

REBREATHER TRAINING COUNCIL MOUTHPIECE RETAINING STRAP SAFETY GUIDANCE NOTICE

1. What Is a Mouthpiece Retaining Strap?

A Mouthpiece Retaining Strap (MRS) is an adjustable means of securely holding a rebreather Dive Surface Valve (DSV) or Bail Out Valve (BOV) in position in the event of Loss of Consciousness (LoC). To optimise its design intent, a well-designed MRS incorporates a flange of suitable material that when correctly fitted, serves to reinforce the lip seal around the bite mouthpiece, whilst stabilising the DSV / BOV in position.



BOV fitted with a MRS: Courtesy of rEVO

2. Why Use a Mouthpiece Retaining Strap?

When using a rebreather, the breathing gas oxygen partial pressure (PO_2) is artificially maintained by mechanical or electro mechanical means. As a consequence, either as a result of human error and / or equipment failure, when compared to open-circuit diving equipment, the probability of exposure to an inappropriate breathing gas is significantly increased. A serious incident or fatal accident is therefore more likely when rebreather diving ^[1].

Inappropriate breathing gas scenarios most frequently associated with rebreather use are: (1) hypoxia; (2) hypercapnia, resulting from increased levels of inspired Carbon Dioxide (CO_2) or hypoventilation leading to retained CO_2 ; (3) hyperoxia. Frequently referred to as the rebreather '*3H hazards*', all can and do lead to LoC with little or no warning. In addition, rebreathers place upon the diver high respiratory loads not encountered at the surface such as static lung load and / or resistive effort. These respiratory loads have the potential to trigger a diving incident / medical emergency, particularly in cases of poor cardiovascular health, which can rapidly lead to LoC.

3. What Does The Evidence Tell Us About Mouthpiece Retaining Strap Use?

“I approached the diver and noticed the mouthpiece was out” is a common rebreather fatality eye witness statement. In a sport diving fatality study undertaken by Divers Alert Network (DAN), the actual cause of death as certified by a Medical Examiner, was drowning in 94% of rebreather cases [2]. Since this study, the trend in rebreather divers drowning following LoC has continued as a consequence of an unprotected airway.



MRS In Use: Image courtesy of Paul Haynes

When worn correctly, evidence indicates an appropriately designed MRS can prevent the rebreather mouthpiece from being dropped. This will significantly increase the probability of preserving the airway, potentially preventing or limiting water aspiration, breathing loop flood, loss of buoyancy and the likelihood of drowning [3].

Because of these potentially life preserving functions, a MRS is a mandatory design requirement for all rebreathers sold within the European Union and United Kingdom. European rebreather standard EN14143:2013 specifies a design requirement for a facepiece (mouthpiece assembly), which shall minimise the ingress of water during normal use and in the event of a diver falling unconscious or having a convulsion. It shall be adjustable or self-adjusting and shall hold the mouthpiece firmly and comfortably in position [4].

Recognising its life-preserving potential, when not using a full-face mask, MRS use has and remains universal amongst the global military rebreather diving community for over six decades. In one military rebreather accident study, drowning following LoC occurred in only 5.5% of cases. This very low percentage of drowning was attributed to the implementation of safety protocols that included the use of a MRS to preserve the airway [5].

4. Additional Benefits of Using a Mouthpiece Retaining Strap

Many rebreather divers report facial muscular strain and discomfort caused by the positive buoyancy of the breathing loop and / or the weight of a DSV / BOV. The use of a MRS improves rebreather diving comfort by reducing jaw fatigue, particularly during extended dives using a heavy DSV / BOV or when in high water flow



MRS: a mandated military rebreather safety requirement. Image courtesy of JFD

environment such as when using a Diver Propulsion Vehicle (DPV). In addition, because the MRS takes the strain needed to retain the breathing loop in the mouth and support the DSV / BOV in position, the need to bite down is greatly reduced, thus reducing the possibility of the actual bite mouthpiece failing during a dive.

5. Installing and Wearing a Mouthpiece Retaining Strap

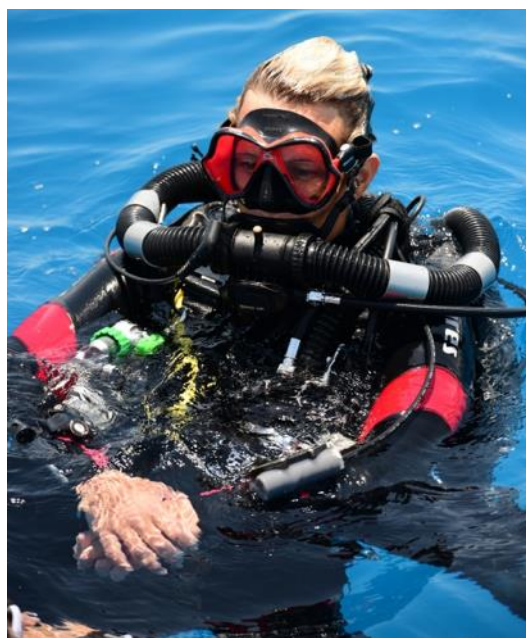
If retro fitting a MRS, particular care should be taken to ensure the MRS is appropriately secured to the DSV / BOV; manufacturer's advice must be followed to ensure correct installation.

Following correct installation, to optimise its life preserving potential, a MRS should be positioned and adjusted so the strap is worn over the back of the head such that when in a relaxed state, the DSV / BOV is held comfortably in position.

When diving with a hood, to avoid mask strap and MRS conflict, one method is to wear the diving mask strap under the hood and the MRS on top of the hood. Alternatively, if no hood is worn or both straps are preferred to be worn on top of the hood, the MRS strap may be positioned over the mask strap, thus readily enabling MRS fitting, adjustment and removal without interfering with the diving mask.

6. Bailing Out When Using a Mouthpiece Retaining Strap

A common misperception concerning MRS use is a belief that it restricts or inhibits access to alternative breathing gas supplies such as 'off-board' bail out. This is not the case. An appropriately designed MRS readily enables the DSV / BOV to be pulled down onto the upper chest enabling it to be replaced with an alternative breathing gas source. Also, now positioned on the upper chest, the DSV / BOV may be easily re-located in the event of going back onto the rebreather.



BOV fitted with an MRS ready to dive:
Courtesy of Mares

During an emergency open circuit ascent, if back mounted counter lungs are required to be manually vented via the DSV / BOV, for example when in an overhead / restricted space environment, the MRS may be loosened and / or removed from behind the head enabling this to be undertaken.

7. Mouthpiece Retaining Strap Cost Benefit Analysis

MRS prices vary dependent upon manufacture. However, if we consider the price of a rebreather to be approximately US\$8,000, separately purchasing a MRS may

amount to little more than 1% of the rebreather purchase price. Set against its potential life-saving and general comfort benefits, the cost of a MRS is considered a small price to pay.

8. Mouthpiece Retaining Strap Culture Change

The use of automotive seat belts was strenuously resisted by the automotive manufacturing industry and the general public when first proposed. However, the implementation of seat-belts has greatly reduced automotive fatalities worldwide. As a consequence, there has been a change in safety culture, and today, few people drive without wearing a seat-belt because the potential life-saving benefits are now self-evident.



MRS: Courtesy of AP Diving

As sport diving industry leaders, we believe it is now time for the adoption of a similar safety culture within the rebreather community (divers, instructors, training agencies, international standards authorities, manufacturers). From the growing body of evidence, it is increasingly evident that rebreather divers are not dying from hypoxia, hypercapnia, hyperoxia, equipment failure or human error; these are disabling injuries and incident triggers. In the vast majority of rebreather fatality cases, drowning is the actual cause of death. Please then help us address the potentially fatal consequence of LoC underwater when using a rebreather by supporting this safety initiative. By acting together to change the culture within the rebreather community, we can help reduce unnecessary loss of life.

9. References

- [1] Fock AW. Analysis of recreational closed-circuit rebreather deaths 1998–2010. *Diving Hyperb Med.* 2013; 43:78-85.
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- [4] European standard EN14143: 2013. *Respiratory equipment - self-contained re-breathing diving apparatus*. European Committee for Standardisation. Para 5.10.
- [5] Gempp E, Louge P, Blatteau JE, Hugon M. Descriptive epidemiology of 153 diving injuries with rebreathers among French military divers from 1979 to 2009. *Mil Med.* 2011;176:446-50.