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Quality.

For the past seven years Cochran has been producing dive instrumentation, product quality has steadily improved while failure rates have steadily declined. We believe our current product quality is the highest in the industry and our failure rates the lowest. For product produced in the last two years, our field failure rate is below one percent. Although no company officially publicizes their field failure rates, in casual conversations we revealed ours to two well known competitors. They both were surprised and expressed desire that their company/suppliers did so well.

This is due in part, to these actions:

1. Quality begins with Engineering. Cochran is the ONLY dive computer manufacturer to design every aspect of a product in-house. Each computer with its specific technologically advanced features is conceived **by divers FOR DIVERS!** Our staff is comprised of long-term divers with varying degrees of experience from recreational through technical and mixed gas, including cave and wreck diving that are involved totally in the development of our products. Many individuals on our staff are Instructors. From initial concept through mechanical, hardware, electronic, algorithm, and software engineering, to manufacturing and Domestic and International marketing. This is all located in our Company-owned, state-of-the-art facility in

Richardson, Texas, which allows us to continually optimize and monitor products for quality, performance, and cost. We have recently upgraded our in-house computing systems to include three high-speed network servers with over 70 work stations.

2. Quality continues with Incoming Inspection and Manufacturing where significant progress has resulted in extraordinarily high first-pass yields. The time required to build our products has declined by over 75%. Computerized work stations monitor, test, and log every production activity on every single product by serial number.
3. Quality Control takes the form of Incoming Inspection of ALL material used in our products. Over the years we have found vendors who now consistently provide us with high quality components. Various in-line inspections ensure that our workmanship exceeds our high standards. Most Quality Control stations have microscopes for inspection of fine details. In addition, we have a Scanning Electron Microscope, dedicated Chemistry Laboratory, hyperbaric chamber, breathing machine, and sophisticated electronic equipment to aid Quality Assurance. No other manufacturer has all of these.
4. Calibration of our products is the most comprehensive in the industry. Our computer-controlled calibration chambers are designed and built in-house. Every single product is tested and calibrated over temperature extremes, extremes of battery voltage, and extremes of depth. For air-integrated products, extremes of high pressure air are included.
5. Before any product is eligible to be shipped after Calibration and Inspection, it is subjected to over 40 in-water dives in our custom-built, repetitive dive chambers. This ensures that the calibration remains within specification, the unit is structurally sound, and water integrity is perfect. Dive profiles are studied to ensure perfect functioning of the product and to ensure that the Calibration remains consistent.
6. Every single returned product is studied and the cause for the return is determined. Corrective action is implemented to prevent a reoccurrence of the return. Product returns AND Quality are discussed at every weekly Staff meeting so that all Staff members are fully informed.
7. Cochran Undersea Technology has been working over the past year towards ISO-9001 certification. While certification is not a guarantee of quality, per se, it does mean that product and processes are documented and tightly controlled to ensure repeatability and consistency. We anticipate achieving certification this year. In addition, Cochran dive computers are CE approved and are certified by the Federal Communications

Commission as well as other regulatory agencies in other countries.

If you haven't tried a Cochran product in the past year or two, we encourage you to do so.

Altitude Issues in Dive Computers and Rebreathers.

In this paper, the term "Dive Computer" will also include any Rebreather with a sophisticated on-line Dive Computer. Altitude issues specific to Rebreathers are addressed towards the end of this document. This paper will discuss some Altitude Diving Scenarios and how some Dive Computers measure and respond to Altitude.

In state-of-the-art Dive Computers there are four basic Altitude scenarios that need to be considered by the diver:

1. Diving at Altitude after a significant Surface Interval so that the dive begins as a "clean" dive with no residual Nitrogen;
2. Changes in Altitude and its effect on Nitrogen loading;
3. Diving at Altitude with beginning residual Nitrogen;
4. Flying in an aircraft immediately after diving.

Most Dive Computers measure Altitude with the low pressure, or depth, transducer. Altitude can be considered to be "negative depth". Since a significant change in altitude is equivalent to a small change in water depth, many Dive Computers do not have the resolution to adequately measure small changes in altitude. These dive computers resort to a system of altitude zones that represent altitude from zero to the maximum altitude of the system. This type of altitude system is called "Zoned". In Dive Computers with good measurement resolution, the altitude range is not broken up into zones, but is "seamless" from 0 to the maximum altitude of the system. Some current Dive Computers do not measure altitude at all, but force the user to input the altitude into the unit. This is called "Manual" altitude adjustment.

"Manual" systems, such as used by Suunto are considered quite primitive and rely on the diver to manage his own altitude diving scenarios and calculations. "Zoned" systems, such as used by Uwatec, and DiveRite typically use four overlapping zones of about 1000 meters each to represent the altitude range. These products do not have the capability to accurately measure altitude and can give the diver a false sense of security by implying that the it is providing all the proper altitude computations with precision. "Seamless" systems, such as used by Cochran products, are the best since they can accurately measure altitude and even small changes in altitude with enough precision to properly manage all altitude Nitrogen issues.

More sophisticated Dive Computers such as the Cochran products, measure altitude once every minute whether awake (on) or asleep (off). Less capable units such as the Uwatec or DiveRite measure every 10 minutes to hours. Even more primitive units such as Suunto don’t measure altitude at all. It is important to recognize that altitude is measured as "negative depth" and may not be exactly the same as the actual altitude above sea level. Since this altitude is dependent on atmospheric pressure, we refer to this altitude as the "Barometric Altitude". Strong low or high pressure weather systems can make the "Barometric Altitude" significantly different from the actual altitude, or distance above sea level. It is this "Barometric Altitude" that is the important factor in a Dive Computer that automatically adjusts to altitude.

When a diver changes from a lower altitude to a higher one, some Dive Computers such as the Cochran products detect this change and add Nitrogen to the tissue compartments. The differential pressure between the Nitrogen in the body and the higher altitude must be equalized (outgassed). This is the same as when a diver ascends to a shallower depth while in a dive. If a dive is started immediately after an increase in altitude, the diver will have some effective residual Nitrogen and the dive will not be started as a "clean" dive. Conversely, when a diver changes from a higher altitude to a lower one, some Dive Computers such as the Cochran products detect this change and remove Nitrogen from the tissue compartments. The differential pressure between the Nitrogen in the body and the lower altitude must be equalized. This effect of increasing or decreasing Nitrogen as a result of increasing or decreasing altitude is sometimes referred to as "Altitude Adaptation" or "Altitude Acclimatization".

In addition to the dynamic altitude adjustments in the Dive Computer algorithm, some more sophisticated units, such as the Cochran products, automatically react to long-term stays at a constant altitude. If a dive is made while at altitude (whether already "Adapted" or not) the Nitrogen algorithm within the Dive Computer is adjusted depending on the exact altitude.

In Cochran products, these small changes in altitude can slightly affect the No-decompression Time predictions, particularly the predictions at shallower depths. These differences can amount to several minutes. Since this disturbs some divers, Cochran allows the user to configure the Dive Computer to consider the altitude from sea level to 2,000 feet to be the same as sea level.

In order to calibrate the more sophisticated Cochran units, a very sensitive barometric pressure instrument is on-line and available to our manufacturing network workstations. This allows our computer controlled calibration systems to know the exact barometric pressure while calibrating the depth transducer. In fact, the system is so sensitive that it measures pressure changes as a result of our air-conditioning and heating systems cycling on and off.

Rebreathers

In addition to the above issues, Closed Circuit Rebreathers with on-line Dive Computers have special considerations with regard to the Partial Pressure of Oxygen (PO2). In more sophisticated units, such as the Cochran Rebreather, altitude is considered during field calibration of the PO2 sensors. When the system is flooded with 100% Oxygen in preparation for calibration, the actual PO2 may not be 1.00 ata if the Rebreather is at an altitude above sea level. The Cochran Rebreather determines the actual PO2 based on 100% Oxygen and the current altitude and automatically adjusts the PO2 calibration accordingly. Rebreathers that do not comprehend altitude can have significant PO2 errors if calibrated at altitude.

Another altitude consideration is the maximum PO2 that can be achieved at very shallow depths. For example, if the user has configured the Rebreather to have a PO2 set-point of 1.3 ata, this cannot be achieved at a very shallow depth. The Rebreather must adjust the set-point so that it does not attempt to achieve an unachievable PO2. Obviously, the maximum PO2 that can be achieved at any given depth is dependent upon the altitude. Therefore, state-of-the-art Rebreathers, such as the Cochran unit, comprehend altitude in these computations.

Hoseless Technology

There are three manufacturers of 'Hoseless' Dive Computer Technology, although there are more than three distributors of those products. Cochran was the first to produce a 'Hoseless' Dive Computer and only sells computers through Authorized Cochran Dealers and Distributors. Uwatec was the next to market, and Oceanic was last. Some issues directly related to 'Hoseless' Dive Computers are:

1. Amount of information to be transmitted in a Packet;
2. Amount of time between Packets and Packet length;
3. Transmitter Power and Receiver sensitivity;
4. Transmitter Frequency;
5. Sensitivity to external noise sources;
6. Sensitivity to other of the same units.

PACKET INFORMATION – In this context, a 'Packet' is a short transmitted burst of data. Only Cochran's technology transmits ALL dive computer information since the Dive Computer and data transmitter are in the same case. The Receiver is a relatively simple device. Fundamentally, the competition transmits only Tank Pressure and Temperature from a relatively simple transmitter. Their receiver is a relatively complex combination receiver and dive computer. The advantage of Cochran's technology is the ability to create other receiving devices such as a Heads-up-Display since ALL information is always transmitted ALL of the time. Another advantage is that you can monitor your buddy's system with a duplicate receiver and your buddy can monitor yours. This is ideal for Instructors. In Cochran's technology, the dive computer and transmitter being mounted on the Tank makes a much more stable platform than the wrist. Wrist-mounted units are more susceptible to false and repetitive Ascent Rate warnings than are Tank-mounted ones. Furthermore, if the Cochran wrist-mounted unit is lost or damaged, it is inexpensive to replace and no dive information is lost since ALL of the information is retained in the Tank-mounted computer. Over the years, we have had a small number of Wrist Units lost, and no Tank Units. Also, since there is more room in the Tank-mounted unit, a more sophisticated computer can be implemented and larger batteries can be used. *Cochran's technology is also far more accurate in computing Breathing Parameter (SAC) and Workload since the computer is attached directly to the high-pressure transducer.*

PACKET TRANSMISSION TIME & LENGTH - Only Cochran's technology transmits once per second while the competition transmits between much longer periods of up to five seconds! The more often data is transmitted, the less likely the loss of a Packet is to be important. In spite of the significant amount of additional information transmitted by Cochran's technology, the Packet time is a very short 15 milliseconds. Uwatec transmits for 90 milliseconds, and Oceanic for 140 milliseconds. Generally, the shorter the packet, the less susceptible the system will be to noise interference. Cochran's technology has a 1.5% duty cycle, Uwatec has 5.6%, and Oceanic has 3.6%, (smaller is better). *Clearly, for this reason alone, Cochran's technology is less noise sensitive.*

<u>TRANSMIT POWER</u> – Cochran's technology transmits with relatively 100 times more power than Uwatec, and 14 times more than Oceanic. This means that the Cochran receiver can have substantially less sensitivity to the transmitted signal. Highly sensitive receivers such as are in the competitors' units, are also much more sensitive to unwanted noise such as from camera strobes, scooter motors, and some communications devices. *Clearly, for this reason alone, Cochran's technology is less noise sensitive.*

<u>TRANSMIT FREQUENCY</u> – Cochran's technology uses a 250 kilohertz transmit frequency while Oceanic is about 36 kilohertz and Uwatec is 8 kilohertz. Unwanted noise sources such as camera strobes, scooter motors, and underwater communications devices range around the same frequency as the competitors' units. *The Cochran frequency is substantially above any noise generated by other underwater devices making the Cochran units far less susceptible to noise interference.*

<u>SENSITIVITY TO NOISE</u> – Cochran's technology transmits more often, has a shorter Packet duration, transmits with more power, and on a frequency band much higher than noise sources. These highly researched and effective attributes of the unique Cochran technology makes Cochran units far less susceptible to unwanted noise. *In tests made in our laboratories, Cochran units performed significantly better than the other units in the presence of noise sources.*

<u>SENSITIVITY TO SAME UNIT TYPE</u> - is an often-overlooked trouble area. All three technologies transmit a serial number in the Packet so that only the intended receiver recognizes that code and computes and displays the data. However, if two or more units in proximity transmit at exactly the same time, their signal is received at the same time and makes neither transmission intelligible by the receiver. Since all technologies transmit on a periodic basis, two or more of the same units in proximity can result in neither one working correctly. Only Cochran's technology addresses this issue by transmitting the Packets on an <u>average</u> of once per second, and slightly randomizing the <u>exact</u> transmit time. *This makes it highly unlikely that two transmissions in a row will be received at the same exact time and cause mutual interference between Cochran units.*

Note that the loss of a Packet using the unique Cochran Technology is not critical since ALL data is transmitted ALL of the time, at a rate five times the competition.

Case Design Issues

Fundamentally, there are three types of case designs employed in current dive computers; Air filled, Silicon Gel filled, and Oil filled

"Air Filled" cases, such as the Cochran units, must be carefully designed to be structurally strong. Since they are filled with one atmosphere air, they must withstand the extreme crush depths. They must also be manufactured with materials that are not affected by 'material fatigue' due to repeated excursions to design depth. This type of design is more difficult because of these issues. Furthermore, case penetration and opening seals must be carefully designed and manufactured to ensure an effective, long-term seal. The payoff is a case that can withstand extreme pressures and stress whether in the water or not.

"Gel Filled" cases, such as some Suunto units, are designed to allow water inside the case. The electronics are protected from the water by the gel. Since the gel transmits the pressure to every component inside the dive computer, ALL components must be carefully chosen to withstand those pressures. This can be very difficult for the electronic components and this issue can be easily overlooked. Furthermore, any penetrations through the gel can allow water to slowly leak along it and get to the electronics. Repair of these units is more difficult and costly since the gel must be removed to allow access to the electronics. While this method can, and is being used, uneven stresses out of the water cannot be tolerated as effectively as the more structurally sound "Air Filled" units. Also, both in and out of the water, these units tend to be heavier.

"Oil Filled" cases, such as the Uwatec units, are designed to withstand the extreme crush depths by filling the sealed case with oil. The case cannot allow the oil to leak out and water or air to get in. Since the case is relatively thin, the oil transmits the pressure to every component inside the dive computer, ALL components must be carefully chosen to withstand those pressures. Like the "Gel Filled" units, this can be very difficult for the electronic components and this issue can be easily overlooked. Furthermore, any penetrations through the oil must be very carefully designed and manufactured. Repair of these units is very difficult and costly since the oil must be removed to allow access to the electronics. While this method can, and is being used, uneven stresses out of the water cannot be tolerated as effectively as the more structurally sound "Air Filled" units. Also, both in and out of the water, these units tend to be heavier.

Because we use the "Air Filled" method, our cases can tolerate extreme pressures and stresses both in and out of the water. We have driven automobiles over our cases, frozen them in blocks of ice, and boiled them in water with no ill effects. **THIS CANNOT BE DONE WITH ANY OTHER TYPE OF CASE DESIGN!!!** In fact, we sometimes throw our dive computer on the floor and challenge anyone to jump on it, then put their dive computer on the floor and do the same.

Flooding of Cochran cases is extremely rare. The battery compartment is sealed from the electronics compartment (except for The Captain) and consists of materials that won't corrode. The few floods we do get are more from user curiosity than all other reasons combined. **DO NOT REMOVE THE LENS OR LID FROM ANY COCHRAN PRODUCT!!!** The lens is now installed with special 'tamper-screws' and there is 'tamper-paint' installed on all products.

Regarding case penetrations, in any method these must be carefully designed. In particular, moving case penetrations are less desirable than static ones. **Moving case penetrations, such as pushbuttons, can wear and deteriorate the case seal or boot over a period of time.** Furthermore, they can be affected by sand, silt, and salt in the water. We have always avoided moving case penetrations because of these issues. We use permanent, stainless contacts and have never had a single product failure due to those contacts. Our electronics can detect the difference between salt water, fresh water, a metallic object, fingers, and our PC ANALYST probe connection. **This is not something that can be done with a pushbutton.**

On some of our units, we also use a sonic/vibration detector inside to allow the user to tap on the case of the unit to effect certain internal functions (patented). On our NEMESIS Wrist Unit, for example, lightly tapping on the unit for five seconds turns it on. Tapping on it once, turns on the back light for a few seconds.

Aggressive Diving Profiles with the Nemesis IIa Nitrox and the Commander Nitrox

Many divers have chosen to seek training and experience outside of the "normal" recreational diving limits recognized by many training organizations. With the formation of new training agencies and expansion of older ones diving beyond these "normal" recreational limits has become more and more popular in the world today. This type of "Technical" diving offers divers the ability to reach deeper depths and to remain at these depths longer than ever before. Many manufacturers have developed equipment to assist divers in planning and decision making during these types of dives if used correctly. These Aggressive Diving Profiles not only require training and experience, but in-depth knowledge by the diver of the use and maintenance of the equipment used to do this safely. Aggressive Diving Profiles are not only deep, but can often be shallow very long dives with the popularity of Nitrox in the diving community.

Dive Computers in general are designed to assist divers in making good decisions not only while underwater but also in dive planning. A select few of the dive computers on the market today have the ability to not only program the Oxygen percentage but to also handle one or two additional decompression gasses during these aggressive diving profiles. The Nemesis IIa Nitrox and Commander Nitrox units are in this category. The Nemesis IIa Nitrox allows the diver to program the bottom blend (21.0 to 50.0) oxygen percentage and two decompression blends (21.0 to 99.9) oxygen percentages. The Commander Nitrox allows the diver to program the bottom blend (21.0 to 50.0) oxygen percentage and one decompression blend (21.0 to 99.9) oxygen percentage. By programming these blends correctly the diver will continue to receive accurate information not only during the planned bottom time but also during the decompression stops. If the diver fails to program the unit correctly or does not understand the operation of the unit, the computed information will be of no use…put simply "GARBAGE IN-GARBAGE OUT"!

The following is an actual example of the very aggressive, decompression diving at Bikini Atoll, where the dive operators claim that the Nemesis IIa Nitrox/Commander Nitrox has failed when, in fact, it has not.

A diver begins a typical set of repetitive decompression dives at Bikini Atoll. The dives are generally in the 120’ to 160’ range using air (21.0% oxygen) as a bottom blend and a surface supplied decompression blend ranging from 50.0% to 72.0% oxygen. Looking at the dive computer configuration for dive #1,2 and 3, the diver programs the unit for 10% conservatism. Not completely understanding how this function works he assumes that this will provide added safety to his diving profile, which it will. What he has actually done is told the Nemesis IIa Nitrox/Commander Nitrox to make every calculation 10% more conservative. What will happen during this type of aggressive diving profile is that the diver will have reduced bottom time and increased decompression time. Internally, the Nemesis IIa Nitrox/Commander Nitrox calculates an additional 10% nitrogen load for each tissue group (this will catch up to the diver later). The diver also decides to not change the blend #2 setting which is set at 58.0% oxygen even though the boat will provide 69.0% oxygen for decompression on this dive. The Nemesis IIa Nitrox/Commander Nitrox will do what it was programmed to do, but the diver will complain about too much required decompression compared to his buddies unit. His buddies unit does not have the ability to add conservatism. The diver also did not program the correct decompression blend correctly. This has now caused not only an increase in decompression time but now the actual residual nitrogen which the Nemesis IIa Nitrox/Commander Nitrox has calculated the diver absorbed is INCORRECT. Remember, "GARBAGE IN-GARBAGE OUT". From this point on during this "Dive Day" all NDC, Decompression and tissue loading the Nemesis IIa Nitrox/Commander Nitrox is calculating are INCORRECT, even though the Nemesis IIa Nitrox/Commander Nitrox is functioning correctly based on how it was (incorrectly) configured. During dive #2 and #3 the diver does not change the Nemesis IIa Nitrox/Commander Nitrox configuration. Unhappy with its performance, the diver still continues to dive the unit. By the end of repetitive decompression dive #3 the Nemesis IIa Nitrox/Commander Nitrox has calculated so much residual nitrogen, because of the 10% conservatism and incorrect programming of the surface supplied decompression blend the unit now is asking the diver for well over 5 hours of decompression. The decompression obligation is displayed using blend #1 oxygen percentage. If the diver had programmed the correct decompression blend the time would have actually dropped faster than the displayed time once they switched to the decompression blend. However, the diver ignores the INCORRECT decompression obligation, caused by INCORRECT programming, and goes to the surface causing the Nemesis IIa Nitrox/Commander Nitrox to go into gauge mode, because of the violation of a ceiling. This example is common when divers do not understand or are not willing to take the time to configure the Nemesis IIa Nitrox/Commander Nitrox correctly for the type of diving planned. The diver complains the unit failed when in reality the unit performed as it should with the configuration it was given.

Unfortunately, we have a number of dive profiles of this nature. If you are unsure of how to properly configure a Cochran unit, contact Customer Service via e-mail at service@divecochran.com or 1-800-856-3483. Our Professional Instructors are ready to assist you in getting the maximum enjoyment from your Cochran product