APECS OPERATIONAL INSTRUCTIONS (v. 2.00)

(Formalizes DRAFT, 5 March 2004)

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Introduction:

The ISC **A**dvanced **P**ersonal **E**nvironmental **C**ontroller **S**ystem (APECS™) 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 family is designed to be used in saturation, military, and recreational roles providing reliable, user friendly operation with room for ISC factory customization to further meet the end users needs. The APECS has a simple self intuitive menu and 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 changes to the breathing media.

Basic Functions/Features:

- Simple self intuitive two button menu and confirm system.
- Independent isolated display system with pressure/gas resistant cabling.
- Independent pressure/water proofed primary and secondary electronics and power supplies.
- Watt miser power efficient automatic oxygen addition system. (Operational time is dependant on diver's use of backlight, ambient temperature, battery make, age of battery, and diver use.) Using the SAFT Lithium battery packs, the estimated operational swing time is 70-100 to hours on Primary system. Secondary electronics system is estimated considerably over 200 hours. Using the Alkaline AA battery packs, experience varies with the Primary, usually 25-50 hours, then for the secondary subsystem at 50-100 operational hours.
- Average PO2 window. (**Bold annotation on display**)
- Tertiary redundant oxygen sensor system
- 3 sensor independent window.
- Voting logic automatic oxygen addition system.
- Voting logic indicator. Indicates what specific sensor is out of tolerance at that moment. (A sensor that may become disconnected or completely fail, the APECS™ will still average and maintain the current set point.)
- Current set point window.
- Breathing loop temp. (Monitors breathing loop temp that the diver is breathing)
- Ambient water temp.
- Set points selectable on the fly: Manual mode (0.20), 0.4, 0.7, 1.0, 1.1, 1.2, 1.3, 1.4.

- Bilinear 2 point calibration system. (For accurate high and low point PO2 information)
- High Altitude Oxygen Sensor Calibration (Both Metric [meters] and Imperial [feet] altitudes)
- Sensor MV indicator. (Gives sensor output (Millivolts) on the fly to the diver in real time. This will indicate to the diver the health of the sensors and voting logic validation)
- Low battery indicators. LOW BATT annotation will appear blinking at 5.0 volts, with the auto disabling of the display backlight further indicating to the diver a low power situation for the primary electronics system.
- Battery no-load/load indicator. (Indicates to the diver the health of the power supply while under a load from the solenoid)
- Back light enable/disable option.
- System monitor: It is the heart beat indicating to the diver that the electronics have not locked up and are functioning.
- Selectable oxygen dosage. May be adjusted on the fly to allow user to set to personal settings according to work effort and depth of dive, this may be used to minimize oxygen spikes. On cycles in seconds of 1.0, 0.5, & 0.25 with 0.5 default. Off cycles of 6 seconds and 8 seconds after injection before re-analyzing PO2. Default is 8 seconds.
- No wet sensors.
- Two minute start up timeout for calibration, and altitude PO2 adjustment.

The Megalodon strengths come from a practical approach based off of designer experience and the application of design principles that closely follows function leading to form. Regarding the functions of the APECS electronics, it is encouraged that the diver feels free to just punch the buttons on the hand sets to see what they do, starting with the **Menu/Confirm** buttons.

DANGER! The Megalodon operates by using batteries, the diver must insure that the batteries are fresh enough to conduct the planned diving operation or the batteries must be replaced if they are in question on reliability. Also, the power switches must be turned on prior to the diving operation. Maximum power is 10.0 loaded volts, and minimum power is 5.0 under load volts See pre dive check sheet.

APECS Operating Instructions:

Power on the power switches on the battery boxes inside the Megalodon head lid and notice on the hand sets the opening screen to both the Primary and

Secondary displays. The opening screen is the ISC logo with the version of electronics and description of the individual display.

Primary Handset: The Main operational page screen will be the diver's primary information on the current status based on operational priorities. In **bold letters** will be **AVG.** The **AVG** is the average PO2 based off of the 3 sensors and the voting logic system. The **AVG** is what you want to observe primarily for decompression reasons and to see how close you are to your desired set point. Below the **bold AVG is** S1, S2, and S3, each sensor is depicted so the diver may observe sensor status. The Diver at any time may observe a **black outline** around one of the depicted sensors, if this is observed, the **voting logic** is voting out the sensor and continuing the averaging of the two remaining sensors. The APECS 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 both displays and being prepared to conduct an immediate action procedure (IAP).

System Status Indicator: The **SSI** is the "heart beat" of the APECS and is indicating the operational status of the electronics, if for any reason the diver observes one single character instead of changing characters the APECS has "Locked up" and the primary system operating the solenoid has failed, the diver will have to use the secondary display to fly the Meg manually and the diver must exit the water ASAP and use IAP' when necessary.

Menu/Confirm System:

Press the Menu button of the primary hand set and scroll through the menu options, the diver will see the following; **Change Set Point? System Monitor, Temperature, BL ENBL/DISBL,** and **OXY INJECT.** The diver may select an option from the **Menu** and press the **Confirm** button and see the option lock into place into a submenu or some operational information the diver may want to see.

The Diver at any time may leave the selected option by making a selected operational change to the APECS or the system will time out in **5 seconds** and go back to the main diving informational screen.

Note: The activation of any of the buttons on the primary display will deactivate the solenoid for 5 seconds. This is used for a possible reset of a failed solenoid in the open or closed position.

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

Change Set Point: Set point selection is accessed from this option pushing the **Menu** button to "Change Set Point? Push the **Confirm** button to lock in the option. The diver will see the first of the set points that can be locked in with the **confirm** button. The first set point is **MAN. Man** stands for **Manual**. The **Manual** set point is an artificial set point of 0.20 and attempts to maintain a loop PO2 of .20 (Air) at all times. The desired use is for swimming pool training, surface swimming while breathing on the loop to avoid **hypoxia**, and for **pre-diving** the Megalodon to avoid wasting oxygen through solenoid injection.
Set Points: The diver has the following set points that may be set on the fly during the dive, or preset prior to entering the water; MAN, 0.4, 0.7, 1.0, 1.1, 1.2, 1.3, and 1.4. The diver may use any of the following at anytime during the dive. The diver must insure that they have a **breathable PO2 at anytime and maintain the planned PO2 to support planned decompression**. Other considerations 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.**

System Monitor: The second menu option after the Change Set Point selection is the System Monitor. The System Monitor is the diagnoses page for the Meg. The diver may access System Monitor during the dive to monitor the **sensor millivoltage** and the **battery no load** (**Normal) and load voltages**. The **Normal** battery indicator shows the drop in voltage when there is a **no load** on the battery. **The load** is the battery load for when the **solenoid is activating** and putting a strain on the battery, it is **this indicator that the diver needs to be aware of for battery performance.** The **lower limit is 5.0 volts** and the diver **must replace** the battery; the high indicator is 10.0 volts (On older APECS 1 hardware running the APECS 2.00 software, the high indicator can only display up to 7.5 volts). **Early low battery indicators** is the failure of the **backlight to turn on** when a button is pushed to see the display in low light conditions, a **second indicator** is the **low battery indicator flashing** on the primary hand set. Both conditions warrant the battery to be replaced ASAP! With the termination of the dive. In most diving scenarios, the diver has adequate time to exit the water safely without sacrificing safety.

The **Sensor Millivoltage** (mv) is an indicator of sensor degradation (health), the diver may see how the sensor is performing at all times during the dive, pre-dive, and post- dive, operations. The diver may record the information on the pre-dive/post-dive check sheet to monitor sensor life and performance over time.

Normal sensor mv is 8.5 to 13.5 in air at sea level**.** Sensor mv output will be less at higher elevations. It is a prudent habit to record the sensor mv at various set points during the dive and to comparison check at later dives.

Temperature: The temperature monitors the ambient water or air temperature and the breathing loop temperature.

BL (Back light): The back light may be disabled at any time by the diver and maintain that setting for as long as the diver wishes. To disable the backlight the diver must access the option to **BL** and push the menu button to **Enable** or **Disable** and push the **Confirm** button to lock in the selection**. Note: The back light low battery indicator will also be disabled if the BL disabled option is selected.**

Oxy Inject: The Oxy Inject is the means to adjust the oxygen injection by setting **three** injection dosages and two timeout intervals. The **first** setting of **0.5- OFF 8** is the **default setting** and may be changed at anytime during the dive to increase or decrease the oxygen injection dosage. The first number is a **half second** time that the solenoid is open to inject a set dosage of oxygen into the loop, the second number is the interval of a time out of the solenoid. The opening of the solenoid may be changed to a **one second** time to increase the dosage of the injection, or .25 second to decrease. The **interval times** may be changed from **8 sec. to 6** sec. time out intervals. **WARNING! Do not use the 1 second injection dosage and 6 off period for fast descents or an oxygen spike will occur! This condition will increase inappropriate exposure to high concentrations of oxygen.**

Defaults, Time outs, and Settings:

The oxygen injection **default (0.5 OFF 8)** is adequate for most diving scenarios with supplementation of oxygen using the oxygen manual bypass. The 1 sec. dosage is good for fast ascents or swimming into a heavy current where the diver is consuming greater oxygen due to a higher work loads, and diver desires more oxygen to maintain a closer set point for physiological advantage decompression. The .25 sec. is used for diving below 150 feet to help insure minimal oxygen spiking of the oxygen to above desired set points. The timeouts are used for allowing the breathing gas time to circulate in the loop for proper gas analysis without again spiking the PO2 by allowing too much oxygen to be injected by the solenoid.

Time out and sleep modes: The APECS **Primary display and secondary display** will time out of all options automatically and also fall asleep in dive mode to save power but will act as a **sentinel** monitoring the operating systems. At anytime below or above the water both displays may be accessed by pushing any button on the display desired as long as the **power supplies are on. It is very convenient to push the out board buttons on handsets to quickly access the first menu page for PO2 status.**

Settings: The APECS may be set for calibration, fresh water and salt water measurements, and Imperial/Metric measurements. The settings may only be accessed within a 2 minute time frame from turning the power on during the pre dive procedures; this is to prevent the diver from creating a hazardous condition during the dive. At anytime during the pre dive the diver may reset the 2 minute window by turning the power off and turning the power on again.

Warning: At no time should the diver enter the water within the 2 minute time frame of turning the power on.

Secondary Handset: The secondary handset shares the same simple two button Menu/Confirm system as the primary handset. The Secondary handset is totally isolated from the primary system in regards to information, power supplies, and calibration. The only commonality between the primary handset and the secondary handset, of course, is 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 on that a severed hand set cable (Bare wires in salt water) on operational dives did not effect the other handset in this case the Primary handset system.

Note: The secondary handset does not operate the solenoid in any way. The sole purpose for the secondary is to provide a proper isolated independent backup measuring the loop PO2 in the case of a primary system failure. The diver may operate the Megalodon manually by manually injecting oxygen into the breathing loop to maintain a manually fixed set point based off of the planned diving operation.

The secondary hand set displays the **AVG** PO2, **Individual sensor outputs**, and the **system monitor** (Heart beat) along with the ISC logo. The secondary has the following menu options; **Main page**, **System Monitor**, **Back light Enable/Disable**, and for those Megalodons that have the option the **Heads Up Display (HUD) Enable/Disable**, and the **HUD brightness control. These menu**

items are available on all APECS 2.00 software to accommodate future HUD installations for systems without a HUD.

The diver may scroll through the **menu** and access the **menu options** the same way as the primary hand set. The diver will notice **one difference** in the **System Monitor** and that the **Normal battery power is displayed** and **not the load**. The secondary does **not operate the solenoid** so such a feature is not needed. The additional features the secondary features is the HUD when equipped.

HUD Operation: The HUD **is** the secondary hand set system; 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. The HUD brightness may also be adjusted to bright and dim. The dim may be used for 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.

Color	PO2	Blinks	
Red	**<0.20**	**One long**	**Ambient Air and possible Hypoxia condition**
Red	**0.20**	**8 blinks**	**Ambient Air**
Red	**0.4**	**six**	
Red	**0.7**	**three**	
Red	**0.9**	**one**	
Orange	**1.0**	**one long**	**Calibration color after calibration procedure.**
Green	**1.1**	**one**	
Green	**1.2**	**two**	
Green	**1.3**	**three**	
Green	**1.4**	**four**	
Green	**1.8 +**	**One long**	**Hyperoxia potential.**

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 harder to explain then to actually do.

Display Calibration Procedures: The APECS is a two point calibration system with high altitude oxygen sensor adjustment. This allows the diver to set the PO2 level based on the diver's altitude zone **at time of calibration** the altitude ceiling is 13,500 feet (4,050) at PO2 of 0.12 ata. The APECS also has a sensor millivolt output indicator displaying on both handsets during calibration procedures to aid the diver in a proper loop flush. The first point of calibration is ambient air and the second point is 100% Oxygen. To best perform the calibration procedure follow the pre dive check sheet and these instructions.

1. During the pre dive check of the Megalodon the checklist will tell you to conduct the air point calibration. After turning the power on, the diver will **scroll** through the primary and secondary handsets **Menu** and push the confirm button when the option is found. On the Primary and secondary handsets you will see the following after selecting the calibration option: **CALIBRATE**, and above that, it will ask "are you sure?" You will see a **Yes** or **No** and you may **push** yes to go on or no to cancel. By pushing yes you will again see the question "**Are you really sure?"** You will then **push** the Yes or No option. After pushing Yes you will be prompted **"Hit confirm when at ambient air"** or **"Menu for Cancel". You will observe on the display the sensor output in millivolts at ambient air, it should read 7.05 to 13.5mv.** At this point of calibration you have just completed the calibration for Air and the **2 minute time out is on hold** for you to complete the next phase of calibration.

2. 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 counterlung and fill the loop with 100% Oxygen until the vent valve vents gas. Let set for 10 seconds.

3. Vacuum the loop again and fill again until the vent valve vents and repeat above.

4. Open the vent valve all the way and tightly pinch the exhaust breathing hose to isolate the exhaust counterlung from the oxygen bypass on the inhalation counterlung.

5. Push the oxygen manual bypass for 3 seconds; this will blow 100% oxygen over the sensors without increasing the loop pressure giving a possible higher PO2 reading.

6. Repeat 5 above.

7. Repeat 5 again.

8. You now have a purged loop with nearly 100% Oxygen. You will observe the sensor millivolt output in both displays and the normal output is in the zone of 35 to 60 millivolts. **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.**

9. Push the yes button on the displays and you have finished the two point calibration.

10. The oxygen sensor calibration upper limit of PO2 is 0.98 ata not 1.0 ata. This compensates for a bad gas fill and a sloppy loop flush by the diver.

Note: You may only calibrate one display at a time under the following conditions; you have not changed the sensors or performed any electrical work, and the millivoltage is within the 7.0 to 13.5 mv ambient air specifications. Calibrating one display can help insure that you have one display to monitor the PO2 during the purge procedure to help insure that you are achieving the proper loop PO2 for calibration.

Note: You may calibrate the other display at your convenience as long as the calibration procedure described above is followed.

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

DANGER! The diver at all times must be aware of the proper operation of the primary and secondary systems. If the primary display at anytime fails to activate and display the PO2, your solenoid will not activate due to the failure. Both the primary and the secondary display systems are programmed to go to sleep for power conservation after 10 minutes of

inactivity (i.e. no switch hits) during the dive until reawaked. Depressing the CONFIRM or MENU switch awakens the subsystem and this inactivity timeout will restart. While the displays are asleep, normal oxygen injection, sensor voting logic and all other essential processing continues in the background.

In closing, user suggestions for corrections and enhancements of this manual are encouraged. If you have any contributions to better improve this document, feel free to contact us.

REVISION INDEX

Date	Revision	CHANGES
28 APRIL 2005	New	