mares


# Horizon

Instruction Manual

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## • IMPORTANT WARNINGS

You must read and understand these warnings in their entirety before using the controller/decompression computer. You must read and understand the controller/decompression computer user manual in its entirety before using the dive computer. **The user manual can be downloaded at www.mares.com.**



Mares adopts a policy of continuing improvement, and therefore reserves the right to make changes and enhancements to any of the products described in this manual without notice.

Under no circumstances shall Mares be held responsible for any loss or damage sustained by third parties deriving from the use of this instrument.

## DISCLAIMER

This manual describes how to operate an instrument and it describes the information provided by the instrument during a dive.

Neither the manual nor the instrument are a substitute for dive training, common sense and good diving practices.

How the information provided by the instrument is interpreted and put to use by the diver is not the responsibility of Mares. Read the manual (the user manual can be downloaded at www.mares.com) carefully and make sure you understand completely how the instrument works and the information it provides during a dive, including information on depth, time, decompression obligations and all warnings and alarms. Unless you fully understand how the instrument works and the information it displays and unless you accept full responsibility for using this instrument, do not dive with it.

**⚠ WARNING**

A controller/decompression computer is an electronic instrument and as such it is not immune to failure. To protect yourself against the unlikely event of a failure, in addition to the dive computer, also use a depth gauge, a submersible pressure gauge, a timer or watch, and dive tables.

**⚠ WARNING**

Do not dive if the display appears unusual or unclear.

**⚠ WARNING**

The controller/decompression computer must not be used in conditions that preclude its use (e.g.: low or no visibility, making it impossible to read the gauge).

**⚠ WARNING**

The controller/decompression computer cannot ensure against possible decompression sickness.

**⚠ WARNING**

- Diving with Nitrox may only be attempted by experienced divers after proper training from an internationally recognized agency.
- Before every dive and after changing the tank, you must make sure that the set oxygen concentration in the controller/decompression computer corresponds to the oxygen concentration in the tank. Setting the wrong oxygen concentration can lead to serious injury or death.

**⚠ WARNING**

Diving in mountain lakes without first setting the controller/decompression computer to the proper altitude setting can cause severe injury or death.

**⚠ WARNING**

Diving after having reset the desaturation is extremely dangerous and is very likely to cause serious injury or death. Do not reset the desaturation unless you have a valid reason to do so.

**⚠ WARNING**

A rapid ascent increases the risk of decompression sickness.

**⚠ WARNING**

- The MOD should not be exceeded. Disregarding the alarm can lead to serious injury or death.
- Exceeding a $ppO_2$ of 1.6bar can lead to sudden convulsions resulting in serious injury or death.

**⚠ WARNING**

When the MOD alarm is triggered, ascend immediately until the alarm stops. Failure to do so could result in serious injury or death.

**⚠ WARNING**

When the CNS reaches 100% there is danger of oxygen toxicity. Start procedure to terminate the dive.

**⚠ WARNING**

Diving with oxygen toxicity at levels of 75% or greater may put you into a potentially hazardous situation, which could result in serious injury or death.

**⚠ WARNING**

Violating a mandatory decompression obligation may result in serious injury or death.

**⚠ WARNING**

Never ascend above the displayed decompression stop depth.

**⚠ WARNING**

During all dives, perform a safety stop between 3 and 6 meters/10 and 20 feet for 3 minutes, even if no decompression stop is required.

**⚠ WARNING**

Flying while the controller/decompression computer displays **NO FLY** can result in serious injury or death.

**⚠ WARNING**

- Diving with more than one gas mixture represents a much higher risk than diving with a single gas mixture, and mistakes by the diver may lead to serious injury or death.
- During dives with more than one gas mixture, always make sure you are breathing from the tank that you intend to breathe from. Breathing from a high oxygen concentration mix at the wrong depth can kill you instantly.
- Mark all your regulators and tanks so that you cannot confuse them under any circumstance.
- Before each dive and after changing a tank, ensure that each gas mixture is set to the correct value for the corresponding tank.

**⚠ WARNING**

Do not blow compressed air onto the controller/decompression computer, because it could damage the pressure sensor area.

# • 1. GENERAL WARNING

## 1.1 GENERAL WARNING

Diving without training from a recognized agency is both dangerous and life-threatening!

A rebreather is a machine and machines break. Do not ask yourself whether a problem will occur; instead ask yourself when it will occur. Be alert for subtle changes in your SCR unit, as these are often early signs of impending problems. Having correct and regularly maintained skills, and applying them appropriately, makes the difference between life and death when a problem occurs.

Reading the instructor's manual does not replace formal training and does not adequately prepare you to dive. The manufacturer and SSI do not endorse any behavior that does not follow approved techniques and manufacturer directions.

Do not change anything on your unit, as this voids the CE-type approval and can turn your unit into an unsafe and dangerous rebreather. The use of any helium gas mixture as a breathing gas is strictly forbidden.

If water enters the gas supply system of the Horizon SCR unit and comes in contact with the electronic addition valve (EAV), the EAV may malfunction, causing the unit to fail. This is a potentially life-threatening situation that must be avoided by preventing water from entering the gas supply system

To prevent this, you should always take the following precautions when assembling and using the Mares Horizon:

- Verify that the breathing gas cylinders are free of any moisture
- Verify that there is no water present in the cylinder valve or the inlet of the regulator first stage when you connect the first stage to the cylinder.
- Verify that there is no water present in the quick-connectors of the gas supply hoses.
- Never enter the water if the gas supply system is not pressurized.
- Never connect any gases to the gas supply system while the unit is in the water.
- Never disconnect any gas supply hoses or regulators while the unit is in the water.

> **NOTE**
> If the gas supply system must be depressurized or disconnected in the water for emergency or safety reasons, a special procedure must be followed immediately after the dive and prior to the next dive to prevent damage to the EAV. (Refer to Chapter 6.3).

- Never depressurize the gas supply system while the unit is in the water.
- Always pressurize the gas supply system prior to rinsing the unit.

The warranty on the Mares Horizon will become void if the EAV malfunctions due to water entering the gas supply system.

# • 2. TECHNICAL OVERVIEW AND SPECIFICATIONS

## 2.1 THE MARES HORIZON

The Mares Horizon is designed with one clear purpose: simplicity! It is easy to setup, transport, dive, and maintain, since every component of the unit is accessible by the user.

The unit's internal components are easily accessed by removing the scrubbers that are located under the main outer cover. To keep everything small and light, the gas supply for the unit comes from one or two off-board cylinders, which gives the diver an experience similar to sidemount diving.

**Dimensions and Weight**
- Height: 54 cm
- Width: 40 cm
- Thickness: 22 cm
- Empty weight: 12 kg
- Weight with filled scrubber canisters: 14 kg

## 2.2 LIMITS OF USE

**Limits of Use**

Gas Limits
- Max $ppO_2$: 1.6 bar
- Minimum $ppO_2$ limit during use: 0.22 bar
- Maximum $ppO_2$ limit during use: 1.60 bar
- Minimum $FO_2$ in any gas supply cylinder: 30%
- Maximum gas flow rate at the surface: 30 l/min

Temperature Limits
- Maximum water temperature: 34°C
- Minimum water temperature: 4°C

Scrubber Limits

In order to test the scrubber efficiency and to comply with the European Conformity (CE) standards, the Mares Horizon is tested in very specific conditions such as at low temperatures and with increased breathing rates. The results are as follows:

**Scrubber material endurance at 40 m, with water temperature = 4ºC:**

Assuming a $CO_2$ production of 1.6 l/min, with a Respiratory Minute Volume (RMV) of 40 l/min (2 l tidal volume), using 2 kg of Sofnolime 797:
- Time until the $ppCO_2$ of the inhaled gas reaches 5 mbar: > 70 minutes
- Time until the $ppCO_2$ of the inhaled gas reaches 10 mbar: > 80 minutes

The Mares Horizon was also tested in more standard diving conditions, with a moderate breathing rate (RMV) and water temperatures above 15 ºC. The results are as follows:

**Scrubber material endurance at 40 m, with water temperature at or above 15ºC:**

Assuming a $CO_2$ production of 1.0 l/min, with an RMV of 22.5 l/min (1.5 l tidal volume), using 2 kg of Sofnolime 797:
- Time until the $ppCO_2$ of the inhaled gas reaches 5 mbar: >180 minutes

Scrubber System Capacity
- Two (2) scrubber canisters, each containing 1.0 kg of Sofnolime 797

Work Rate Conditions

Maximum work rate conditions:
- 75 RMV at 40 m, $CO_2$ production of 3 l/min for 5 minutes

Work of Breathing (WOB) at 40m, with water temperature = 4°C:
- 75 RMV (3 l tidal volume), using 2.0 kilograms of Sofnolime 797: < 2.75 J/l

Scrubber Material and Approved Lubricant:
- Approved scrubber material: Sofnolime 797
- Use only oxygen-compatible lubricants like Tribolube 71 anywhere in the unit

## 2.3 PRINCIPLES OF THE VARIABLE FLOW SCR

**Metabolism**

Our bodies use or "metabolize" a relatively low amount of oxygen from each inhaled breath. Excess oxygen and other gases like nitrogen are exhaled without being used, which is why we can re-use the gas in a rebreather. Imagine breathing from a closed, sealed bag filled with air. A normal human could easily manage a few inhale and exhale cycles before breathing became uncomfortable. This discomfort is caused by the exhaled carbon dioxide ($CO_2$) building up in the sealed bag. If we added a device to remove the $CO_2$ from each exhalation, there would be no discomfort and one could take a few breaths without an issue.

**Metabolic Rate**

"Metabolic rate" is the amount of oxygen consumed each minute. It is commonly expressed as "$VO_2$", and is measured in liters of oxygen (actually the number of oxygen molecules in one liter of gas at surface pressure) per minute (l/min). Metabolic rate changes based on personal fitness and workload during the dive.

We generally state that an average human body metabolizes approximately one liter of oxygen per minute under a moderate workload.
- At rest, the average human body consumes 0.6 l/min
- Hard continuous work would consume about 2 l/min
- In more strenuous conditions, the metabolic rate can increase to approximately 3 l/min, which can generally only be sustained for a few minutes.

Metabolic rate is not affected by changes in depth. This means that the body requires the same amount of oxygen at 30 m as it does at the surface. This is a significant difference from open-circuit diving, where an increase in pressure increases the rate of gas consumption.

This gradual consumption of oxygen from the breathing loop explains why the gas mixture coming from the stage cylinder has a higher fraction of oxygen than the gas in the breathing loop. We constantly consume some of the injected oxygen, and rebreathe the gas a few times before dumping it.

**The Breathing Cycle**

SCRs use nitrox, not pure oxygen. Since the body is constantly metabolizing the fraction of oxygen, you must inject a volume of nitrox that is higher than the fraction of oxygen you actually want to breathe. If you did not do this, the fraction of oxygen would gradually decrease, and you would quickly lose consciousness. The goal is to keep the fraction of oxygen in the loop above 21%, so that when you are at the surface you can still safely breathe the gas.

To accomplish this, you must know two terms:

- Flow rate: the amount of gas injected into the loop, expressed in l/min
- Cylinder fraction of oxygen: the amount of oxygen in the injected gas mixture

Since the system is constantly injecting nitrox into the loop, and we are not metabolizing the inert gases, any excess gas must be vented or "dumped" from the loop. Without this step, the loop would continually inflate and quickly become over-pressurized. The over-pressure valve (OPV) is responsible for maintaining the loop's pressure within an acceptable range. It allows a slight over-pressurization, but opens to release gas beyond the upper limit.

**The Fraction of Oxygen in the Loop**

Table 2.3.1 shows what happens to the loop fraction of oxygen (loop $FO_2$) as the flow rate is increased. The diver has a metabolic rate ($VO_2$) of 0.8 liters/minute, and the supply gas in the cylinder is EAN 36

**Table 2.3.1 Increasing Loop $FO_2$**

| | **Flow Rate (l/min)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $VO_2$ | 5 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 24 | 30 |
| 0.8 | 24% | 26% | 29% | 30% | 31% | 32% | 33% | 33% | 33% | 34% | 34% |

Table 2.3.2 shows what happens to the loop $FO_2$ when air is used as the supply gas. The diver has a metabolic rate of 0.8 l/min.

**Table 2.3.2 Loop $FO_2$ When Diving with Air**

| | **Flow Rate (l/min)** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $VO_2$ | 5 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 24 | 30 |
| 0.8 | 6% | 9% | 12% | 14% | 15% | 16% | 17% | 17% | 18% | 18% | 19% |

Even for the very high flow rates and a low metabolic rate, the gas would be hypoxic (lower then 21% oxygen). At a moderate or high work rate, the loop $FO_2$ would be far too low! For safety reasons, and due to CE regulations, the lowest acceptable fraction of oxygen in the SCR at the surface is 21%. This is why air cannot be used as our supply gas when diving with an SCR.

Table 2.3.3 shows what happens to the loop $FO_2$ when EAN 30 is the bottom gas for different flow rates and metabolic rates.

**Table 2.3.3 Flow Rate (l/min)**

| | **Flow Rate (l/min)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $VO_2$ | 5 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 30 |
| 0.6 | 21% | 24% | 26% | 26% | 27% | 27% | 28% | 28% | 29% |
| 0,8 | 17% | 22% | 24% | 25% | 26% | 26% | 27% | 27% | 28% |
| 1.0 | 13% | 20% | 22% | 24% | 25% | 25% | 26% | 26% | 28% |
| 1.5 | 0% | 14% | 18% | 20% | 22% | 23% | 24% | 24% | 26% |
| 2 | -17% | 7% | 13% | 16% | 18% | 20% | 21% | 22% | 25% |
| 3 | -75% | -12% | 0% | 7% | 11% | 14% | 16% | 18% | 22% |

With a flow rate of 30 l/min and a metabolic rate of 3 l/min, we are very close to the minimum allowable loop $FO_2$ of 21%. We could increase the flow rate to increase loop $FO_2$, but it would require increasing the flow rate to an impractically high level. We would be better off breathing from the cylinder regulator! After considering all safety limits and practical considerations, we understand that we established two limits with regards to our equipment:

- The SCR unit will supply a flow rate of up to 30 l/min.
- The minimum permitted cylinder fraction of oxygen is 30%.

The previous examples show us that an Active Semi Closed rebreather like the Horizon should provide varying flow rates depending on the gas being supplied and the diver's metabolic rate. This is exactly the fundamental design feature behind the Mares Horizon.

**The Variable Flow SCR**

The Mares Horizon is an active SCR with variable flow rates to maintain the desired fraction of oxygen in the breathing loop. To achieve a constant loop $FO_2$, the SCR unit must constantly change the flow rate from 5 to 30 l/min, depending on the metabolic rate of the diver. For example: if the average diver metabolizes +/- 1.0 l/min of oxygen during a relaxed diver, and uses an EAN30 while his 'target fraction' of oxygen he is breathing is 25%, the gas consumption will be 14 l/min (see table 2.3.3).

The Mares Horizon maintains a minimum flow rate of 5 l/min via the orifice at all times. During a dive, the fraction of oxygen in the loop is constantly measured. When the fraction drops below the set point, an electronically-controlled valve or 'Electronic Addition Valve' (EAV) opens. This valve injects fresh nitrox into the breathing loop until the fraction increases to reach the set point.

- The minimum set point fraction is 23%.
- The maximum set point is the actual cylinder fraction minus 3%.

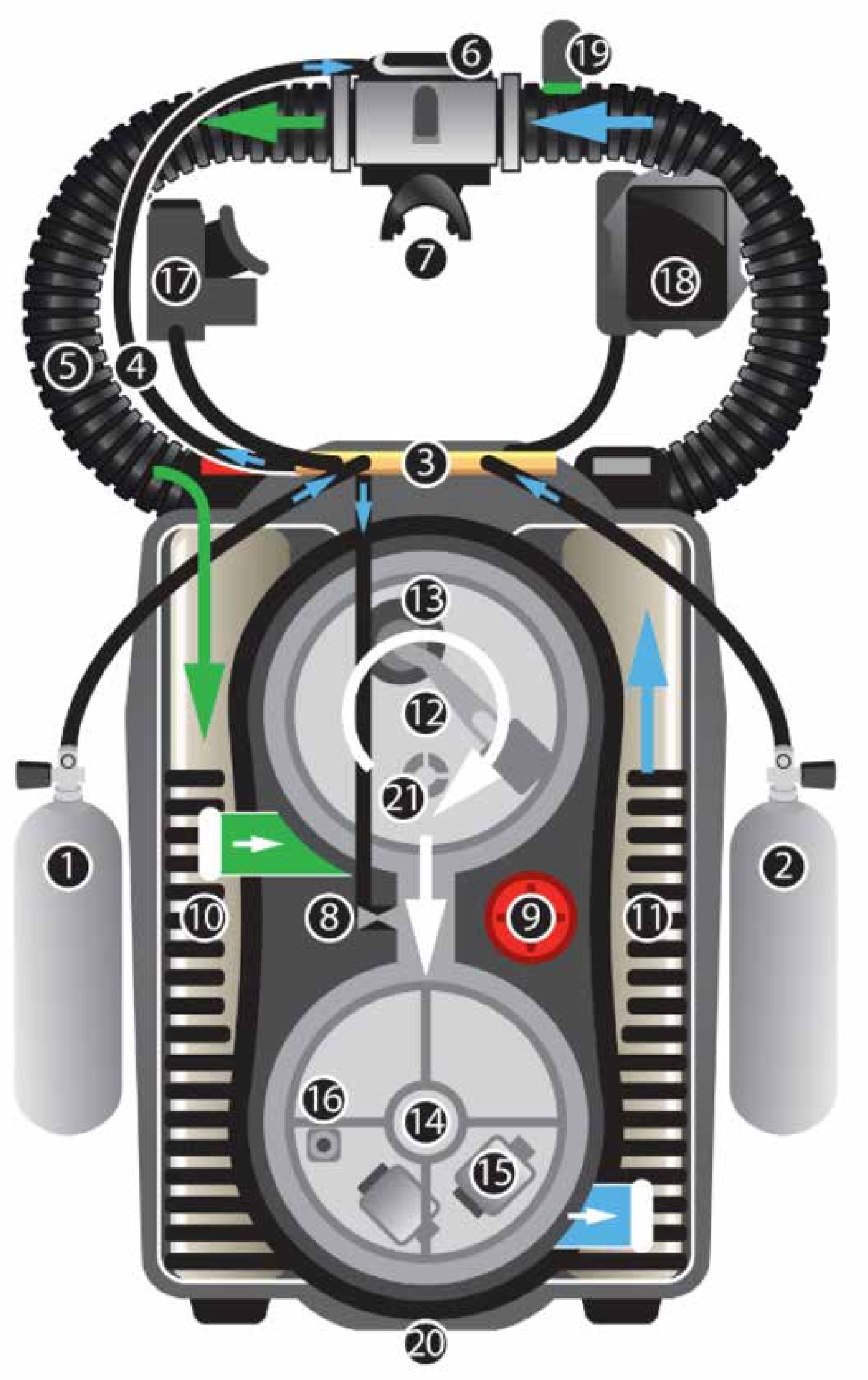
For example, when the fraction of oxygen in the cylinder is 36% (EAN 36), the target fraction (set point) can be set at any value between 23% and 33%. There is one exception to this rule. At or near the surface, we prefer a fraction of oxygen much higher than 21% in the breathing loop. The Mares Horizon controller keeps the loop $FO_2$ at a minimum of 25%. This means that the unit will override the set point inputted by the user if it was set below 25%.

• 3. THE MARES HORIZON SCR

## 3.1 HORIZON COMPONENTS

**Overview of the Mares Horizon**

1. Bottom gas cylinder
2. Decompression gas cylinder (optional)
3. Gas block/manifold
4. Bail-out valve supply hose
5. Breathing hose
6. Bail-out valve (BOV)
7. Mouthpiece
8. Orifice and one-way valve
9. Battery box
10. Exhale lung
11. Inhale lung
12. Exhale scrubber canister (upper canister)
13. Auto-delivery valve (ADV)
14. Inhale scrubber canister (lower canister)
15. Oxygen sensors (2 pieces)
16. Electronic addition valve (EAV)
17. Inflator connection
18. Controller/decompression computer
19. Heads-up display (HUD)
20. Weight pockets
21. Over-pressure valve (OPV)




**Picture 3.1**

### Breathing Hose Assembly

The breathing hose assembly consists of corrugated rubber hoses connected to each side of the unit's mouthpiece. The mechanism to open and close the mouthpiece can be operated in a wide range of water temperatures. A safety strap, also known as a "gag strap", is fixed to the mouthpiece. When correctly adjusted, the gag strap prevents the mouthpiece from falling out of your mouth, even in the unlikely event that you lose consciousness. Hose weights can be added as needed to help the hoses and mouthpiece maintain a comfortable in-water position.

### Hose Connections

The breathing hose connections have clearly labeled markings for the inhale and exhale sides to prevent confusion and accidental switching. The connectors also have different size diameters as an additional precaution to prevent wrong connections.

### Bail-out Valve (BOV)

The bail-out valve, or BOV, is a device that allows an SCR diver to close their breathing loop while automatically switching to a small but high performing built-in second stage regulator that allows the diver to breathe in "open-circuit", eliminating the need to remove the breathing loop from the mouth if the unit malfunctions. The BOV uses the same gas that supplies the rest of the unit. This means that when the diver switches to the BOV, they will breathe from either the bottom gas or decompression gas (if present) depending on which is the active gas in the SCR.

### Heads-Up Display (HUD)

The HUD is an independent device that communicates with the other electronic components in the system. It is attached to the bail-out valve and has a single LED light that uses a simple "good/bad" indication of whether we are breathing a safe fraction of oxygen.

The LED has three status indicators:

- Green (pulsing softly) = SCR unit status is OK, and the fraction of oxygen in the breathing gas is safe. The soft green pulsing simulates the relaxed 'breathing pulse' of the diver, when all is ok with this rebreather. by gently increasing and decreasing the intensity of the green light, at a slow speed
- Red (blinking slowly) = Indicates a WARNING - the diver should look at their controller to identify the issue
- Red (blinking rapidly) = Indicates an ALARM - the diver must bail-out to open-circuit immediately

### Controller

The Mares Horizon has a customized, wrist-mounted set point controller that automatically maintains a predefined fraction of oxygen. The electronic addition valve (EAV) is mounted in the pressure line and is operated by the controller. In addition, the Mares Horizon controller has all the functions of dive a computer such as displaying depth, time, calculate deco, compass and many more. One of the most important functions of the Mares Horizon controller is displaying warnings and errors on the screen.


### Counterlungs

The Mares Horizon counterlungs are made from a food grade, elastic polyurethane that is sealed with a high-frequency welding technology to ensure gas tightness. Both the inhale and exhale counterlungs are located backmount-style behind the diver's body in the main case of the unit.

The main case is contoured to fit the diver's back and protects the counterlungs from damage in environments like wrecks, caverns, or cenotes. This placement also leaves the diver's chest unobstructed and does not limit movement or vision. This makes it very easy to work with additional stage cylinders or other extended range equipment. The exhale and inhale lungs are connected by two scrubber canisters mounted in sequence that are thermally insulated by an additional gas chamber.

The oxygen sensors are located below the bottom canister, where the flow of warm gas through the breathing loop helps to keep them dry. An overpressure valve (OPV) is mounted on the back side of the unit on the exhale side.

### Scrubber Canister Configuration

The only job of the scrubber material is to remove carbon dioxide from your exhaled breathing gas. The Mares Horizon has a unique dual-scrubber system that uses two scrubber canisters mounted in sequence to allow gas to flow from the upper scrubber to the lower.

### Compact Design

The two scrubber canisters are mounted in a serial top-to-bottom configuration. They have a large diameter but a relatively low height. This limits the total thickness of the unit and creates a more streamlined profile during the dive. Each scrubber canister holds a maximum of 1 kg of scrubber material. The low ratio of height to surface of the scrubber canisters also results in a low breathing resistance. Any condensation created during the dive remains in the counter lungs, leaving the scrubber material unaffected. This is true for both horizontal and vertical diving positions. The risk of gas channeling (gas trying to follow a path of less resistance through the sorb, due to less compacted areas in the scrubber material), is strongly reduced compared to a single-canister configuration.

## Controlling Gas Flow

### The Orifice

The Mares Horizon uses an orifice to guarantee a constant volumetric flow of breathing gas. This flow rate is 5 l/min at the surface. As the intermediate pressure of the first stage increases with depth, the corresponding mass flow rate through the orifice also increases.

In most situations, this is not a sufficient supply of gas, so the Mares Horizon has an electronic addition valve to supplement the flow through the orifice. The orifice has a non-return, or one-way valve, mounted on the outside to help prevent dirt, moisture, or dust in the exhale lung from entering the orifice.

### The Electronic Addition Valve

The Electronic Addition Valve, or "EAV", is located below the second scrubber canister. It is an electronically-controlled valve that can be triggered by the unit controller when required. By using the EAV, up to 25 l/min of additional gas flow can be added to the breathing loop. The Mares Horizon uses both the orifice and the EAV to ensure you always have a safe fraction of oxygen in your breathing gas.

### Auto-Delivery Valve

An Auto-Delivery Valve, or "ADV", is mounted under the top scrubber canister on the exhale side. It is activated by the pressure change during descent and can be adjusted like a regulator, to decrease or increase the inhale resistance.

### Over-Pressure Valve

An Over-Pressure Valve, or "OPV" is also mounted under the top scrubber canister. This valve dumps excess gas from the breathing loop. By design, SCRs continuously inject and dump gas at the same time.

### Weight System

The Mares Horizon has two integrated weight compartments, one at the top of the unit and one at the bottom. Each compartment can carry a maximum of 2.5 kg of weight, for a total of 5 kg. If more weight is needed, the diver can mount pockets onto the Mares Horizon harness buttplate, or carry a weight belt.

An alternative method of how to add weight to the Mares Horizon system is to use steel cylinders instead of aluminum cylinders. This method of adding weight in the cylinders is only possible due to the fact that at no point during the dive will there be the need to remove either the bottom gas or decompression gas.

## 3.2 THE SCRUBBER SYSTEM

**The Dual-scrubber System**

The Mares Horizon uses a unique scrubber canister configuration. There are two axial canisters mounted in a serial configuration to improve streamlining and to reduce the size of the unit. Each canister holds approximately 1 kg of scrubber material. The two canisters are connected by a channel in the main case cover.

**Scrubber Material**

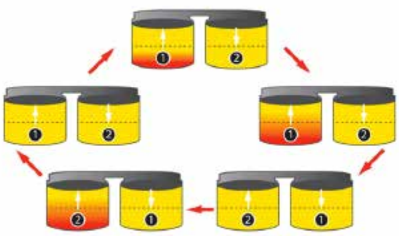
The scrubber material that is closest to the point where gas flows into the scrubber canister is saturated first. The scrubber material in the far end of the scrubber canister should never become saturated because you will always change the scrubber material before it becomes completely saturated.

Saturated scrubber material does not look significantly different from new scrubber material, so you cannot visually determine exactly how much is saturated and how much fresh scrubber material remains. To maintain a large safety margin, which is needed if you must suddenly increase your workload, you have to replace the scrubber material more frequently than is actually necessary. In a normal single canister configuration, a large amount of unused scrubber material is always discarded as part of this process. In a dual-scrubber configuration, like used in the Mares Horizon, only the saturated scrubber material is discarded after diving

**The Scrubber Replacement Cycle**

Image 3.2.1 illustrates the saturation level of scrubber material during diving. The saturated scrubber material is highlighted in red and unsaturated scrubber material is in yellow. The scrubber system used in the Mares Horizon is only effective if the correct procedure for changing the scrubber material is used. Each scrubber canister is labelled to avoid mistakes.

**Image 3.2.1 Scrubber Replacement Cycle**



**Cycling Scrubber Canisters**

Start with two canisters that are filled with fresh scrubber material:

- Place "Canister 1" in the upper cavity (on the exhale counterlung).
- Place "Canister 2" in the lower cavity (on the inhale counterlung).
- After a period of use, Canister 1 is removed and emptied.
- Canister 2 is removed from the lower cavity and placed in the upper cavity.
- Canister 1 is refilled with fresh scrubber material and is placed in the lower cavity.
- The cycle is repeated as necessary, with the canister from the bottom cavity replacing the canister in the upper cavity.

During the refill and replacement phase of the cycle, half of the total scrubber material is discarded. Since you always discard the half from the top canister, where $CO_2$ saturation begins, the most saturated scrubber material, or the material closest to the incoming gas, is always discarded first.

By placing the fresh unused scrubber material in the lower cavity, we ensure that any $CO_2$ that is not absorbed by the partially saturated absorbent is captured by the fresh material in the second canister. When compared to a single-canister system that completely replaces the scrubber material each time, this process decreases the use of the scrubber material by about 50% without affecting safety.

**The TOP Marker**

Confusing which scrubber canister contains fresh scrubber material is a potentially dangerous mistake. To help avoid this error, the Mares Horizon includes a "TOP marker". This marker is a small indicator that is installed on the top of the canister in the upper cavity over the exhale lung. Make it a habit to immediately empty a canister when you remove the TOP marker. This will help prevent making mistakes when you exchange/fill/ replace canisters.

Follow this procedure exactly:

- Take the top canister with the TOP marker out of the upper cavity.
- Unscrew the TOP marker and immediately empty that canister of the used scrubber material.
- Re-screw the TOP marker onto the canister that still contains scrubber material and put that canister into the top cavity.
- Refill the empty canister and put it in the lower cavity.
- Record in the log that the bottom canister was refilled with fresh scrubber material.

**Scrubber Material Duration**

The approved scrubber material for the Mares Horizon is Sofnolime 797. The duration of the scrubber material is calculated and communicated to the diver by the dive controller via the Remaining Scrubber Time (RST) algorithm. If the algorithm is not available the diver must calculate the remaining time on their scrubber material manually.

**Normal Workload**

**For normal dive conditions with a normal workload, using Sofnolime 797:**

- If the water temperature is < 15°C the maximum dive time is 3 hours, and both scrubber canisters must be refilled. There is no cycling permitted.
- If the water temperature is > 15°C the maximum dive time is 3 hours, and the cycling procedure can be applied: one canister must be refilled.
- If the diver accidentally exceeds the maximum dive time of 3 hours, both scrubber canisters must be refilled.

## 3.3 THE SCRUBBER MONITORING SYSTEM

**The Scrubber Monitor**

One of the features of the Mares Horizon controller is its ability to monitor and calculate the Remaining Scrubber Time (RST). On the main screen of the controller the diver will be provided with information on how much remaining time the scrubber system has. Prior to the dive it is extremely important to check the RST to ensure that there is enough for the planned dive.

**The Monitoring System in Action**

Every scrubber material has a limited capacity to absorb a volume of carbon dioxide ($CO_2$) before breakthrough will occur.

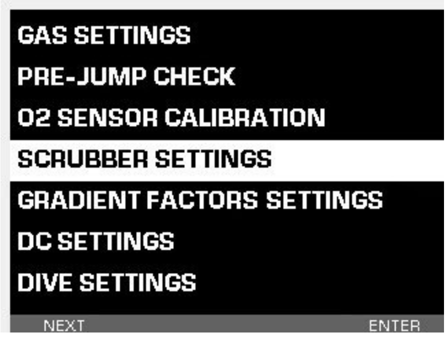
**$CO_2$ Breakthrough**

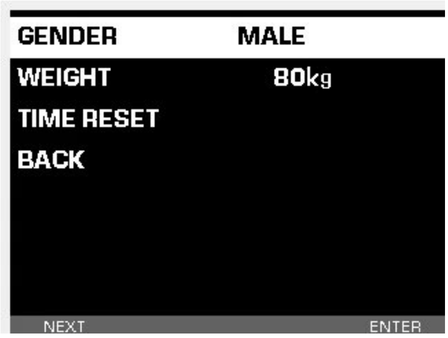
Is defined as the condition in which the exhaled gas passes through the scrubber material without the $CO_2$ being removed from the breathing gas.

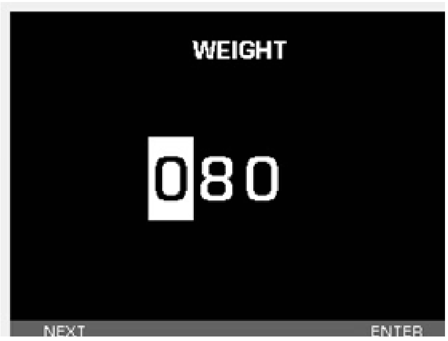
The amount of $CO_2$ that a scrubber can absorb is a function of temperature and depth. The Mares Horizon has a maximum depth limited to 40m and so this has a minor influence. The scrubber monitoring system knows the total volume of the scrubber material that can be held and it also has the ability to measure the water temperature, which means that it can calculate how many liters of $CO_2$ can be absorbed before breakthrough occurs.

**Biometrical Data**

It is necessary to enter the diver's personal biometrical information such as weight and gender in the scrubber settings in order to estimate the $CO_2$ production.




**Oxygen Metabolism**

The human body is producing $CO_2$ in a more or less fixed ratio to consumed oxygen.
By measuring how much oxygen is being metabolized, the monitoring system can calculate how much $CO_2$ is being produced and when the scrubber will be expired.

The Mares Horizon is a variable flow SCR (see section 2.3) which means that the flow rate of oxygen rich gas is adjusted based on a defined gas fraction in the breathing loop, the gas in the cylinder and the diver's oxygen metabolic rate.

**Example**

If the diver's oxygen metabolic rate is 1 liter per minute and the gas in the cylinder is EAN32 and the defined setpoint is 26% the required flow rate of EAN32 is 12 liters per minute.

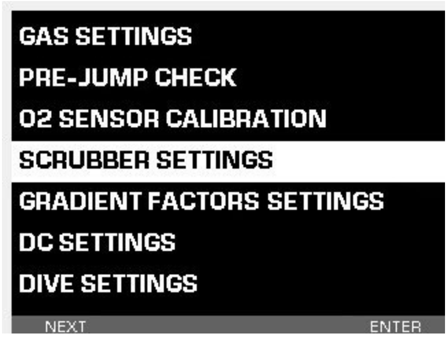
As the Mares Horizon is adjusting and calculating the required flowrate, it can easily calculate the diver's oxygen metabolic rate and so in turn calculate the $CO_2$ being produced by the diver.

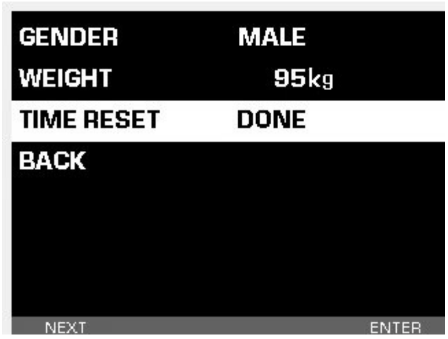
**How to use the Scrubber Monitoring System**

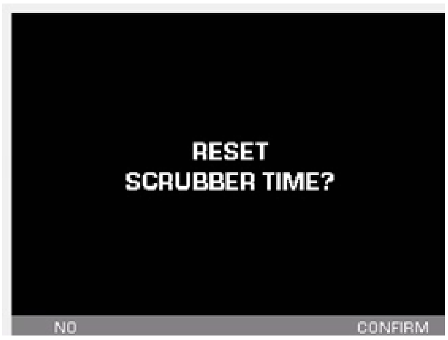
When both canisters are filled with fresh scrubber material the Scrubber Monitoring System must be reset. This can be done by completing the following steps:

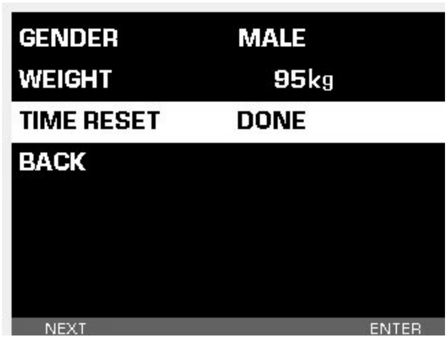
1. Go to "SCRUBBER SETTINGS/TIME RESET
2. Confirm that the scrubber time should be reset

The RST will be reset and will now be calculated based on the water temperature recorded from the last dive and the diver's estimated $CO_2$ production.

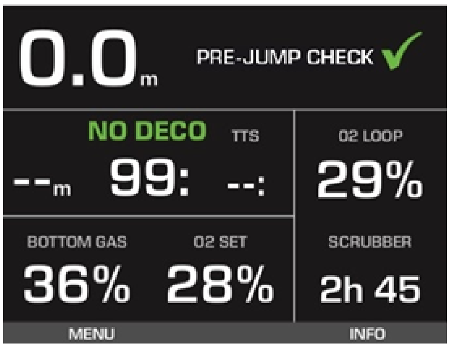



After confirming the TIME RESET, the main page will show you the remaining time the diver has on a freshly changed scrubber, for example: 2h45.




**The Importance of Biometrical Data**

As previously discussed, when the scrubber material has been replaced the RST on the controller must be reset. After making the reset, the controller will indicate an RST of for exaple '3h 20'. This value is calculated based on the temperature recorded from the last dive and the diver's biometrical information which is entered in the scrubber settings.

At this time, as the diver is not breathing from the unit, the controller is not able to calculate $CO_2$ production based on gas injection, simply because no oxygen rich gas has been injected yet. The controller must assume a fixed $CO_2$ production, based on the diver's weight and gender information. It is with this information that that the controller estimates the RST.

If any incorrect biometrical data has been entered into the controller, the prediction of the RST after replacing the scrubbers will be inaccurate. Due on the incorrect biometrical data entered into the scrubber settings, the controller will either show a higher or lower RST than it should. This inaccuracy of RST will continue during the dive and will cause the RST to decrease or increase at rates that are not meaningful to the diver.

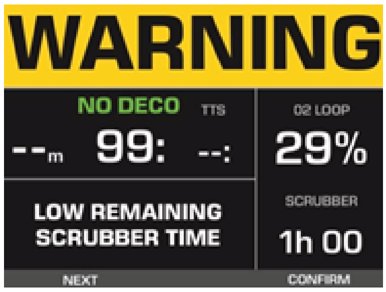
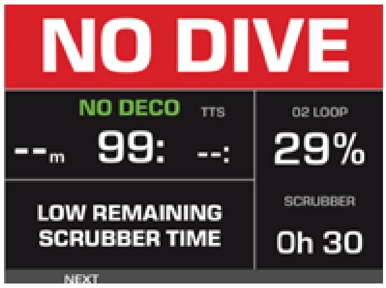
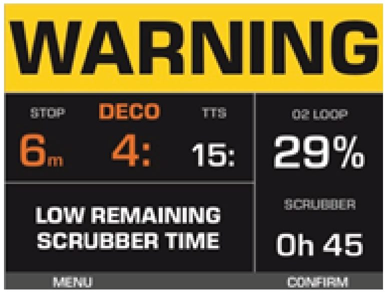
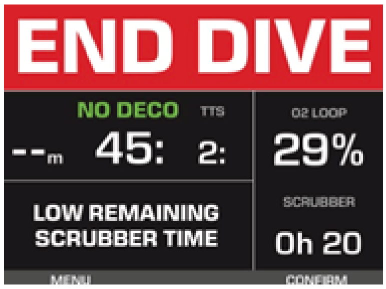
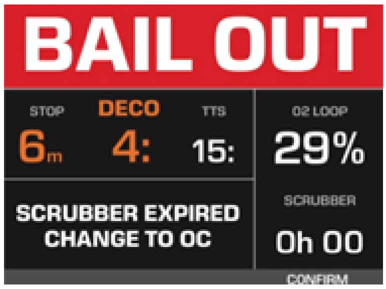
But as the RST is coming closer to zero, the time of breaktrough will become more accurate, and in any case, the RST will reduce to ZERO before any $CO^2$ breakthrough will occur.

This means that the diver is never in danger when wrong data is entered, only the prediction times of RST will be less accurate.

## 3.4 THE SCRUBBER WARNINGS

**Scrubber Monitoring System Warnings**

During the dive the Scrubber Monitoring System will constantly calculate $CO_2$ production and adjust the RST accordingly. There are two levels of warning that will be presented when the RST time is running low. The importance and consequence of the warning will depend on if it occurs on the surface or during the dive:

| SURFACE / DIVE | RST | TOP BAR MESSAGE | BOTTOM BAR MESSAGE | EAV Fail Safe Mode | SCREEN |
|---|---|---|---|---|---|
| SURFACE | RST < 1:00 | WARNING | Low remaining scrubber time | NO |  |
| SURFACE | RST < 0:30 | NO DIVE | Low remaining scrubber time | YES |  |
| DIVE MODE | RST < 0:45 | WARNING | Low remaining scrubber time | NO |  |
| DIVE MODE | RST < 0:20 | END DIVE | Low remaining scrubber time | NO |  |
| DIVE MODE | RST = 0:00 | BAIL OUT | Scrubber expired. Change to OC | YES |  |

## 3.5 OXYGEN SENSORS

### Inside the Sensor

The top portion of an oxygen sensor has a circuit board with a connector, in case of the Horizon, a male Molex connector. The underside of the board is covered in electronic components. The bottom portion has the body of the sensor, also called the galvanic sensor, with two connector/wires attaching it to the circuit board. On the bottom of the sensor's body is a white membrane where the oxygen uptake occurs.

### Installation

The Mares Horizon is using two oxygen sensors;

- T sensor (Test sensor)
- F sensor (Fraction sensor)

### Fraction Sensor

During the dive, the fraction sensor is used to measure the oxygen concentration in the breathing loop. Unless a gas check procedure is being performed, the reading that is displayed on the main screen of the controller is coming from the fraction sensor.

### Test Sensor

The test sensor is used to perform a number of tests both before and during the dive. During the Pre-Jump Check the test sensor is checking to verify if the correct gases are programmed into the controller and that the correct cylinder is open. During the dive, after the descent, the test sensor is checking again to verify if the cylinder is open. It could be that the cylinder passed the Pre-Jump Check but then the cylinder was closed due to a long transit to a dive site. Eevery five minutes of dive time the test sensor is checking again to verify if the correct cylinder is open and the correct gas programmed into the controller. If any of these tests fails, an alarm or warning is displayed.

### Location of the Oxygen Sensors

Both of the oxygen sensors are located within the unit electronics in the inhale counterlung. The sensors are secured in place by either a black holding screw or a white plug connected to the gas line. Each one has a Molex connector attached. It is important to ensure that the connector is in the correct position and that it is not forced into position as this may damage the pins on the sensor. Record the installation date of each specific sensor and write the date on the sensor itself to track its exact age.

- The fraction sensor is installed on the sensor grid using the black threaded ring. It should be connected to the molex connector labeled "F".
- The test sensor is installed on the sensor grid using the white plug connected to the gas tube. It should be connected to the molex plug labeled "T".

Replace the sensor grid into the cavity, ensuring that it is correctly aligned, and that none of the wires are pinched or kinked.

### Replacement

The Mares Horizon controller has only one sensor reading displayed on the main screen. The second sensor is used by the controller to validate the gas injection during the dive. Every 5 minutes, nitrox from the supply cylinder is injected in front of the sensor. If the controller knows what gas is in the cylinder and the current depth, it expects the sensor to read the fraction of that gas. If the gas validation fails, the units generates an alarm.

You should mark the date of installation on each sensor. Every six months, replace the oldest sensor in the unit with a new one as this will reduce the probability of both sensors failing at the same time during a dive. This is because the sensors come from different production batches and have different dive histories once you start using them.

Only use sensors that are approved by the manufacturer. If a sensor fails prior to the six months change interval, immediately replace it with a new sensor.

## 3.6 GAS MANAGEMENT

### Gas Management

The Mares Horizon is a Semi-Closed Rebreather. A variable, electronically controlled flow of nitrox gas is injected in order to maintain a desired oxygen fraction in the breathing loop. Unlike most other rebreathers on the market, the Mares Horizon does not feature cylinders built into the unit. Instead, off-board cylinders, like stage or bail-out cylinders, are used.

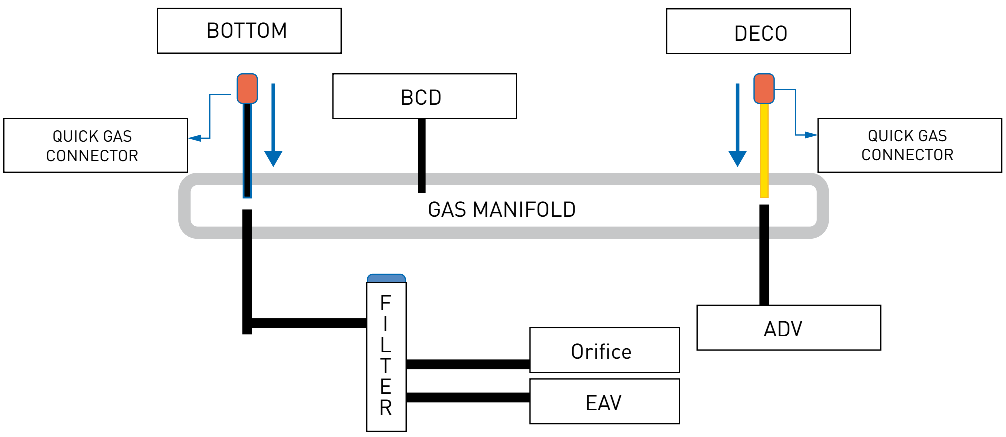
The Mares Horizon is designed to allow for diving within the no-decompression limits or for decompression dives up to a maximum depth of 40 meters. To accelerate decompression two different gas mixes can be used; bottom gas and decompression gas. The bottom gas is used during the descent and bottom phase of the dive and the decompression gas is used for the decompression phase of the dive. Both bottom and decompression gases must meet the following criteria:

- Minimum Oxygen Content: 30%
- Maximum Oxygen Content: 100%

### Gas System Schematics

The Mares Horizon uses both the orifice and the Electronic Addition Valve (EAV) to maintain the desired fraction of oxygen ($FO_2$) in the loop. Additional devices such as the Auto Delivery Valve (ADV) and the Bail-out Valve (BOV) are also supplied by the off-board gas supply. All gas management devices (Orifice, EAV, ADV, and the BOV) are connected together into one gas line. Once the gas supply is disconnected, none of these devices will be able to supply gas.

### 3.6.1 The Gas System Schematic of the Mares Horizon.



The cylinders are connected to the unit via quick gas connectors which originate from the main gas manifold. It is this gas manifold that permits the injected gas to be distributed to all other devices.

To avoid humidity and debris from entering the orifice and the EAV, a small filter is installed between the main gas manifold and the orifice/ EAV. Please note that both the bottom and the decompression gas are connected to the same gas manifold.

**For safety reasons when diving the Mares Horizon the bottom gas cylinder should never be closed.**

In order to add the decompression gas to the system the only action required is to open the decompression cylinder. The bottom cylinder must remain open. The Mares Horizon is supplied with stage cylinder regulators with quick gas connectors. The stage regulators are assembled and adjusted with different Intermediate Pressures:

- Bottom Gas 1st stage IP: 10.5 bar overpressure
- Decompression Gas 1st stage IP: 12 bar overpressure

**Active Gas**

This simple system of having different first stage intermediate pressures allows for the diver to choose which gas is to be injected into the rebreather. We call this the Active Gas. Correct gas injection is achieved due to the fact that the higher intermediate pressure gas (12bar) will always override the lower pressure gas (10.5). Table 3.5.1 shows which gas will be the Active Gas in different cylinder open/close combinations:

**Table 3.5.1 Active Gas Comparison Chart**

| Bottom Cylinder | Decompression Cylinder | Active Gas |
|---|---|---|
| Open | Closed | Bottom |
| Open | Open | Decompression |
| Closed | Open | Decompression |
| Closed | Closed | None |

**Quick Gas Connectors**

The bottom gas and the decompression gas are both connected to the unit via quick gas connectors. Custom designed and built by Mares, these connectors allow for an adequate flow of gas to supply the unit and the open-circuit bail-out valve (BOV). The quick gas connectors are both-side-sealed which means that both sides can be pressurized when disconnected and they will not release gas.

When using the quick gas connectors the following procedures must be adhered to:

- During normal operation, when connecting or disconnecting the quick gas connectors the system must be depressurized from both sides: the stage regulator and the rebreather
- The quick gas connectors should never be connected while in the water or when water is present on any sides of connector
- In the case of an emergency, if the gas connectors have to be disconnected in the water, this may be done while the pressure is still on
- If a quick gas connector has been disconnected while underwater it should not be re-connected until it has been completely rinsed and dried
- If the breathing gas supply system must be depressurized or disconnected for emergency or safety reasons while in the water, a special procedure must be followed immediately after the dive and prior to the next dive to prevent damage to the EAV. (Refer to Chapter 6, Diving Considerations).

**Quick Gas Connections**

In order to prevent accidental underwater disconnection of the quick gas connectors, these are designed with a special locking mechanism. In order to connect them the diver needs to simply pull back the locking ring on the female side of the connector and insert the male part into the female part of connector. This procedure is very much like the traditional low-pressure inflator hose connection.

In order to disconnect the gas connection hose, the diver needs to first release the locking mechanism. To do so, both female and male sides of the connector need to be pushed against each other. Once pushed together the locking ring can be released and the connector can be disconnected.

## 3.7 THE ELECTRONIC ADDITION VALVE

**The Electronic Addition Valve (EAV)**

The Mares Horizon is a variable flow SCR with a fixed flow of 5 liters per minute on the surface through the orifice. In most cases this flow rate is not enough to maintain the desired fraction of oxygen ($FO_2$) in the loop (setpoint) and so additional gas injection is performed using the Electronic Addition Valve (EAV).

The EAV is an electromechanical valve that is regulated by the controller. When the EAV is constantly open it can supply a total of 25 liters per minute of gas at the surface. The Mares Horizon controls the gas flow to the diver via the EAV. The EAV is constantly adjusting the total flow rate into the unit from as little as 5 liters per minute up to a maximum of 30 liters per minute. This adjustment of flow rate allows the unit to maintain the desired $FO_2$ in the loop even when the diver's oxygen metabolic rate is changing during the dive.

**Fail-Safe Mode**

Although electromechanical valves are commonly used in the rebreather industry, the Mares Horizon EAV has a unique safety design. All mechanical parts of the EAV are designed to be open to the gas flow. This means that the controller needs to send an electrical signal to the EAV to actually close it to shut off the gas flow. This unique design is an important safety feature. If any problem should occur with any of the electronic devices the power supply to the EAV will be cut off: it will then be in its open position and this will result in 25 liters per minute of nitrox gas flowing into the breathing loop. This is referred to as the "Fail-Safe Mode". In addition to the EAV providing 25 liters per minute of gas an additional 5 liters per minute flow rate is supplied from the orifice, so in Fail-Safe Mode the unit is actually providing a total of 30 liters per minute of gas on the surface.

This is an adequate volume of gas to maintain a safe breathable gas even for a diver with an oxygen metabolic rate of 3 liters per minute and with EAN30 being injected. It is for this reason that the Mares Horizon requires the diver to use nitrox gas with a minimum oxygen content of 30%.

## 3.8 THE ELECTRONIC SYSTEM

**The Electronic System: Dive Controller, E1 and E2**

The Mares Horizon is equipped with three independent electronic systems;

- The Dive Controller (DC)
- Electronic Board 1 (E1)
- Electronic Board 2 (E2)

Each of the three electronic systems have their own power supply and work independently of each other. All of the electronic systems use a digital communication line called a CAN Bus. This architecture allows for each electronic component to communicate with each other and to act accordingly if a problem with any of electronic systems occurs.

**The Dive Controller (DC)**

The Mares Horizon Dive Controller (DC) is a high end, reliable dive computer that also plays an important role in configuring and executing dives with a variable flow SCR. It allows the user to enter breathing gas data as well as defining oxygen fraction setpoints to maintain during the dive. Chapter 4 outlines the complete functioning of the DC.

**Electronic Board 1 (E1)**

Electronic Board 1 (E1), along with Electronic Board 2 (E2), are located in a sealed compartment in the inhale scrubber canister. It is powered by an external, rechargeable battery which is located in the battery box outside of the breathing loop. During the dive E1 is the main electronics responsible for the correct functioning of the rebreather. It measures the oxygen level in the breathing loop, opens or closes the additional gas flow through the EAV and computes the RST. As previously discussed, the EAV is designed in a way that an electric signal needs to be received in order to close the gas flow. If the $FO_2$ in the breathing loop drops below the defined setpoint, E1 will cut off the power supply to the EAV which will in turn open the gas flow and thus add more oxygen-rich nitrox gas into the breathing loop.

E1 is also constantly communicating with the DC and with E2. If either of them is not working correctly, E1 will force the unit into Fail-Safe Mode by cutting off the power to the EAV.

**Electronic Board 2 (E2)**

Electronic Board 2 (E2), is powered by an embedded re-chargeable battery. The main function of E2 is to control the Heads-Up Display (HUD) located on the BOV. The HUD contains one LED light that can be either green or red. If everything is fine with the unit, all three electronics are working and communicating with each other, the correct $FO_2$ in the loop is being maintained and all safety checks are being passed, the HUD will blink in a green slow breathing pulse light.

If any error or warning occurs the HUD will switch to one of two warning modes:

- Low Warning Mode - A blinking red light
- High Warning Mode - A fast blinking red light

Both warnings are designed to attract the diver's attention and force them to check the problem description on the DC.

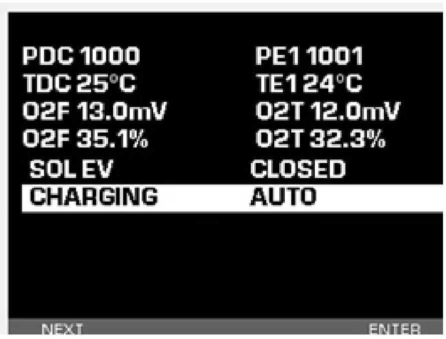
E2 is also constantly communicating with the DC and E1. If either of them is not working correctly, E2 will force the unit into Fail-Safe Mode by cutting off the power to the EAV.

**Intelligent Charging**

The Mares Horizon has two options for charging:

- Auto Mode
- Forced Mode

The diver can choose between these two modes by entering into the Setup settings and from there to the Monitoring menu, where the two options of Auto and Forced can be selected.




**Auto Mode**

The intelligent Auto charging of the Horizon prioritizes the charging to the electronics that have the lowest remaining dive time. This ensures that even a short charging time allows to rapidly increase the total minimum dive time of the complete electronic system in the Horizon. This intelligent charging is only active during direct charging using either an external charger or a power bank. Either type of power source must be at a minimum connected to the battery pack or to the battery pack and the DC.

It is worth noting that if a charging device is connected only to the DC, this will not charge the battery from E1 or E2. This is done for redundancy so that no power can ever be lost from the battery of the DC or E2 towards the battery of E1.

The intelligent Auto charging is also active when no external charger or power bank is connected. The charging system will route available power towards the system with the lowest remaining dive duration. For example, if the DC battery has the lowest remaining dive duration, the battery from E1 will transfer an amount of power to the DC, so that both can have more or less the same remaining dive duration.

Auto charging mode is also active during dive mode.

**Forced Mode**

The Forced Mode setting will route power away from battery E1 to both other batteries in the DC and to E2 until the E1 battery is nearly empty. This means that not all three batteries are balanced.

This Forced mode is a useful feature when the diver has no access to any external charging. A fully charged E1 battery which has been charged in a different location can charge all other batteries until it itself is nearly empty. After that, the E1 battery can be re-charged again or replaced with a spare, fully charged E1 battery. When forced mode is activated, the display of the DC switches off after one minute to avoid power loss while charging it from E1.

**Intelligent Charging Considerations**

- The Auto charging mode is only possible when the DC is on. Once the DC is off, the power distribution between all three batteries is discontinued.
- The Forced charging mode must be selected each time a forced charge is required. The default charging setting is Auto charging and the charging selection will automatically go back to Auto when the DC is switched off or when the unit goes into dive mode or when Forced is switched off in the menu settings

# • 4 THE MARES HORIZON DIVE CONTROLLER

## 4.1 OPERATING MODES

**Operating Modes**

The functions of the Mares Horizon Controller can be grouped into three categories, each corresponding to a specific mode of operation:

- Surface Mode
- Dive Mode
- Sleep Mode

**Surface Mode**

Surface mode is when the controller is dry and out of the water. It is in this mode that you can change settings, review your logbook, use the dive planner, see remaining desaturation after a dive, download to PC and much more. In surface mode, the controller will maintain the desired setpoint by opening or closing the gas flow through the EAV.

**Dive Mode**

The controller will enter into dive mode when it is at a depth of 1.2 meters or greater. In this mode the controller monitors depth, time, temperature and performs all decompression calculations. Dive mode itself can be broken down into two sub categories:

**SCR Mode:** when the rebreather is fully functional, the decompression calculation is based on sensor readings regarding gas in the breathing loop and the setpoint of $FO_2$ is maintained.

**OC / Bail-out Mode:** in the event of a malfunction where the diver has switched to breathe from an open-circuit gas supply either from the BOV or an off-board bail-out regulator. The decompression calculations are based on a fixed programmed gas. The Mares Horizon is now in the Fail-Safe Mode (Refer to Chapter 3, The Electronic Addition Valve).

**Surfacing**

Upon surfacing, the controller will stay in dive mode for three minutes after which it automatically switches back to surface mode. During those three minutes the dive time calculation is halted but if the diver submerges within those three minutes then the dive is resumed including the time spent on the surface. This feature allows a diver, for example, to surface momentarily to set a bearing towards the boat, then re-submerge again and swim towards the boat.

**Sleep Mode**

During sleep mode the controller appears to be turned off completely, however it is still active. In the background it computes tissue desaturation and checks the ambient pressure once every 20 seconds for uninterrupted monitoring of the environment.

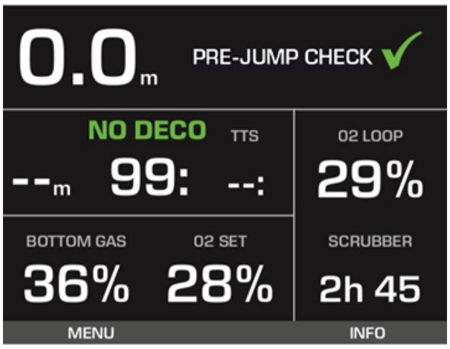
**Surface Mode**

We can divide the surface mode into two parts:

- Pre-Jump Check OK
- Pre-Jump Check not OK

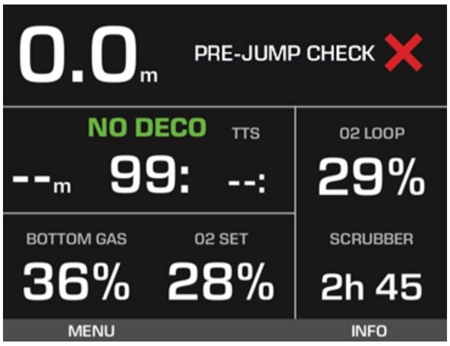
**Pre-Jump Check OK**

When the Pre-Jump Check is OK it is indicated by a green tick. The controller would be expecting the diver to now begin a dive. This means that the correct cylinders are connected and open, all checks have been done successfully and the diver is safe to breathe from the rebreather. When the Pre-Jump Check is OK the controller is performing a gas check procedure every 5 minutes.



### Pre-Jump Check not OK

If the gas check fails, the controller presents a warning or an alarm (refer to chapter 5) and Pre-Jump Check status will change to "not OK" indicated by a red X. In this situation, the dive cannot begin until the Pre-Jump Check procedure is re-performed and completed successfully.




When the Pre-Jump check is not OK, the controller assumes that the diver is not going to dive and so the gas check procedure is no longer being performed. If the diver chooses to ignore the failed Pre-Jump check and tries to begin their dive an alarm will occur and the unit will go into Fail-Safe Mode.

### Surface Mode Screen Information

The Mares Horizon Dive Controller is a high-end, LED screen, which is very easy to use both in Surface and Dive modes. In Surface mode you can access the Mares Horizon menu and other options by pushing the left piezo button and scrolling through the information screens by pushing the right piezo button.

### Top Information Bar

It is in the top information bar where the actual depth and Pre-Jump check status are displayed. During dive mode, the dive time is also displayed in this top information bar.


### Decompression Information

In the center of the screen is where the decompression status information about the dive is displayed. During the surface mode only the no-decompression limit is displayed.

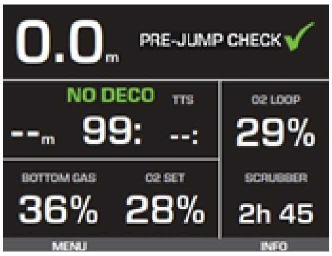

### Loop Oxygen Information

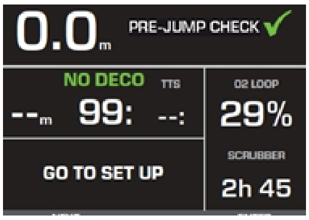
To the right of the screen is where the oxygen concentration and RST is displayed. The controller is continuously measuring the oxygen content in the loop and displays it on the main screen. Unless a gas check procedure is performed, this information comes from the fraction sensor. If the Pre-Jump check is OK, the gas procedure will occur and so the oxygen loop information will be replaced by "check" information. (Refer to Chapter 4, The menu System)

Below the oxygen concentration display is the Scrubber information. This value represents the remaining duration in hours and minutes during which the scrubber material can absorb $CO_2$ efficiently. (Refer to Chapter 3, The Scrubber monitoring System)

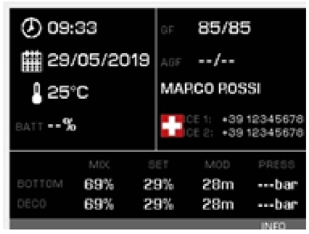

### Bottom Information Bar

By default, in this bottom information bar the active gas oxygen content and the current setpoint are displayed. It is from this display in both surface mode and dive mode that you can initiate the switch between bottom gas and decompression gas as the active gas. The bottom information bar is also where the problem description is displayed when a warning or alarm is triggered.

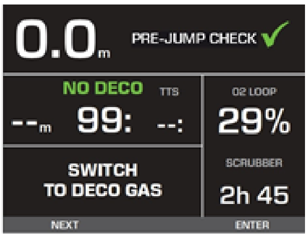


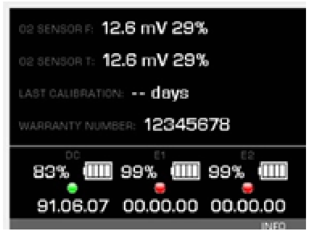

Press ENTER to go to SETUP
or NEXT for next option



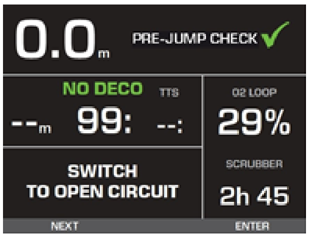

Press INFO to go to next option



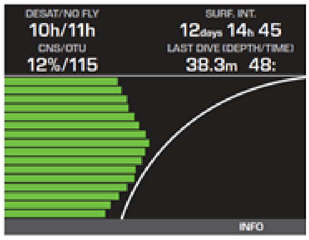

Press ENTER to SWITCH GAS
or NEXT for next option

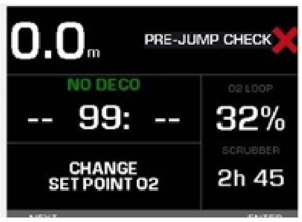



Press INFO to go to next option

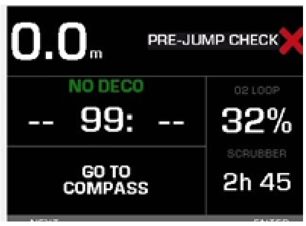



Press ENTER to SWITCH TO OC
or NEXT for next option




Press ENTER to CHANGE SETPOINT
or NEXT for next option



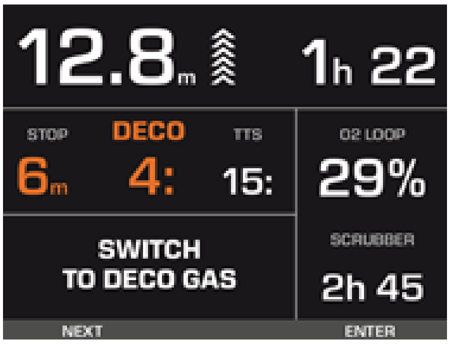

Press ENTER to GO TO COMPASS
or NEXT for next option

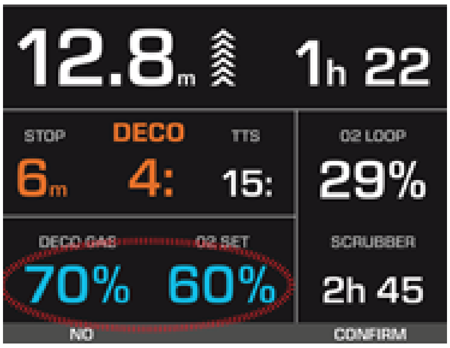
### Changes Confirmation

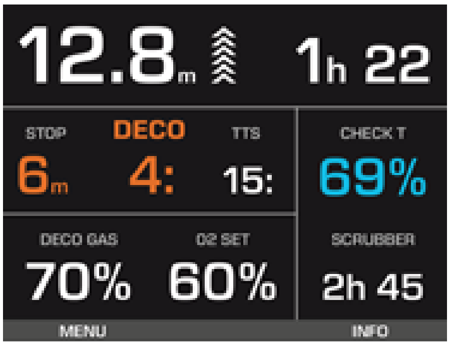
Any time changes are made on the controller either in surface mode or in dive mode, the change needs to be confirmed. For example, when changing from the bottom gas to the decompression gas, press the left button (MENU) to bring up the SWITCH TO DECO GAS OPTION, then press the right button (ENTER) to see the decompression gas values, then press the right button (CONFIRM) to confirm these values.

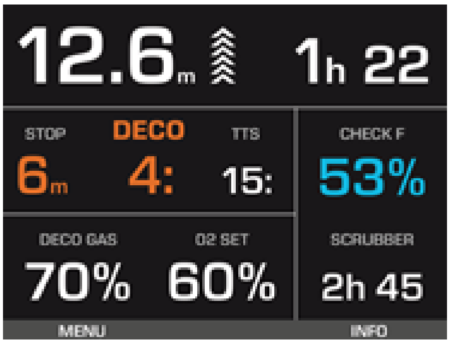
Even though in the bottom information bar you already see the decompression gas, it still requires a confirmation. The font of the chosen selection will be highlighted in blue until a confirmation is made, which makes it clear that the proposal has not yet been confirmed. To make the confirmation, you need to press the right button. Once confirmation is made the font will turn to white and the proposal becomes the real situation. If you press the left button instead (NO), the bottom gas will remain the active gas.

The following screens highlight the process of a gas switch sequence:



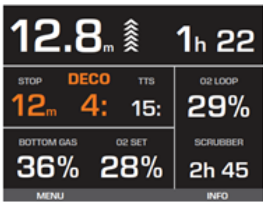




### Dive Mode

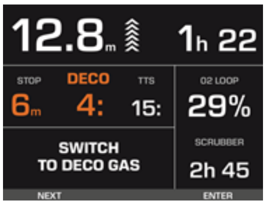
Once the controller is at a depth of 1.2 meters or greater it will switch automatically into dive mode. First, the gas check procedure is performed to ensure that the dive is started with the correct cylinders open and with the correct gas inside. From that point on, every five minutes a gas check procedure is performed.

The on-screen information on the controller in dive mode is very similar to the information in surface mode. Within the top Information bar, the dive time is now shown instead of the Pre-Jump Check. The left button options are also very similar. Access to the setup menu is no longer available but now there is access to the settings to change the gradient factors.

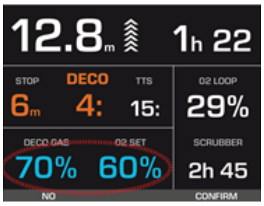
Menu options in Dive Mode



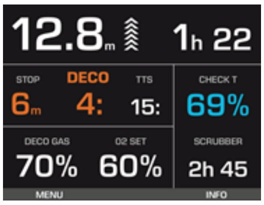

Press MENU to view the first option in the MENU sequence.



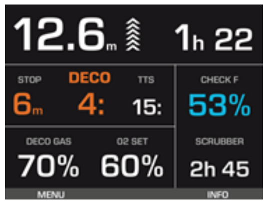

Press ENTER to initiate gas switch or NEXT for next option



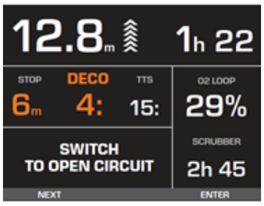

Press NO to cancel or CONFIRM to change gas



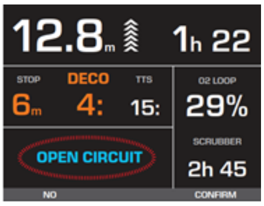

Once confirmed, Gas Check Procedure is performed to check if tank with EAN70 is open.



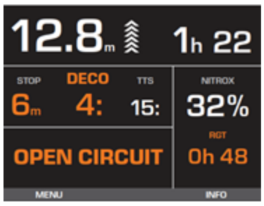

When both the Check T (gas in the tank) and the Check F (comparing both sensors while measuring the fraction in the loop) are succesfull, the display shows the fraction in the loop again in white



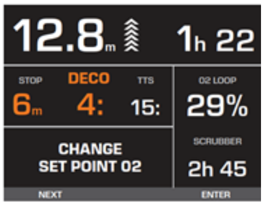

Press ENTER to change to OC or NEXT for next option



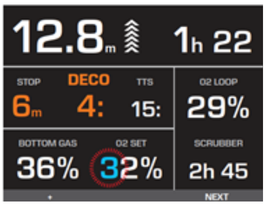

Press NO to cancel or CONFIRM to change to OC



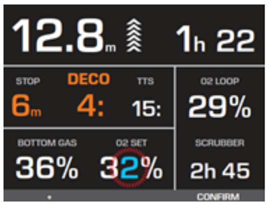

Once confirmed, unit goes to Fail Safe Mode and calculates deco based on OC Gas. RGT option to be implemented in future update.



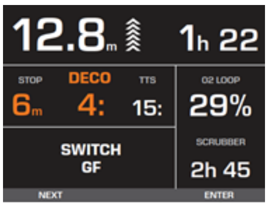

Press ENTER to change SP or NEXT for next option



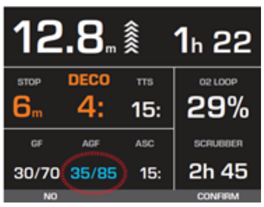

Press + to increase value (after 9 it starts again from 0) and NEXT to confirm value

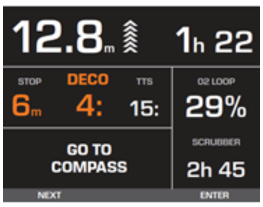



Press + to increase value (after 9 it starts again from 0) and CONFIRM to confirm value and exit menu.




FOR FUTURE UPDATE



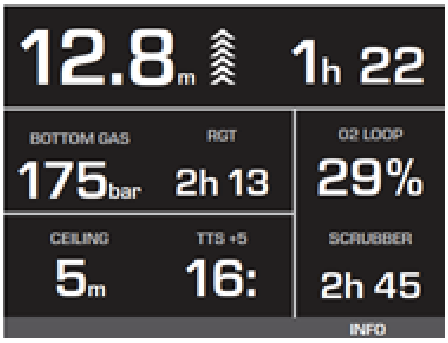



### Information Screens in Dive Mode

By pressing the right button you have access to additional information screens, each corresponding to one button press.

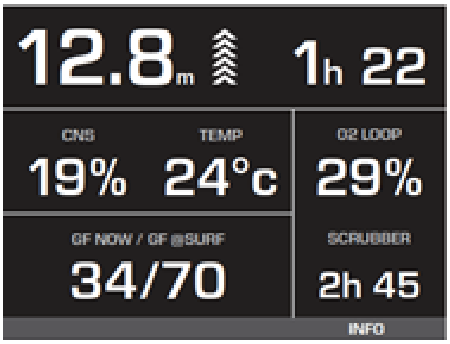
### Information Screen One

In the decompression information bar, the active gas cylinder pressure and the Remaining Gas Time (RGT) are displayed.



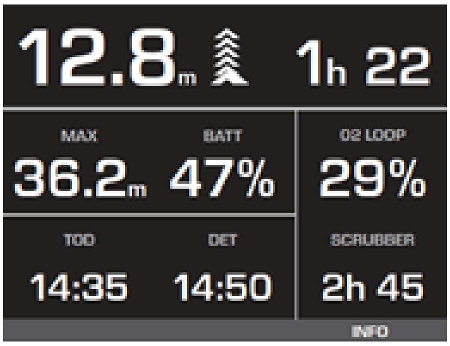

### Information Screen Two

In the decompression information bar, the current CNS loading and the water temperature are displayed. In the bottom information bar, the current low and high gradient factors are displayed.




### Information Screen Three

In the decompression information bar, the maximum depth of the dive and the battery charge status are displayed. In the bottom information bar, the Time of Day (TOD) and the Dive End Time (DET) are displayed.

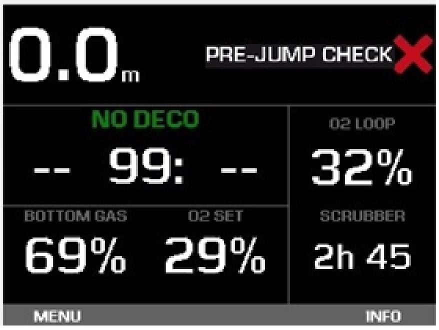


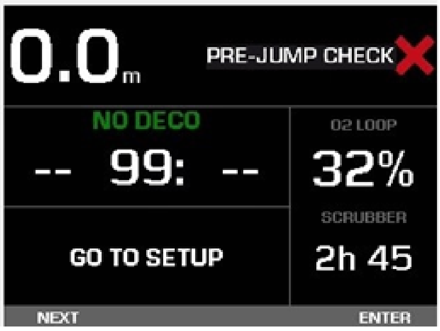

## 4.2 THE MENU SYSTEM

### Menu System

The Mares Horizon Controller uses two piezo buttons to navigate through its various menus.

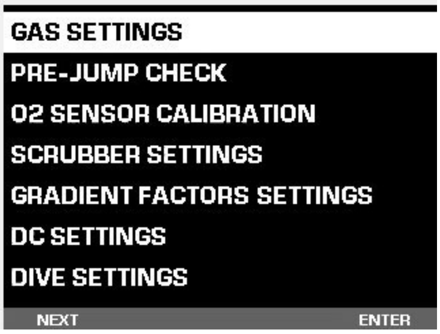
Pressing the left button in surface mode will provide access to the main menu. Continue to press the left button to scroll through the various menu options. To select a menu option, use the right button to enter.




### Gas Settings

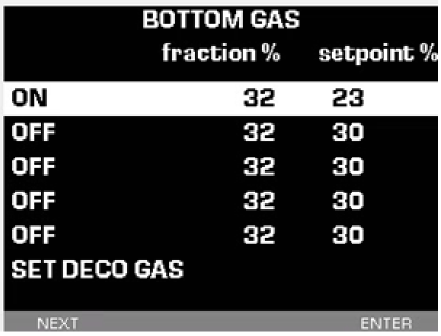
The gas setting menu is where the breathing gas oxygen fractions along with their desired setpoints are defined. Up to 5 gas mixes can be defined for both bottom and decompression gas, but only one for each gas can be switched on for a given dive.




### Setting the Bottom Gas

When entering the gas settings, the bottom gas is the first gas to be defined. Each gas can be modified by pressing the right "enter" button while the gas is highlighted.

Only one gas mix can be set to ON.



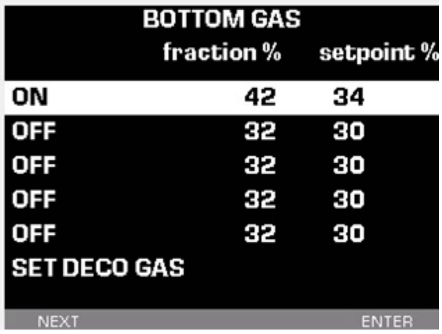

To move to the next setting, press the left "next" button. To change the fraction of oxygen or the setpoint of the gas, you need to press the left "+" button. This then provides the ability to scroll upwards to modify each number while it is highlighted. When you want to set the next number, press the right "enter" button and modify that number in the same way.

When all modifications have been completed, press the right "enter" button to go back to the bottom gas settings menu.

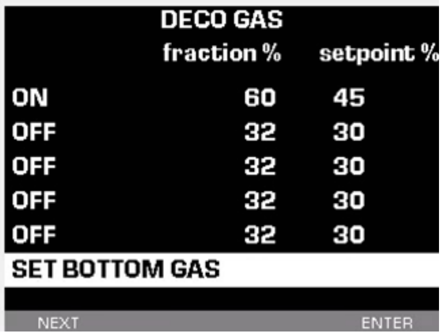

### Setting the Decompression Gas

To enter the details for the decompression gas mixes, scroll down the menu by pressing the left "next" button until the "Set Deco Gas" option is highlighted. Confirm the selection by pressing the right "enter" button.

The format and functioning of the decompression gas settings screen is the same as the bottom gas settings screen. You may enter up to five decompression gases. It is possible to have all decompression gases set to "off" to allow for those dives when only the bottom gas is being used.



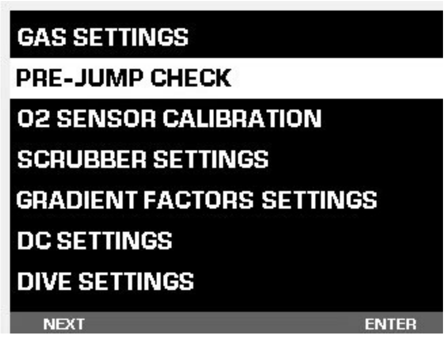

When all decompression gases have been entered you have the option to either go back to the "Set Bottom Gas" screen or to go back to the "Main Settings" menu by pressing the left "next" button until the desired option is highlighted.




### Pre-Jump Check

The Pre-Jump Check, is one of the most important procedures in rebreather diving. This procedure ensures that the rebreather is properly functioning, that all gases are correctly connected, that cylinders are opened and all settings in the controller are correct prior to entering the water. The Pre-Jump Check must be performed and successfully completed prior to every dive.

By selecting this option in the menu, the Pre-Jump Check procedure will be initiated. If the Pre-Jump Check is successful it will be displayed on the main screen in the top information bar along with the green confirmation tick.




### Pre-Jump Check procedure

When the Pre-Jump Check is selected there will be an initial three-second countdown during which the controller checks and records the current ambient pressure.

### Negative Pressure Check

Once the countdown is completed, the controller display instructs the diver to "Start vacuum on loop and press enter". It is at this time that a negative pressure test should be conducted. To do this the diver must put the BOV in the mouth, inhale through the mouth and exhale through the nose. After a few repetitions there will no longer be any gas in the loop, a negative pressure has been created. Whilst making a final inhalation, the BOV needs to be closed to ensure the loop remains in negative pressure. Once this is done the diver can press the right "enter" button.

At this time the rebreather will compare the initial pressure in comparison to the vacuum pressure and both pressures will be displayed on the screen in bar. The vacuum pressure must remain constant for a minimum of five seconds in order to pass the test. If there is an increase in the vacuum pressure, this would suggest that a connection of the unit is not sealed allowing the pressure inside and outside of the loop to equalize. The vacuum test will then fail.

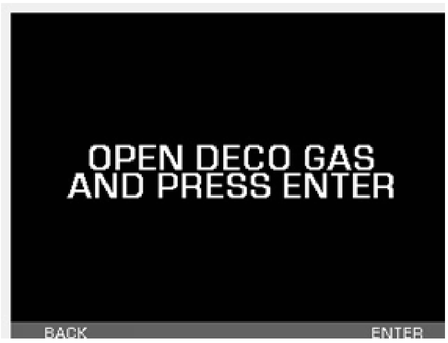

Step 1


Step 2


Step 3

### Gas Verification and Installation Check

The next step of the Pre-Jump Check procedure is to verify if all programmed gases are connected correctly and if the correct cylinder is open. The controller will prompt the diver to follow the onscreen instructions. To begin with, the decompression gas should be opened. By pressing the right "enter" button you are confirming that the decompression gas is open. If no decompression gases have been switched on in the gas settings, this step will not appear.




Once the decompression cylinder is open and confirmed, the controller will then prompt the diver to also open the bottom gas cylinder. The right "enter" button needs to be pressed to confirm that the cylinder is attached and that the valve is open. It is at this point that both cylinders are attached and open.


Even though both cylinders are now open, it will only be the decompression gas being injected by the EAV due to the higher IP of the decompression gas regulator. (Refer to Chapter 3, Gas Management). It is at this point that the controller is expecting the decompression gas to be injected by the EAV, if this does not occur, the test will fail.


After the decompression gas has been successfully verified, the controller will prompt the diver to close the cylinder and confirm it is closed by pressing the right "enter" button. As the bottom gas cylinder is still open, the EAV will now be injecting that gas.


This part of the Pre-Jump test ensures that the bottom and decompression gases have been entered into the controller correctly. The dive will begin with the bottom cylinder open and the decompression cylinder closed.

### Oxygen Sensor Check

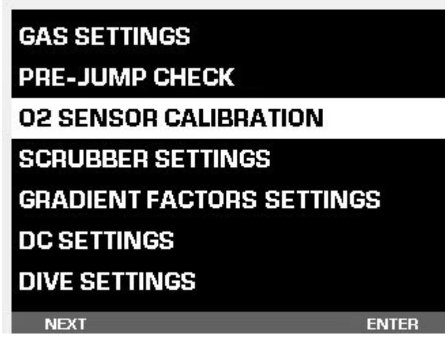
The final step in the Pre-Jump Check is to verify the functioning of the two oxygen sensors. The controller will prompt the diver to begin breathing and to continue to breathe from the rebreather and to confirm this by pressing the right "enter" button. During the next 20 seconds, no gas is being injected, and so the controller is aiming to verify that the test sensor reading and the fraction sensor reading are the same as they are both located in the same place. If the readings between the sensors is different the test will fail.

If the test has been succesfiul, the controller will display that ther sensor is OK and the dive can begin. The Pre-Jump check is now complete.




### $O_2$ Sensor Calibration

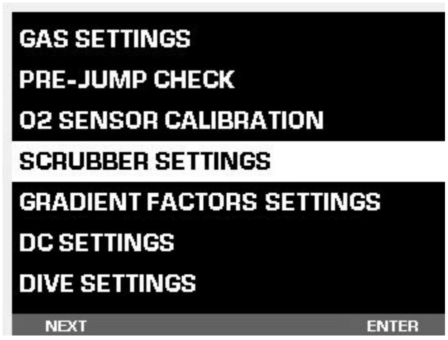
In order to calibrate the oxygen sensors this option in the menu needs to be selected. The calibration should be performed in air. The controller will prompt the diver through a series of on-screen instructions in order to complete a successful calibration. (Refer to Chapter 6, Setting up the Mares Horizon)




At a minimum the unit will demand a calibration every 30 days. If no calibration is performed the controller will not permit diving.

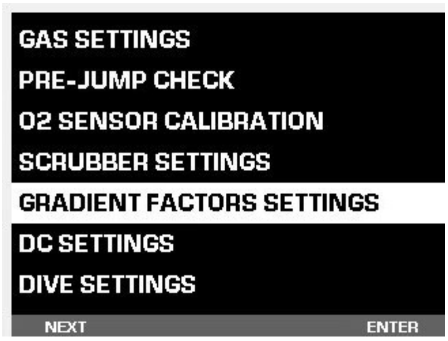
### Scrubber Settings

It is in the Scrubber settings where the diver enters their specific biometrical data: gender and weight. This information is necessary for the calculations of the RST. It is also within the scrubber settings where the RST can be reset following a complete refill of the scrubber material. (Refer to Chapter 3, The Scrubber Monitoring System)




### Gradient Factor Settings

The level of conservatism used for the decompression calculations can be defined within the gradient factor settings.




The Mares Horizon Controller uses the unmodified Bühlman ZH-L16C algorithm with gradient factors. Gradient factors are used to lower the maximum tolerated supersaturation in the tissues with respect to Bühlmann's original values. This results in less nitrogen in the body at the end of the dive, which under normal circumstances makes the dive safer.

### Gradient Factor Terminology

### GF Low

Gradient factors are expressed in pairs: the first value called the GF low, represents the percentage of the original Bühlmann value that defines the beginning of the final ascent (relevant only in decompression dives).

### GF High

The second value, called the GF high, represents the percentage of the original Bühlmann value that defines the residual nitrogen at the surface at the end of a dive.

For instance, a configuration of GF 50/85 will get you to the surface with a 15% additional margin with respect to Bühlmann's original maximum tolerated supersaturation and, if this was a decompression dive, your first decompression stop would have been at a depth such that you would not have exceeded 50% of Bühlmann's original value at that depth.

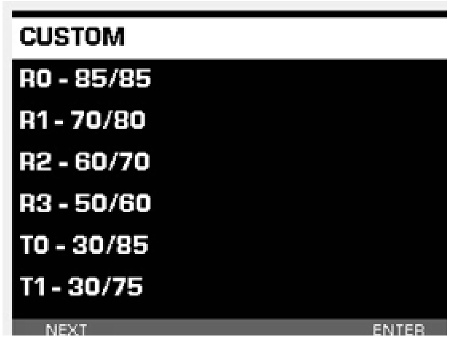
*For more information about gradient factors, please refer to www.mares.com/sports/diving/gradientfactor*

### Main GF

Once the main Gradient Factors setting has been selected, a sub menu is offered. It is in the Main GF screen where you set the conservatism level of the ZH-L16C algorithm via gradient factors. The controller uses Bühlmann's original values reduced by 15% as a starting point, from there the diver can choose to make the algorithm more conservative. There are four predefined sets of gradient factors with an increasing level of conservatism for recreational and for technical dives.

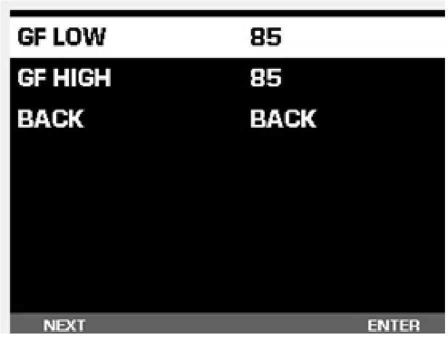

| Recreational | | Technical | |
|---|---|---|---|
| R0 | 85/85 | T0 | 30/85 |
| R1 | 70/80 | T1 | 30/75 |
| R2 | 60/70 | T2 | 25/60 |
| R3 | 50/60 | T3 | 25/40 |

The default value is R0 (85/85) but other more conservative options are available, to suit the dive and personal preferences. In addition, the diver has the option to enter the GF low and GF high values directly via the "custom" setting.



### Alternate GF

The Mares Horizon Controller allows for an alternate set of gradient factors to be defined for use when the decompression schedule needs to be cut short in the event of an emergency. This set of alternate gradient factors cannot be more conservative (i.e. lower) than the most conservative GF existing in the main set of GF values. The most conservative GF is the default value of R0 (85/85).




### Personalization
### (to be implemented in future update)

The personalization setting allows the diver to define additional levels of conservatism in a way similar to going from R0 to R1, R2 or R3 but in a more personal way. It comprises of two submenus; Main and Alternate, each of which has three additional submenus; Physio, Dive and I Today.

The values set in each menu are subtracted from the respective Main GF and Alternate GF values previously set which are being used for the decompression calculations.

### Physio

Within the "Physio" setting the diver can further define an additional level of conservatism based on their personal health status and the diving overall. There are three steps:

- Low
- Medium
- High

For instance, to account for general level of fitness, pre-existing injuries or illness etc. Each step from low to medium to high will incrementally reduce both gradient factor values by 10.

### Advanced

Within the "Physio" setting there is also additional option for personalization called "Advanced". This option will increase the gradient factor by 5 to enable a maximum GF of 90/90 to be achieved. This is only for experienced divers who have accumulated enough experience to know that their body can tolerate such high levels of inert gas. Mares does not recommend to use such an aggressive profile as it increases the risk of decompression sickness. In order to use this setting a code (1234) must be inserted.

The values set in "Physio" will remain stored until manually changed. The default value is set to off.

### Dive

The "Dive" setting allows additional conservatism to be defined based on personal feelings about the diving conditions. There are three steps:

- Low
- Medium
- High

If it is suspected that there will be strong currents or if the water temperature is expected to be very cold, one of these options should be selected. Dive conditions can actually be different from what is expected which is why this option can be edited during the dive via the underwater menu. Each step from low to medium to high will incrementally reduce both gradient factor values by 3.

The values set in "Dive" will reset automatically to "Off" at midnight. The default value is set to off.

### I Today

The "I Today" setting allows additional conservatism to be defined based on personal feelings about yourself today. There are three steps:

- Low
- Medium
- High

For instance, to account for a restless night or not having hydrated sufficiently. Each step from low to medium to high will incrementally reduce both gradient factor values by 5.

The values set in "I Today" will reset automatically to "Off" at midnight. The default value is set to off.

### Repetitive Dives

The original Bühlmann algorithm assumes normal offgassing of inert gas via diffusion after a dive. This seems to work well for most people and indeed most dive computers available today compute repetitive dives like this. There is evidence however that some people produce bubbles after a dive, or produce more bubbles than others, and these bubbles though harmless slow down the offgassing process.

Surface intervals of three hours or longer are known to dissipate most if not all bubbles. The Mares Horizon Computer allows you to account for this by applying an additional conservatism to repetitive dives, reducing both gradient factor values by 8 upon surfacing from a dive and then increasing it again by 1 every 15 minutes of surface interval.

When setting **REP DIVE** to **ON** you will have recovered the full gradient factor values after a two-hour surface interval. Any dive started before such surface interval will carry an automatic additional gradient factor reduction. If you set the value to **OFF**, the GF values are not modified during a surface interval.

The setting can be applied independently to the MAIN GF and ALTERNATE GF values. The default values are **OFF** for MAIN GF and **OFF** for ALTERNATE GF.

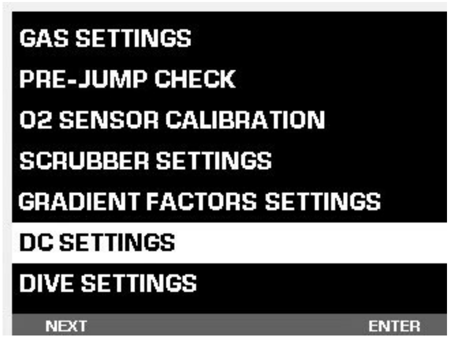
### Multiday

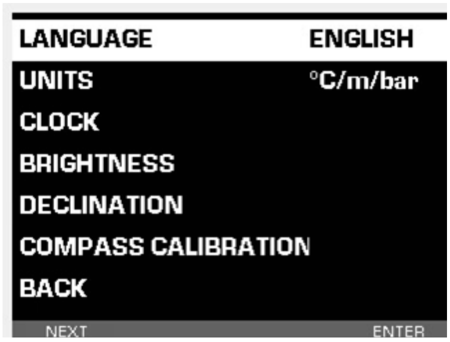
Increasing inert gas load on your tissues over several days of diving has effects that are not fully understood and are different from person to person. Most dive computers available today do not account for this and compute simple inert gas offgassing by diffusion. The Mares Horizon Computer allows you to increase the conservatism automatically for each day of diving with less than 24-hours of surface interval by reducing both gradient factor values by 2 on the second day, an additional 2 on the third day and an additional 2 on the fourth day up to a maximum of 6.

Default values are **OFF** for MAIN GF and **OFF** for ALTERNATE GF.

### DC Settings

Basic computer settings such as setting the language, units (temperature, depth, pressure) date and time, screen brightness and the compass calibration can be found within the Dive Controller settings.




### Language

Accessing the language setting allows the diver to set the language for the user interface, all menus and all warning messages during the dive.

### Units

The units option allows the controller to be set to either metric (m, C, bar) and imperial (ft, F, psi) units.

### Clock

The date, time and time zone can be adjusted in the clock setting. It Is also possible to set a wake-up alarm.

### Brightness

This menu allows you to change the brightness of the display to adapt to various levels of light conditions. Upon entering this menu, a sliding bar will appear across the display which will change as the brightness is being adjusted.

### Declination

Depending on the exact location on the planet, there can be a deviation between true North and magnetic North. Any compass will always show magnetic North, so via this menu you can set a value for the so-called declination that will make the compass show true North instead.

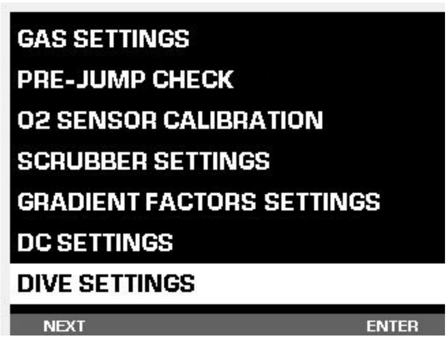
### Compass

The digital compass is calibrated from the factory and does not require, under normal circumstances, any further maintenance.
In certain instances, however, such as after exposure to extremely intense magnetic fields, it may be necessary to recalibrate the compass to ensure its accuracy. If you notice an obvious deviation in the indication of the compass, access this menu and perform the calibration as described below.

1. Enter the security code, 1234.
2. Hold the Controller horizontal to the surface and perform one slow counter clockwise circle.
3. Once the circle is finished, the calibration is completed.

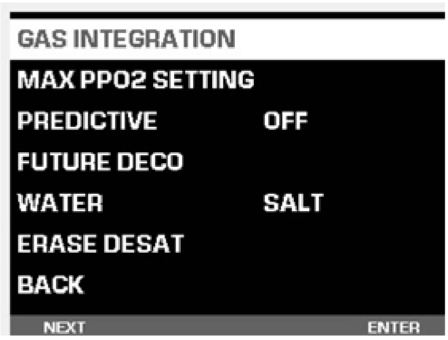
### Dive Settings

Basic and advanced dive options can be defined within the Dive Settings menu.



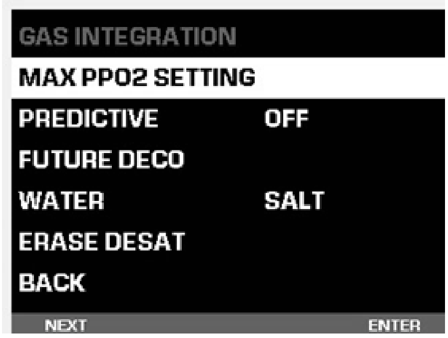

### Gas Integration

The Gas Integration setting allows the diver to pair their tank pressure transmitters for the bottom and the decompression cylinder if being used.




### Max $ppO_2$ Settings

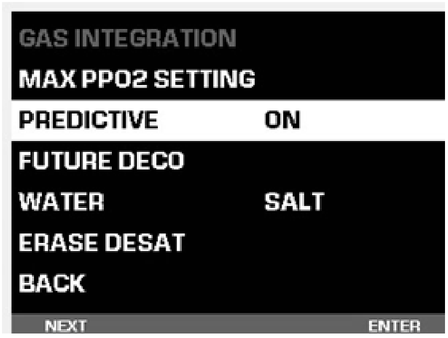
The Maximum $ppO_2$ setting allows divers to set a personal $ppO_2$ limit for the MOD of a gas or the gas switch depth less than the default of 1.6.




### Predictive

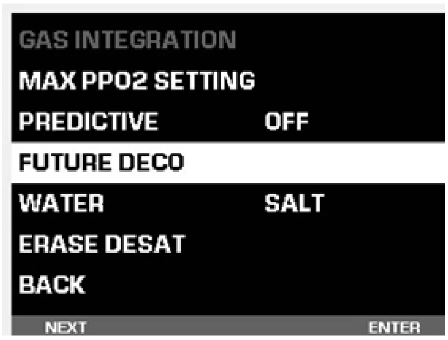
When the predictive setting is switched to "on", the controller will consider both the bottom and the decompression gas in the decompression calculations. It will assume that the decompression gas switch will be performed at the MOD of the gas.
If the predictive setting is set to "off", the decompression calculations will only be based on the breathing gas currently being used.

The default for this setting is "on".

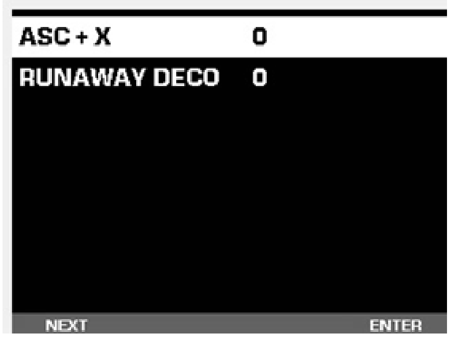



### Future Decompression

While conducting a decompression dive, the ASC+5 feature will allow the diver to see what would be the mandatory decompression obligation if they were to stay at their current depth for an additional 5 minutes. This is a useful feature as it gives a good indication on how the decompression status is being affected by remaining at a set depth. With the slower tissues accumulating nitrogen, the decompression time could grow very rapidly, so much so that the diver may not have enough gas to complete the required decompression.




The prediction of ASC can be manually set between 3 and 10 minutes.




### Runaway Deco

In addition to the ASC setting there is also the option to add in a warning for when a "Runaway decompression" will occur. The trigger point of the Runaway decompression alarm can be manually set between 2 and 4 times the value of the ASC – X.

**Example**

The ASC – X value is set to +6 and the runaway decompression value is set to 3. This means that the alarm will be triggered when the difference between the current ASC and the predicted one 6 minutes later is 18 minutes (6 x 3) or greater.

### Water

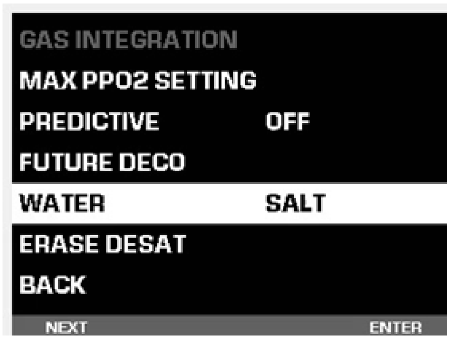
There are three options regarding the type of water in which the controller can be set:

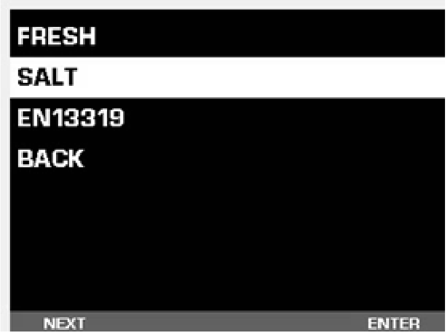
- Fresh Water
- Salt water
- EN13319 Calibration

The selection made will depend on where the dive will be conducted. An incorrect setting will entail an error in the depth measurement to a maximum of 3%. For example, while diving in fresh water to a depth of 30 meters, the controller, if set to salt water, will show only 29 meters. Whereas diving in salt water to a depth of 30 meters with a controller set to fresh water will show 31 meters.

The selection of the type of water does not affect the proper functioning of the computer as the computer performs all of the calculations based purely of pressure measurements.

EN13319 corresponds to a water density of 1.0197 kg/ and is used as the European norm 13319






Erase Desat
This setting allows the diver to reset the inert gas saturation to zero, thereby erasing the effects of a previous dive. This is only recommended in the situation where the SCR unit will used by somebody else who has not performed a dive within the last 24 hours.

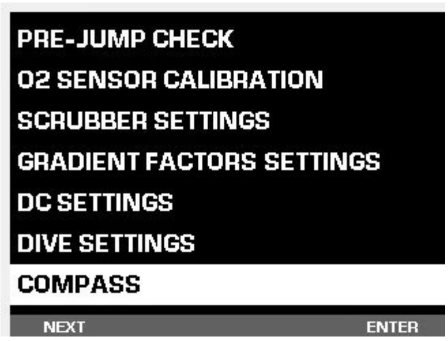
**COMPAS**

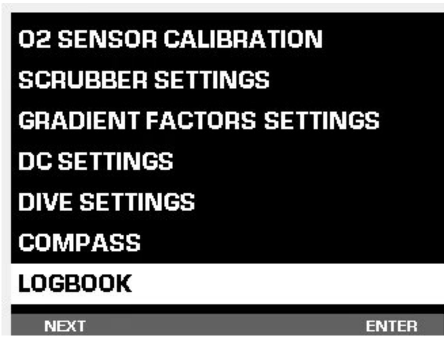
**LOGBOOK**

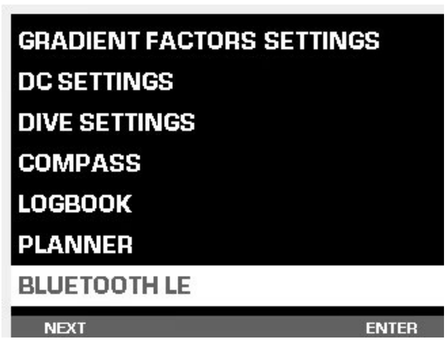
**PLANNER**

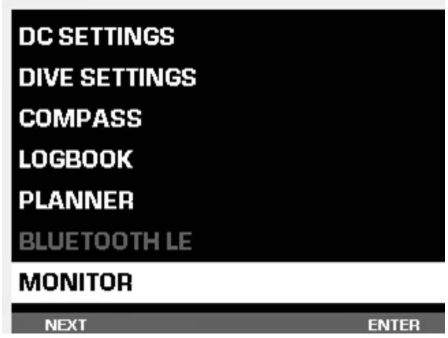
**BLUETOOTH**

**MONITOR**




## 4.3 GLOSSARY

| | |
|---|---|
| **AGF** | Alternate Gradient Factor |
| **AIR** | Air dive |
| **ASC** | Total ascent time, the time it takes to perform the ascent from your current depth to the surface in a decompression dive, including all decompression stops and assuming an ascent rate of 10 meters per minute |
| **ASC + X** | The overall ascent time inclusive of all decompression stops if the dive is extended by X minutes at the current depth |
| **AVG** | Average depth, calculated from the beginning of the dive |
| **CNS** | Central Nervous System. CNS% is used to quantify toxic effects of oxygen |
| **D-TIME** | Dive time, the whole time spent below a depth of 1.2 meter |
| **DESAT** | Desaturation time. The time needed for the body to eliminate the nitrogen taken up during diving |
| **Gas Integration** | The feature in Mares Horizon Computer to include tank pressure information in its calculations and to display it on the computer screen |
| **Gas Switching** | The act of changing from one breathing gas to another |
| **GF** | Gradient factor |
| **Gradient Factor** | Percentage of Bühlmann's original value of maximum allowed supersaturation |
| **Heliox** | A breathing gas containing Oxygen and Helium |
| **Max Depth** | Maximum depth attained during the dive |
| **MOD** | Maximum Operating Depth. This is the depth at which the partial pressure of oxygen ($ppO_2$) reaches the maximum allowed level ($ppO_2$ max). Diving deeper than the MOD will expose the diver to unsafe $ppO_2$ levels |
| **Multi-gas** | Refers to a dive in which more than one breathing gas is used (air and/or Nitrox) |
| **Nitrox** | A breathing mix made of oxygen and nitrogen, with the oxygen concentration being 22% or higher |
| **No deco time** | This is the time that you can stay at the current depth and still make a direct ascent to the surface without having to perform mandatory decompression stops |
| **NO-FLY** | Minimum amount of time the diver should wait before taking a plane |
| **$O_2$** | Oxygen |
| **$O_2$%** | Oxygen concentration used by the computer in all calculations |
| **Pairing** | The act of establishing a coded RF communication between computer and a dedicated device, such as a tank module |
| **$ppO_2$** | Partial pressure of oxygen. This is the pressure of the oxygen in the breathing mix. It is a function of depth and oxygen concentration. A $ppO_2$ higher than 1.6 bar is considered dangerous |
| **$ppO_2$ max** | The maximum allowed value for $ppO_2$. Together with the oxygen concentration it defines the MOD |
| **RGT** | Remaining Gas Time, it is the time that a diver can spend at the current depth before having to ascend in order to reach the surface with the tank reserve still available |
| **SURF INT** | Surface interval, the time that has elapsed since the end of the dive |
| **Switch Depth** | The depth at which the diver plans to switch to a higher oxygen concentration mix while using the multi-gas option |
| **Trimix** | A breathing gas containing Oxygen, Nitrogen and Helium |
| **TTR** | Time To Reserve, it is the time that a diver can spend at the current depth before reaching the tank reserve |

## • 5 THE WARNING / ALARM SYSTEM

### 5.1 GENERAL WARNINGS AND ALARMS

The Mares Horizon was designed with safety as a priority which is why it has three redundant electronics and a sophisticated warning and alarm system.

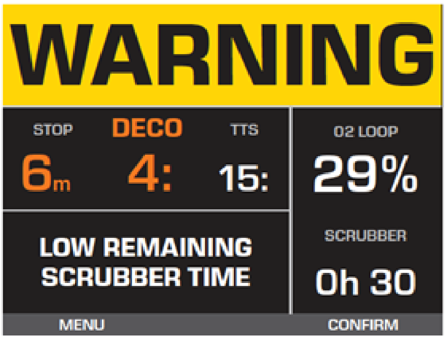
**General Warnings**

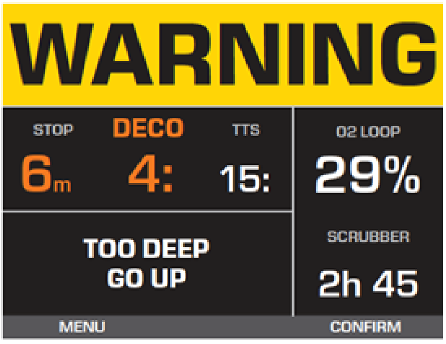
When a warning occurs, it is displayed in the top bar of the controller display highlighted in yellow. This message is alternating with the standard top bar information such as depth and time.

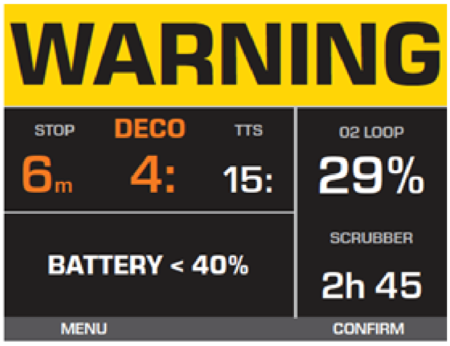
A warning is issued if any dive parameter is outside of its expected operating range. These warnings are displayed in situations where the diver's life is not in danger. Examples of these types of warnings are:

- Low battery < 40%
- Low remaining scrubber time
- MOD exceeded (but what is not too far)

The type of warning will be described in the bottom information bar and can be confirmed by pressing the right "confirm" button. Once this has been done the warning message will disappear.




**HUD Warnings**

When a warning is issued, the HUD will change from a green, slow 'breathing simulating' pulse to a series of red pulses. Dependent on the reason for the warning, after confirmation, the HUD may go back to the green pulse or it may keep blinking red until the problem is solved.

**Buzzer Warnings**

In addition to the on-screen warning message and the change of the HUD to red flashes, there is also an audible alarm device built into Mares Horizon Controller. In any warning situation the buzzer will be activated in a low alarm mode.

**Low Alarm Mode**

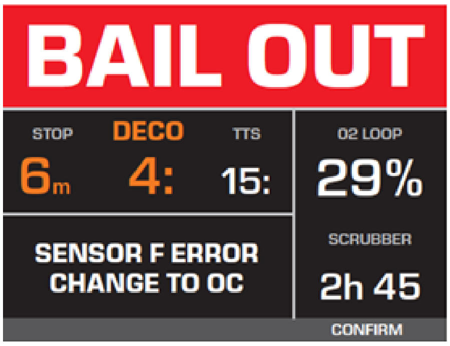
Every 60 seconds the buzzer will beep 5 times until problem is solved.

**Alarms**

An alarm is displayed if a life-threatening situation should occur. This is a serious and potentially dangerous situation and the diver should take immediate action when an alarm occurs.

In the top information bar the controller will display a big alarm message highlighted in red. This message will be alternately changing with the standard top bar information such as depth and time. Depending on what is the cause of alarm, a message will be displayed. There are four different messages that may be displayed:

- End Dive
- No Dive
- Go Up
- Bail-out




Regardless of the reason for the alarm the diver should immediately bail-out to open-circuit and whether the diver remains on the rebreather or not the unit will go into fail safe mode (Refer to Chapter 3, The Electronic Addition Valve)

The type of alarm will be described in the bottom information bar and can be confirmed by pressing the right "confirm" button. Once this has been done the warning message will disappear.

**HUD Alarm**

When an alarm is issued, the HUD will change from a green, slow pulse to fast red pulses. The HUD will only go back to a green, pulse or it may keep blinking red when the problem is solved.

**Buzzer Alarm**

In addition to the on-screen alarm message and the change of the HUD to red fast flashes, there is also an audible alarm device built into Mares Horizon Controller. In any warning situation the buzzer will be activated in a high alarm mode.

**High Alarm Mode**

There will be continuous beeps until the problem is solved.

## 5.2 WARNINGS AND ALARMS TABLE

**Warnings Table**
The Warnings Table outlines all the potential warning messages that can occur along with the required action to be taken by the diver.

| TOP INFORMATION BAR | BOTTOM INFORMATION BAR | HUD ALARM | BUZZER | Fail Safe Mode | Action |
|---|---|---|---|---|---|
| **WARNING** | Calibration > 14d | Low | Low | No | Calibrate oxygen sensors |
| **WARNING** | Battery < 40% | Low | Low | No | Charge battery |
| **WARNING** | Sensor F low mV | Low | Low | No | Replace Fraction Sensor |
| **WARNING** | Sensor T low mV | Low | Low | No | Replace Test Sensor |
| **WARNING** | Low $O_2$ fraction near surface | Low | Low | No | $PO_2$ < 0.26 bar. Make sure correct tank is open. Observe $PO_2$ if not dropping. |
| **WARNING** | Wrong active gas | Low | Low | No | Check if the correct tank is open |
| **WARNING** | Too deep go up | Low | Low | No | Depth > 42m. Ascent to 40m or shallower. |
| **WARNING** | Low remaining scrubber time | Low | Low | No | RST < 1:00. Make sure dive will be finished within 1:00. |
| **WARNING** | Battery < 25% | Low | Low | No | Abort the dive in SCR mode |

**Alarms Table**
The Alarms Table outlines all the potential alarm messages that can occur along with the required action to be taken by the diver.

| TOP INFORMATION BAR | BOTTOM INFORMATION BAR | HUD ALARM | BUZZER | Fail Safe Mode | Action |
|---|---|---|---|---|---|
| **ALARMS ON SURFACE** | | | | | |
| **NO DIVE** | Low remaining scrubber time | High | Low | Yes | Refill scrubbers and reset RST in menu |
| **NO DIVE** | System fail E1 E2 change to OC | High | Low | Yes | Restart DC. If problem occurs, contact Mares Service Center |
| **NO DIVE** | Battery < 25% | High | Low | Yes | Re-charge battery before diving |
| **NO DIVE** | Calibration > 30d | High | Low | Yes | Calibrate oxygen sensors |
| **NO DIVE** | Error depth sensor | High | Low | Yes | Contact Mares Service Center |
| **NO DIVE** | Check calibration | High | Low | Yes | Calibrate oxygen sensors. If problem not solved, replace oxygen sensors. |
| **NO DIVE** | Gas check failed change to OC | High | Low | Yes | Check connected gases. If corrected perform gas check. |
| **NO DIVE** | No gas on SCR change to OC | High | Low | Yes | Check tanks connection and tank valves. If corrected perform gas check |
| **NO DIVE** | Sensor F error | High | Low | Yes | Replace F sensor, calibrate oxygen sensors |
| **NO DIVE** | Sensor F too low MV | High | Low | Yes | Replace F sensor, calibrate oxygen sensors |
| **NO DIVE** | Sensor T too low MV | High | Low | Yes | Replace T sensor, calibrate oxygen sensors |
| **NO DIVE** | Sensor F too high MV | High | Low | Yes | Replace F sensor, calibrate oxygen sensors |
| **NO DIVE** | Sensor T too high MV | High | Low | Yes | Replace T sensor, calibrate oxygen sensors |
| **ALARMS DURING THE DIVE** | | | | | |
| **END DIVE** | Low remaining scrubber time | High | High | No | RST < 0:20, Abort the dive |
| **END DIVE** | Battery < 15% | High | High | No | Abort the dive, re-charge battery |
| **END DIVE** | Battery < 10% | High | High | Yes | Abort the dive, re-charge battery |
| **GO UP** | Too deep for active gas | High | High | No | If possible ascend to active gas MOD |
| **BAIL OUT** | Predive check not ok | High | High | Yes | Dive started without Pre-Jump Check OK. Abort the dive. |
| **BAIL OUT** | Gas check failed change to OC | High | High | Yes | Change to OC and abort the dive |
| **BAIL OUT** | No gas on SCR change to OC | High | High | Yes | Change to OC. Check if tank open. If open, abort the dive. |
| **BAIL OUT** | Sensor F error change to OC | High | High | Yes | Change to OC. Abort the dive. Change F sensor. |
| **BAIL OUT** | Error depth sensor | High | High | Yes | Change to OC. Abort the dive. Contact Mares Service Center |
| **BAIL OUT** | Fraction too low change to OC | High | High | Yes | $PO_2$<0.22 bar. Change to OC |
| **BAIL OUT** | Wrong gas change to OC | High | High | Yes | F or T sensor $FO_2$ > DECO MIX. Change to OC. Abort the dive |
| **BAIL OUT** | Scrubber expired change to OC | High | High | Yes | RST < 0:00. Change to OC. Abort the dive |
| **BAIL OUT** | System fail E1 E2 change to OC | High | High | Yes | Electronic failure. Change to OC and abort the dive. Contact Mares Service Center |

## • 6 EQUIPMENT CONFIGURATION

### 6.1 SETTING UP THE MARES HORIZON

**Fitting and Adjusting the Harness**

The Mares Horizon is completely assembled before it is shipped. Before the unit is dived for the first time, the backplate and harness must be adjusted to ensure it fits the body correctly. A correctly fitting unit will minimize the work of breathing when diving with the Mares Horizon.

The unit comes with a comfortable harness which has adjustable arm straps, chest strap and a crotch strap. For the best fit, the unit should be positioned high on the back. The harness should be fixed close to the diver's back so that the curve of the unit follows the contour of the diver's back as closely as possible. The harness may need to be slightly readjusted after the first pool/confined water session.

Correct

Incorrect

If it is not possible to comfortably position the unit on the back high enough, the harness shoulder straps can be further adjusted. There are four nuts that hold the soft back plate in place. Once these have been unscrewed and the harness has been removed the straps can be adjusted.

**Filling the Scrubber Canisters**

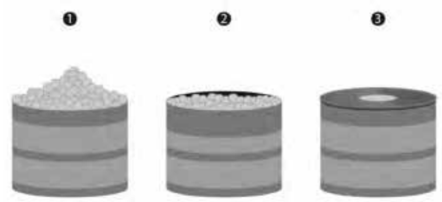
Packing a scrubber canister must be done methodically, carefully, and using the same procedure each time. Failure to follow the directions can lead to channeling, or carbon dioxide that is not absorbed from the breathing gas. The granulated composition of scrubber material can create fine dust during the packing process. If possible, pack the canisters in an open-air environment to avoid breathing in the dust. If a wind is present, stand upwind so that the dust is blown away from you.

**Emptying the Canister**

- First, unscrew the handle of the canister, and remove the spring, the top plate and the filter: make sure to not lose the top filter
- Place each part in a safe and secure place.
- Discard the used scrubber material and remove any remaining dust by gently tapping on the canister.
- Make sure that the bottom filter stays inside the canister.

**Refilling the Canister**

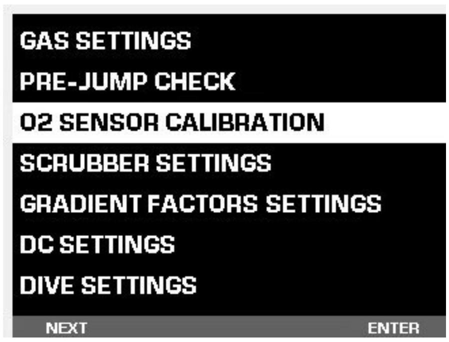
- Set the canister on a stable, horizontal surface.
- Pour the scrubber material from a height of approximately 20-30 centimeters into the canister.
- Allow the wind to carry away any dust.
- Continue pouring the scrubber material until a small pyramid forms in the canister. The sides of the pyramid should be about one centimeter below the top of the canister.
- Gently tap on the sides of the canister with one hand while turning the canister with the other hand to level the scrubber material.
- When the scrubber material fills the canister and the central screw is free, reinstall the filter, top plate, spring, and handle, and turn the screw until the spring is completely compressed. Avoid over-tightening the spring.
- Continue evenly tapping the side of the canister with both hands for about one minute while tightening down the top plate. Continue turning until the spring is completely pushed down, and do not over-tighten, as this can separate the bracket from the cross screw.
- An alternative to tapping the sides of the canister is to gently tap the entire canister on a hard surface. Only one side of the canister should contact the ground and the thumbs should push down on the mesh. The scrubber material on the side making contact with the ground will settle faster, so rotate the canister to evenly settle the scrubber material around the canister's circumference.
- The canister is correctly filled when, after tapping, there is approximately 5 millimeters between the top of the top plate and the top side of the canister.
- The fresh canister is now ready to use. Always check that the sealing o-ring near the bottom of the canister is correctly mounted, clean and not damaged.

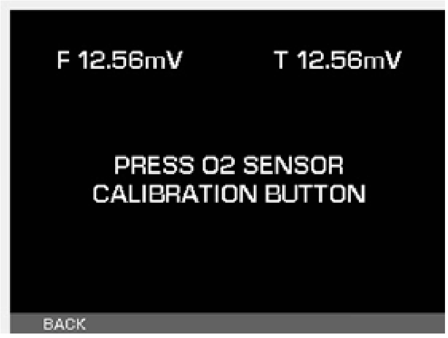



**Sensor Calibration**

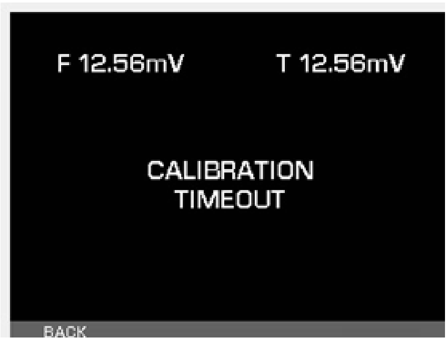
Standard air must be used for calibration of the sensors when using the Mares Horizon. The unit must be open, the scrubber canisters removed, and the sensor tray must be outside of the unit. This ensures that the oxygen sensors are only exposed to air during the calibration process.

On the controller, select "Menu", then "Calibration". Confirm by pressing the calibration button on the bottom of the scrubber canister housing. If the sensors are correctly calibrated, the controller will display a confirmation message.









Calibration confirmation button

## 6.2 CHECKLISTS

### Checklists

**The importance of checklists**

The Pre-Jump assembly process is a key part of any SCR dive. Many diving accidents could have been prevented if the Pre-Jump checks were properly completed.

You must inspect every major component of the unit for damage or failure, calibrate the oxygen sensors, and verify that the non-return valves are functioning correctly. Using a checklist is the best way to avoid missing steps or performing steps incorrectly.

The Mares Horizon has three checklists that must be followed prior to starting the dive. Do not skip or alter any of the steps on this list and ensure that you are using the most current version of the checklists for your unit.

Remove yourself from any distractions like phones or other divers while performing these checks, and limit conversations to those necessary to complete your checks. With practice, you will only need a few minutes to complete your checklists without rushing, so it should not be a problem to "switch off" from your environment until they are finished.

**Pre-Jump Assembly**

The Pre-Jump assembly checklist is used to methodically and logically assemble and prepare the Mares Horizon unit for diving.

**Checklist steps:**

1. Analyze, pressure check, and label the cylinders.
2. Install the bottom gas regulator on the cylinder, and then verify proper installation and function of the regulator.
3. Install the decompression gas regulator (if used) on the cylinder, and then verify proper installation and function of the regulator.
4. Verify the newest oxygen sensor is less than seven (7) months old and is reading correctly. Replace if necessary and mark date.
5. Select "Calibration" mode on the controller and follow the on-screen instructions to complete the calibration.
6. Install the sensor grid and verify the cable routing is correct.
7. Inspect the remaining time on the scrubber material. Refill with fresh scrubber material if necessary.
8. Inspect the scrubber canister O-rings, clean sealant surfaces, and grease if necessary.
9. Install the scrubber canisters into the unit with the TOP marker on the exhale scrubber canister.
10. Close and clamp the individual scrubber caps.
11. Verify that the battery level on the controller is greater than 30%.
12. Close and secure the main cover.
13. Inspect the non-return mushroom valves in the breathing loop mouthpiece. Inspect the mouthpiece and O-rings on the breathing loop, clean sealant surfaces, and grease.
14. Install the breathing loop onto the unit. Install the low-pressure hose to the bail-out valve, and ensure it's screwed-in and tighted.
15. Connect the heads-up display to the bail-out valve.

> ⚠ **WARNING**
>
> Make sure the LP hose connected to BOV is correctly installed, screwed-in and tighten. This is standard second stage hose connection that might be loosed when not pressurized, i.e during unit transportation after assembly. If the tank will be connected and open while LP hose is not correctly installed it might loose completely and fly around the unit, hurting the diver.

**Closed Check**

Once the Pre-Jump assembly checklist is complete and the unit is built, you must verify proper function, breathing loop integrity, and an adequate volume of breathing gas for your planned dive. This process is completed using the "Closed Check" checklist.

**Checklist steps:**

1. Open the bottom cylinder valve and verify that the pressure is appropriate for the planned dive, then close the cylinder valve and depressurize the regulator.
2. Open the decompression cylinder valve (if used) and verify that the pressure is appropriate for the planned dive, then close the cylinder valve and depressurize the regulator.
3. Inspect the breathing gas supply connections and connect them if no water is present.
4. Ensure the necessary gases and set points are programmed into the controller.
5. Verify the battery shown on the controller is greater than 30%.
6. Verify the over-pressure valve is functioning properly.
7. Select the "Pre-Jump Check" mode on the controller and follow the on-screen instructions.
8. Completely inflate the wing and verify that it holds its volume.
9. Breathe in any gas from the loop to verify that the auto-delivery valve is functioning properly.
10. Close the cylinders and switch off the controller.
11. Inspect the harness, crotch strap, and gag strap for wear and tear, correct positioning, and proper attachment.

**Pre-Jump Check**

Just before you dive the Pre-Jump Check must be performed. You do this check when the unit is on your back, or laying down, the cylinders are connected, but not yet open. In the controller menu select "Go to setup" and choose "Pre-Jump Check". (Refer to Chapter 4, The menu System).

If the Pre-Jump Check is not performed or has been unsuccessful, the dive cannot be executed. If the diver descends, an alarm will be triggered and the unit will go into Fail-Safe Mode.

## 6.3 DIVING CONSIDERATIONS

### How to Dive the Mares Horizon

Once all of the settings are correct and all checklists have been completed, it is now time to dive. Diving the Mares Horizon is effortless and simple. However, care and attention must always be paid during the dive to the controller for any warnings or alarms. You should always know your oxygen concentration when diving a rebreather

### Buoyancy

The Mares Horizon is an active flow Semi-Closer Rebreather. It is for this reason, your counterlungs will remain almost always fully inflated. Unlike open-circuit diving, inhalation and exhalation will not affect buoyancy control. The total gas volume is traveling between the diver's lungs and the counterlungs of the unit and so the overall volume is not changing, it is just varying in its location. Buoyancy control is achieved through use of the wing or the dry-suit.

In the event that a diver will dump some of the gas out from the counterlungs, like when clearing a mask, that gas loss will be quickly supplemented by the continuous flow rate of the breathing gas.

### Gas Connectors

While diving, the bottom gas quick gas connector hose should always be connected. The Mares Horizon decompression unit is equipped with an additional yellow decompression gas connection hose. When conducting shallow, no-decompression dives, it is very likely that this gas connection hose will not be required. In this situation there is no need to remove the decompression gas hose due to the fact that the gas connector hoses are sealed from both male and female sides which means that no water will enter through the hose and also that no gas will escape. Once the bottom gas is connected and the cylinder is open, it will pressurize the complete gas system, including the decompression gas hose, so that no water can enter.

If for any reason a quick gas connector will be disconnected underwater, it should never be re-connected. This will cause water inside the connector to enter the gas line and damage the orifice and the EAV.

If that will happen the diver should go to OC second stage off board regulator and abort the dive. Keep in mind that once gas supply for Mares Horizon is disconnected, no gas will be supplied to breathing loop, BOV or BCD. BCD can be always inflated orally. Quick Gas Connectors are designed the way to avoid accidently disconnect.

However if this will happen and in absolute emergency, disconnected underwater, no second source for gas in the BC available, and need to reconnect to activate the BC, then water will come into the EAV, and the unit must be sent to service center for check/ repair.

### Gas Check Procedure

Gas Check procedure description

At the start of the dive, and at certain moments during the dive, the electronic addition valve opens, and the fraction of the gas that is injected into the unit is measured: the Horizon verifies that it is the correct gas that is programmed and active at that moment during the dive. It the sensor measures a different gas, or no different gas than what is in the loop, a warning will be showed to the diver that the gas is wrong, or that no gas is connected or the tank is closed, and the diver is urged to bail out.

After this first check, the electronic addition valve is closed for a short time, and at that moment, the readings of the 2 sensors are checked, and verified if they both read the same fraction: this way the sensors are verified if they work correctly.

This check is also done when a gas switch is done (from bottom gas to deco gas or visa versa).

### Troubleshooting

What is the correct procedure if water is suspected in the gas feeding lines?

If you suspect that water has entered into the gas line, action must be taken to avoid orifice and EAV damage:

- Disconnect the low-pressure hose from the BOV
- Connect the bottom gas regulator to the bottom gas connector hose
- Gently and slowly open the bottom gas cylinder valve until you feel and hear that gas is escaping through the disconnected low-pressure hose. Make sure that you hold the hose in one hand so that it does not fly around
- Allow the gas to flow for a few seconds until all water has been blown out from the line
- Close the bottom gas cylinder
- Connect the decompression gas cylinder (if being used) and repeat the procedure with the decompression gas

> ⚠ **WARNING**
>
> Caution must be taken every time you dive the Mares Horizon to prevent the disconnection of the quick gas connectors during the dive so to avoid water enter gas line.

### What to do if unit is flooded?

If for any reason the unit was flooded with water is should be rinsed and cleaned as soon as possible. Leaving a flooded unit closed for a longer period of time will cause the oxygen sensor connectors to get damaged because of the water mixing with an absorbent solution around the connectors causes the connectors to corrode. Flooded oxygen sensors should always be replaced.

In case if flooding the following procedure must be taken:

- Open both of the scrubber canisters and dispose of the scrubber material
- Disconnect the oxygen sensors from the sensor tray
- Disconnect the breathing hoses from the unit
- Fill the counterlungs with luke warm water and then empty them to rinse all the residual water mixed absorbent from both of the counterlungs
- Gently rinse the oxygen sensor compartment to avoid water entering the test sensor hose
- Gently rinse the top exhale counterlung compartment
- Use compressed air (if possible) to dry the oxygen molex connectors
- Install new oxygen sensors

> ⚠ **WARNING**
>
> Never pull the rear dump valves underwater. This will allow water to enter the counterlung and flood the unit!

# 7 TAKING CARE OF THE MARES HORIZON

## 7.1 POST DIVE CARE

### Post Dive Care

#### Maintenance Between the Dives

When you finish a dive with the Mares Horizon, there are a few steps that you must perform in order to prepare the unit for the next dive.

1. Remove the breathing hose assembly and rinse it with cold or lukewarm freshwater
2. Close the mouthpiece and pour water into the inhale side. Never use high-pressure or very hot water, as these can damage the mushroom valves or membranes in the mouthpiece
3. Let the water drain out from counterlungs and drain any excess water through the rear dump valve
4. Check the remaining scrubber material time and replace the scrubber material if needed
5. Record your used scrubber material time

#### Maintenance After Diving

When the diving day is over, the post-dive actions checklist should be used in order to rinse, clean, and disassemble the Mares Horizon.

1. Stand the unit upright or lean it gently forward onto the wing – do not lay the unit on its cover
2. Ensure that the rebreather is completely closed, including the bail-out valve, and rinse the entire unit with freshwater from the outside
3. Unscrew and remove the low-pressure hose that feeds the bail-out valve
4. Simultaneously press and pull the quick release tabs to disconnect the breathing loop from the unit
5. Rinse the loop thoroughly. Never use high-pressure or very hot water, as these damage the mushroom valves or membranes in the mouthpiece
6. Remove the main back cover and put to one side
7. Unclamp the individual scrubber canister caps and remove the scrubber canisters

8. Inspect the scrubber canisters for any water that exceeds general condensation, and discard the scrubber material if water is found
9. If the scrubber material is not expired, put the scrubber canisters in a double plastic bag or an airtight container
10. Remove the sensor grid
11. Rinse the internal components and counterlungs with freshwater
12. Drain off any excess water through the rear pull dumps or the upper breathing loop openings
13. Let the unit air dry, then re-install the sensor grid and scrubber canisters
14. Close the individual scrubber canister caps and the main cover

## 7.2 MAINTENANCE

**General Maintenance**

The Mares Horizon is a very easy unit to maintain, as long as you properly complete your Pre-Jump and post-dive checklists. To keep your unit working properly, you must regularly inspect, lubricate, and replace O-rings as needed. Ensure that you use the proper amount of lubricant, since excessive lubricant can attract dust and debris, reducing the effectiveness of the O-ring. Only use oxygen-compatible lubricants like Tribolube 71 with the Mares Horizon

Lubricating O-Rings

Scrubber Canister Cap O-Rings

To lubricate the O-rings on the Mares Horizon scrubber canister caps, remove the four O-rings from their seats, and clean them with a lint-free cloth or a neutral soap. Inspect each O-ring for cracking or damage and replace as necessary. O-rings may also need lubricant if they are too dry, or to replace contaminated lubricant. Take a small amount of oxygen-compatible lubricant and spread it onto the ring by pulling the ring between thumb and fore finger. Spread the lubricant evenly over the entire O-ring, inside and out. Be careful not to use too much lubricant. The excess lubricant is pushed away when replacing the cap onto the scrubber canister. Clean and apply a small amount of lubricant to the inside of the cap where it contacts the O-rings.

Breathing Hose Connector O-Rings

Visually inspect the O-rings on the connections of the breathing hoses without removing them. If you find sand, traces of dirt, or other debris, remove the O-ring and clean it using the process outlined above. If no contamination is found, slightly lubricate the O-rings in place without removing them.

Parts that Contact Oxygen

Any part that comes in contact with oxygen must be kept in a pure and clean condition. They must not be contaminated with dirt, lubricant, or other substances. Pay close attention to the connection between the first stage and cylinder valve, since this location is especially prone to contamination.

## 7.3 SERVICING

**Servicing the Mares Horizon**

The components and hardware in the Mares Horizon are very durable and will last for years of regular diving as long as you complete your checklist and inspection. Like any physical product, this equipment will eventually degrade and wear out. You must track the lifespan of each component in your unit and ensure the proper service intervals are maintained.

Five-Year Inspection

We recommend that you have your Mares Horizon unit completely inspected every five years by an authorized Mares service center or the unit manufacturer.

Service Life

The maximum lifespan of the rubber components, non-oxygen gas tubing, and the counterlungs in the Mares Horizon is ten years. The maximum lifespan of the internal oxygen gas tubing is five years. After this period, you must replace every rubber component in the unit, including breathing hoses, mouthpieces, and O-rings. If the unit is exposed to direct sunlight over a longer period of time, these components can degrade, requiring a shorter service interval. If you notice worn or broken parts during your inspections, replace the affected part.

Replacing Components

Internal Components

The internal gas tubing and counterlungs must be replaced by the manufacturer or an authorized service center. This is done during the required five-year inspection of the unit.

Cable Ties

You can inspect any connection that uses cable ties, like the connections from the mouthpiece to the breathing hoses and the bail-out valve. If these connections are weak, or the cable ties are worn or damaged, replace them with new ties. If there is any doubt about their integrity, they should be replaced immediately.

Regulators

An authorized service technician must service the first stage of the regulators at least once per year. These regulators are cleaned for oxygen use and have specific intermediate pressures, based on their use, that must be correctly set during service.

Intermediate Pressures:

- Bottom gas regulator: 10.5 +/- 0.5 bar
- Decompression gas regulator:
  12 bar +/- 0.5 bar

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