors. Remove sensor from plate by unscrewing sensor nut.
1
2
3
WARNING
THIS EQUIPMENT IS A HIGHLY SPECIALIZED LIFE SUPPORT SYSTEM AND SHOULD ONLY BE OPERATED AND MAINTAINED BY PROPERLY TRAINED AND QUALIFIED PERSONNEL.
DANGER
THIS DEVICE CAN RENDER YOU UNCONSCIOUS WITHOUT WARNING AND INCAPABLE OF SELF RESCUE
DANGER


Double O-seal For CO2 canister
O-ring Pull tab
Top sensor carriage and plate O-ring
Threads on sensor carriage
Sensor plate Bottom O-ring


Sensor Lock Nut
Sensor plate Locking O-Ring
Battery Box Lid screws
Oxygen Sensors Ports
Battery Box lid
WARNING
Secondary Network Power supply
1 or 2 9 volt batteries can be used. Batteries operate Solenoid and primary Network


Drop sensors in respective docking ports and secure with Sensor plate.
Sensor 1
Sensor 2
Sensor 3
Only use ISC I22D Sensors



Replacing Meg 15 9 Volt head batteries: The Meg 15 head has two independent ISCAN networks the Primary and Secondary that are individually powered by 9 volt batteries in respective pressure proof boxes. The Primary side has the “Danger” sticker on it and the Secondary has the “Warning” sticker on it.

Each network is independent from the other and the **Primary** is the only side that **powers the solenoid that feeds the oxygen** to the breathing loop assuming the set point oxygen addition system is used **and oxygen is turned on.**

Each network can independently operate off of one 9V battery or two, and having one 9V battery in the Primary network will effect the endurance of the electronic powered solenoid. If the Primary battery dies, the diver will have to maintain the fixed PO2 (Set point) manually and that should never be a problem for a well-trained CCR diver.

At worst case if the diver kills the Primary or Secondary 9 Volt battery, the APECS 4 handsets themselves to including the ISC/Shearwater DiveCAN computer can power the network itself, but again not the Oxygen solenoid.

Battery replacement steps:

- Turn off all electronics at the handsets.
- Unscrew the respective top of the power supply.
- Carefully remove either one or two batteries.
- Reinstall new battery and carefully place wires on top.
- Coat the O-ring seal inside the battery box with Dow Corning 111 and replace battery lid.
- Screw down screws being careful not to cross the threads.
- Only screw down screws until snug and not tight!
- Turn on system and check for battery levels and document in Pre-dive assembly check sheet.
- **Insure you turn off all the networks from the APECS handset or Shearwater DiveCAN handset or the system will be operating and kill the batteries.**

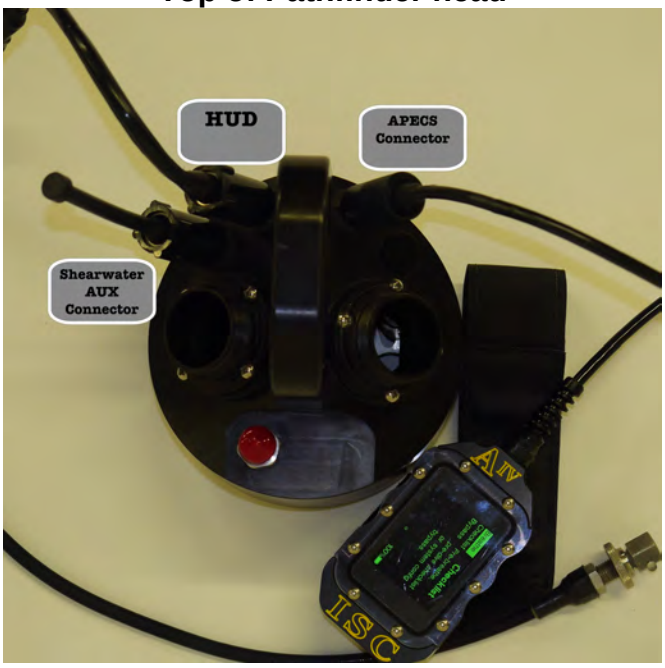
NOTE: Replacing batteries will activate the ISCAN networks. It is the divers responsibility to insure they are turned off.

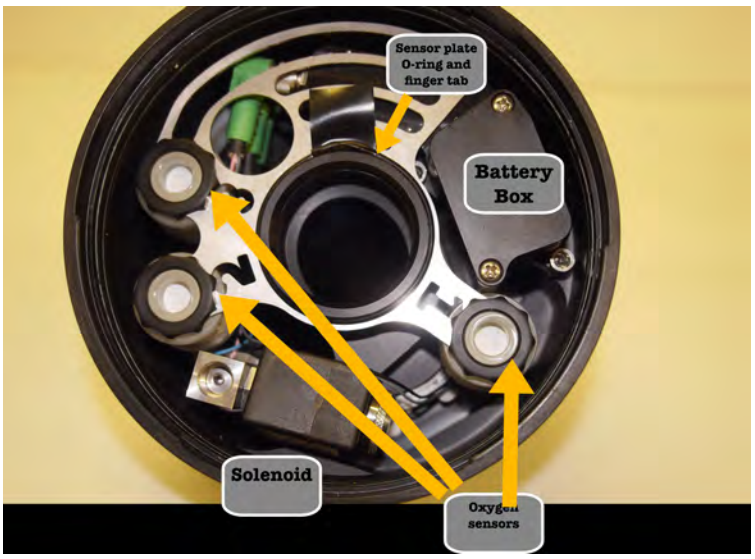
4 Activation commands to activate the ISCAN systems.

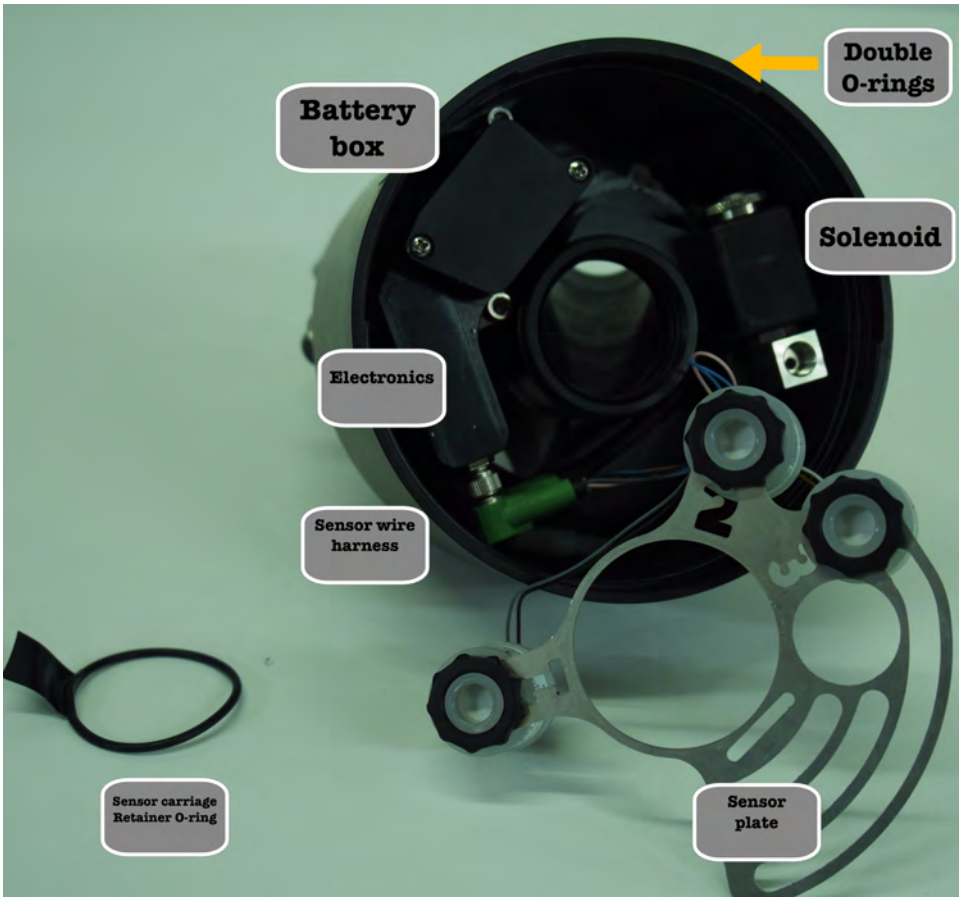
- Pushing the Menu and Action button together.
- Wet sensor activation.
- Plugging in the SubConn connectors.
- **Replacing batteries!**

PATHFINDER HEAD

Top of Pathfinder head




Sensor plate O-ring and finger tab
Battery Box
Solenoid
Oxygen sensors


Double O-rings
Battery box
Solenoid
Electronics
Sensor wire harness
Sensor carriage Retainer O-ring
Sensor plate


Remove sensor
from sensor plate

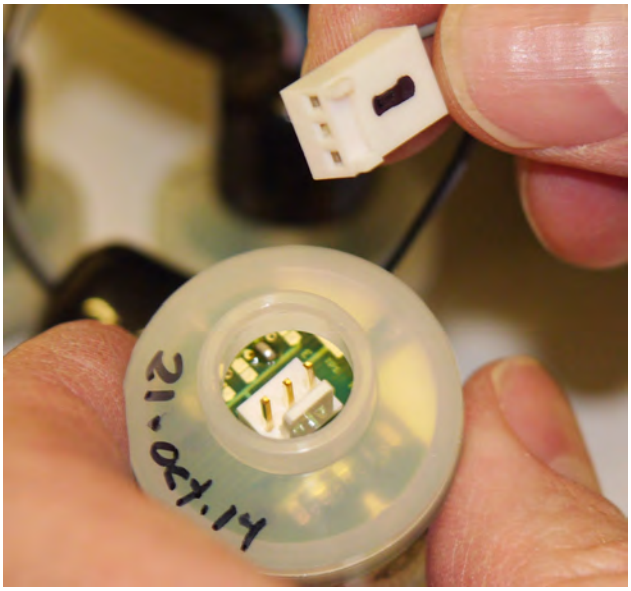

Remove
sensor from
Molex
connector
Unlock Molex
From sensor

Removal or Oxygen sensors:

- Use only ISC I22D sensors.
- Remove retaining O-ring from sensor plate.
- Remove sensor plate.
- Remove sensor from plate.
- Remove Molex connector from sensor by using a pick or gently wiggling the connector. Do not pull on sensor wire.

NOTE: DO NOT PULL ON SENSOR WIRES TO REMOVE MOLEX CONNECTORS! YOU WILL DAMAGE THE CONNECTOR!

Replacement of oxygen sensors:
Do the reverse of above. Insure the sensor plate is placed as it was before removal to prevent damaging of wires.



Installation and removal of batteries:

The removal and installation of the 9 Volt batteries are the same as the Meg 15 but with the exception, the Pathfinder uses one 9 Volt battery per network.

Meg 15 and Pathfinder system requirements with APECS 4:

1, 1 or 2 9Volt batteries for each operating Primary and Secondary network.
2, Micro USB to Standard USB cable and charging adapter for charging APECS 4.
3, 3 ISC I22D oxygen sensors that are within 1 year of receiving date.
4, Molycote 44, Molycote 111, Dow Corning 111 for Subconn connector lubrication.
5, 100% isopropyl alcohol and soft brush for cleaning electrical contacts.
6, Oxygen analyzer for analyzing 100% oxygen in supply cylinder.
7, Ambient air or 100% oxygen for calibration.
8, Meg 15 or Pathfinder checklist.
9, These directions and phone number to contact ISC if there is any questions on safe operation.
10, A safe diver that assumes responsibility to read and learn these directions and applies them as well as the skills and proper attitude along with physical ability, as intended for safe underwater CCR diving operation. Failure to apply equals a dead diver or at the very least a very scared one.

ADVANCED OXYGEN SENSOR KNOWLEDGE

Calculating mv: The diver knowing what the expected mv output from each oxygen sensor at relative PO2 exposure is a handy tool. The diver can calculate the calibrated PO2 from the mV. This tool can insure that the diver is in fact using 100% oxygen for calibration or know an expected PO2 at depth. This can aid in finding a sensor that is not performing as expected or a bad gas.

The ISC I22D oxygen sensors have a mV output of 9 to 13mV at sea level, ambient air, at temperature of 77°F/25°C. It stands to reason doing some simple math the mV output of sensors at 100% Oxygen would be 43.0mV to 62.2mV, assuming a 9.0-13.0mV output. So the diver if using an analyzed gas of 100% Oxygen, would expect to see the above results.

The math is simple.
1, Measure the sensor mV output in ambient air at sea level, using the CCR electronics.
2, Divide the sensor output (mV) by the ambient air (20.9). **(First convert relevant numbers to decimal).**
3, Multiply the calculated output by 100 (100% oxygen) The expected answer will be the mV output for 100% oxygen.
(Note: The mV output can vary between the independent networks due to differences in electrical components. That is one more reason why we calibrate).

Example 1: Calculate the expected mV output when calibrating with 100% Oxygen.
1, Sensor 1 measures **9.0mV** in ambient air.
2, 9.0⁄.209=**43.06mV Calculated** at 100% Oxygen.

Example 2: Calculate the expected mV output when calibrating with 100% Oxygen.
1, Sensor 1 measures **13.0mV**.
2, 13.0⁄.209=**62.20mV calculated** at 100% Oxygen.

The CCR diver can use this math to do a tabletop linearity check on the sensors if they did not calibrate that day assuming the supply gas is in fact 100%.

What if the diver did not get the calculated mV output on the linearity test or during calibration what was thought to be 100% Oxygen?
1, Sensor 2 in air measures 10.6mV.
2, 10.6mV⁄.209=**50.71mV**
3, 50.71mV×1.0=**50.71mV calculated.**
4, But the actual mV output was 40.68mV. Why?
5, What is the % of Oxygen?
6, 40.68mV⁄50.71mV=.8022
7, .8022×100(O2%)=80.22% Oxygen. Why?

The question above is….
1, What is wrong with the oxygen analyzer?
2, Why did the diver only get 80% oxygen instead of 100%?
3, Why is this cylinder filled wrong?
4, Was it labeled wrong?
5, How old are the CCR sensors? Are they within one year shipping from the factory?
7, Is the diver using ISC I22D sensors or non-approved sensors.

The rule is; If there is any doubt than there is doubt, do not dive unless you are 100% convinced of what you are breathing and you will be safe.

The next calculation is calculating PO2 at depth using the sensor mV.
1, Sensor 1 measures 9.0mV.
2, 9.0⁄.209=43.06mV
3, 43.06mV**×1.3** PO2 (Set point)=**55.978mV calculated mV output.**
4,**55.97mV expected** output of oxygen sensor at 1.3 set point at any depth below 10fsw/3msw.

The proper technique is to calculate all the sensors in air and then multiply that result by the intended S.P. and write it down on a piece of white electrical tape using a permanent sharpie pen. Place the tape on the side of the handset and the diver can compare the outputs on the fly during the dive, especially when the APECS 4 is in Sens menu displaying all of the millivolts and the calibrated PO2. When the diver is at 330 fsw/100msw deep in a cave there is no better feeling when all the Oxygen sensor millivolts are within 1 or 2 mV to what the diver calculated and all the displays are in agreement.

What does the diver do if the calculated mV does not match the actual output?

When in doubt bailout! Do not try to understand what is wrong just save your life or the life of your buddy!

Understanding why the sensors are not matching up with the calculated mv or calibrated PO2.
1,How old are the oxygen sensors. Are they within 1 year of shipping from the factory?
2, Are they ISC approved sensors? (ISC I22D).
3, Were the electronics calibrated correctly?

- Ambient air.
- Correct Oxygen %.
- Correct altitude.
- Possible barometric pressure swings.
- Correct depth and oxygen exposure assuming at depth calibration. (Saturation diving only)
- Calibrating under pressure when not designed to do so.
- Extreme over pressurization of oxygen sensor during calibration, I.E excessive oxygen flow, breathing loop above 30mb, encapsulated over pressurization.
- New oxygen sensors not conditioned prior to installation.
- Possible tolerance stacking or errors.
- Premature calibration when the oxygen levels were not appropriate at the moment of calibration.
- Excessive moisture buildup on sensors prior to calibration.
- Conductor wires damaged or excessive corrosion.
- Excessive water on sensor effectively shorting out or interrupting outputs.
- Diver mistaking the incorrect button for calibration.
- Power interruption or fluctuation interfering with output.
- Damaged sensors from handling. I.E. dropped.
- Sensors stored or exposed to excessive temperatures before calibration.

Avoiding the dreaded voltage limited sensor:

Most eCCR's rebreathers share a common voting system called "Sample data control". All rebreathers should have 3 sensors, as the saying goes, 1 is none, 2 is 1 and 3 is two. With 3 sensors you have an odd number system that can "Vote" the odd man out or bad sensor in this case, but it can also vote the good sensor out.

Since the sensors are the eyes of the rebreather, they send millivolts (Voltage) down wires to the electronics, and the electronics via calibration make sense of what the output is from the sensors, and the diver understands that as PO2 displayed on the handset.

If a sensor is somehow compromised such as being too old, it will not put out the proper level of millivolts and in fact it will be too low and if it is a single failing sensor it will be voted out and removed from oxygen addition system that controls the solenoid. The other two sensors will then average the PO2 and send signals to the solenoid to add oxygen when required.

The dreaded mV limited sensor is when two sensors go bad or all three go bad and average the millivolts from the sensors and they cannot reach the required mV to achieve a set point above 1.0 or higher, and they keep injecting oxygen to try to reach the required mV output. But what happens is the diver thinks they are breathing a PO2 of 1.3, but in reality a 2.0 or 4.0 PO2! And suffer an O2 hit as a result.

HOW TO AVOID! CHANGE THE SENSORS YEARLY!!! USE ONLY ISC SENSORS!!! As of 12 March 15, ISC has had a 0.03% failure of ISC sensors. A near perfect performance.

DIVING SIGNS OF mV LIMITED SENSORS!

- **A Sensor gets voted out and stays voted out.**
- **Sensors that are acting slow.**
- **Solenoid keeps injecting or you are constantly adding oxygen manually, and you are not ascending.**
- **You know you have old sensors or you know you are diving the wrong ones!**

Bailout if you have doubt! If there is any doubt then there is doubt and bailout!

ISC CCR ORDER OF PRIORITY.

The order of priority is simply an organized set of rules that establishes an organization maintaining the breathing loop and buoyancy to help the CCR diver to "Get it right" as fast as possible, and minimize task loading and maximize fun.

There are no exceptions to these rules!

1, **Know your PO2!** This includes:

- Checking the PO2 of oxygen in the breathing loop every 1 to 4 minutes, and this includes your CCR buddies.
- Analyzing all breathing mixes to including the oxygen and properly labeling all cylinders with MOD in meters or feet, mix contents with Oxygen first, followed by Helium, and date of analyzing, and the initials of person who analyzed, and is using the cylinders.

2, **Maintain proper loop volume!** This is not minimum loop volume, which is improper but "optimal loop volume". Optimal loop volume is the same breathing volume experienced during fast moving activities such as a fast walk. The diver does not experience any collapse and bottoming out of the counter lungs except on descents and increasing depth of breathing that requires the addition of diluent gas via the ADV. Minimum loop volume is to be avoided as it unnaturally increases the expired PCO2 in the divers body and work of breathing (WOB) to include levels of stress.
3, **Drysuit:** If the diver is a diving a drysuit the addition of any gas is next on the order of priority.
4, **BCD:** The BCD is the last order of priority and should not be used until the other three are addressed with Oxygen addition and PO2 being first, loop volume next and dry suit. Fundamentally the BCD should never be used unless on the surface. If the dry suit is used, the diver is over weighted with lead or is using a foam dry suit, and it compresses at depth leaving the diver overweight and compensating using the BCD.

The point of above is to maintain the rebreather in a safe condition and keep the diver alive, next is to address buoyancy issues for the diver to increase comfort and minimize task loading.

How to survive on a CCR.

Bailout?: Carry the appropriate amount of bailout, but you all ready knew that. This is not about carrying bailout, this is about staying safe on the CCR so you never need the bailout. If you do the below correctly, only someone else will need bailout.

Assuming your are properly trained: Your initial training is not enough, you must use your CCR to maintain proficiency on the equipment and skills. Get training from the best instructor possible.

Do not let apathy control behavior: The wrong attitude doing any risky sport leads to higher risk of failure and it does not add to any enjoyment to the sport.

Do not suffer from normalcy bias: Also known as analysis paralysis, if you know something is wrong or suspect, **DO SOMETHING ABOUT IT!!!** Do not freeze and delay or think about it. React appropriately and save a life.

Follow the Pre-dive assembly checklist to the letter: Before using your rebreather, put it together correctly using a check sheet and insure it works before moving it to the beach or boat. Give your rebreather the same respect and care as you would a parachute, firearm, or even a small child. Hygienically clean it at the end of the diving weekend or every three days of diving.

Analyze, analyze, analyze!: Know what is in your cylinders at all times. FO2, PO2, END/EAD, He, Argon, CO and label everything with gas contents, date of analysis, and your initials. Write MOD on the side of the cylinder and the bottom. Use the best O2 and He analyzer. For all diluent cylinders insure that you check for He also. What you think is air could have He in it.

Have the correct sensors installed: Use only ISC I22D sensors and change them every 12 months from date of receiving them from the factory. All other sensor manufactures have failed to live up to scrutiny and only proved to pre-maturely fail.

Turn on your oxygen: This is so obvious, but many divers have died or had close calls because of this simple valve.

Pre-breath prior to the dive: Pre-breathing is a process of insuring gases are on, all cylinder gases can flow into the loop, all displays agree, no alarms, and

check valves work to circulate breathing gas and breathing loop is sealed. It has nothing to do with pre-heating the CO2 absorbent.

Watch your PO2 and your buddies every 1 to 4 minutes: Be aware of yourself and buddy.

Learn to assist another diver in distress: If you were in trouble underwater, you would want help from someone who is trained to render help. Trained divers have saved unconscious divers.

Do not dive if you have any doubt: If there is doubt then there is doubt. Do not breathe from the breathing loop.

Stay alert stay alive: Exercise situational awareness and enjoy yourself at the same time.

NOTES

REVISION INDEX

Date	Revision	CHANGES
1 Nov 14	NEW	
1 Dec 14	Meg 15	Added Meg 15 system
9 March 15	Pathfinder	Added Pathfinder system.
15 April 15	Edit	Official draft