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## SAFETY of OCEAN REEF Full Face Snorkeling Masks

Recently, several US news outlets have questioned the safety of full face snorkeling masks (“FFSM”). These concerns have seemingly arisen as some of the reported Hawaiian snorkeling deaths in 2018 occurred while the victim was using a FFSM.

Since, first responders are primarily concentrating on rescuing and saving lives, often, the products that the victim was using at the time of the accident are not collected. This leads to some uncertainty as to whether the deaths occurred due to health-related reasons or if they were product related. And, if product related, what manufacturers made the product?

The most common concern expressed regarding FFSM use is that CO<sub>2</sub> could accumulate inside some brands of FFSMs and result in injury or death.

OCEAN REEF is in a unique position to discuss and share information on this topic. OCEAN REEF invented the FFSM in 2012. And, since then, more than **1,000,000** masks designed and manufactured by OCEAN REEF have been sold and safely used throughout the world.

Additionally, OCEAN REEF has more than 25 years of design and production experience in the US/EU military, professional, and recreational full-face scuba diving mask, and gas mask industries.

It is important to note our products have not been involved in any reported incident or death. However, as one of the few American companies producing and selling FFSMs, we want to share our knowledge related to FFSM safety, specifically related to potential risks concerning CO<sub>2</sub>. Our hope is to help educate consumers and communicate that when properly designed, manufactured, tested, and used, FFSMs are safe for recreational snorkeling use.

## CO2 – quick facts



- CO<sub>2</sub> (the chemical abbreviation for carbon dioxide) is a gas naturally present in the air we breathe.
- Concentration of CO<sub>2</sub> in the air is approximately **0.04%**.
- Concentration of CO<sub>2</sub> in exhaled air (the “waste” of our breathing cycle) is around **4.5%**.
- **An atmosphere containing more than 5% of CO<sub>2</sub> (Carbon Dioxide) is considered toxic** to humans and animals, since it may saturate hemoglobin in the blood and prevent it from binding to oxygen, thus interfering with tissue oxygenation.

The limits set by OSHA for the concentration of carbon dioxide in workplace environments are:

- 0.5% (5000 ppm) for continuous (10hr periods for 40hr weeks) exposure.
- STEL (Short Term Exposure Limit) is 3%. STEL is usually considered 15 minutes or less.

### **Some information about how we design and test our FFSM:**

A FFSM is a crossover design product that aims to increase comfort and enjoyment while snorkeling. It is considered a crossover of 2 classes of products: Gas Masks and Snorkels.

Some also consider a third inspiration, the Full Face (Scuba) Mask, which is a cross-over between gas masks and scuba regulators (and which OCEAN REEF has designed and manufactured for 25+ years.)

However, the FFSM does NOT contain a breathing apparatus to reach depths in water and does NOT decompress air; nor is it a breathing system. Rather, it performs like a traditional mask + snorkel gear.

Thus, the closest product to a FFSM, in terms of function and engineering – is a gas mask. (As previously mentioned, Ocean Reef Group has also been making gas masks for 25+ years.)

## Gas Mask vs Full Face Snorkeling Mask



In a gas mask, there are 2 separated volumes:

- **Upper volume.**
- **Lower volume** – technically called **Orinasal Pocket**.

The FFSM shares this same design, which means that the breathing cycle of both products perform in the same manner (see graphics below):

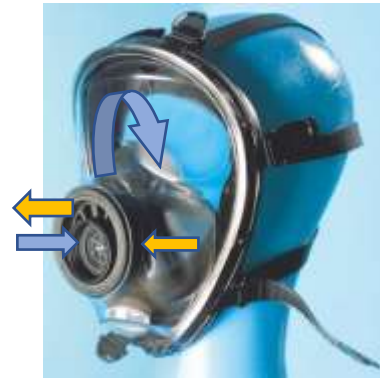
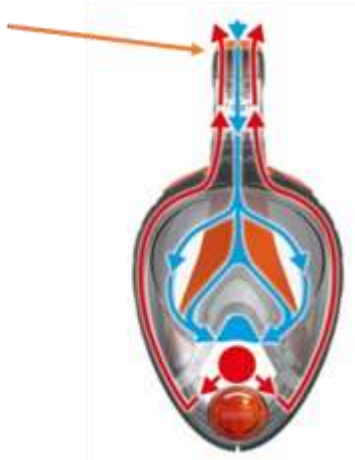
1. Inhaled air goes from outside to inside the mask (from the filter in a gas mask, from the snorkel in a FFSM).
2. Inhaled air is transferred from the upper volume (where it fogs visibility through the mask) to the lower volume, via the one-way valves in the orinasal pocket, reaching the inside of the orinasal pocket.
3. The air is, then, inhaled by the user.
4. Exhaled air cannot move back into the upper volume, because the orinasal pocket seals the nose and mouth around the cheeks. The valves are one-way valves and do not open upwards.
5. The exhaled air moves in the only direction it can: through an exhalation one-way valve (in case of gas masks) and through the exhalation channels, and one-way valves in the snorkel (in case of **our** FFSM).

This breathing cycle is called, ***one-way breathing circulation***.

The benefit is to separate fresh air, containing only 0.4% CO<sub>2</sub>, from used, exhaled air with 4% CO<sub>2</sub> concentration.



Set of 3 one-way valves to avoid mixing of exhaled air with fresh air.



Both Gas Masks and FFSMs operate at ambient (surface) pressure.

The similarity in the air flow (breathing circulation) can be seen in the above graphics.

### What is DEAD AIR SPACE?

Dead Air Space is the area inside the mask where there is a mixing of fresh air with exhaled air.

This volume is limited to the orinasal pocket, in gas masks and our FFSMs.

However, if one-way valves are NOT installed at the top of a FFSM's snorkel, the dead air space would also include the snorkel, along with any other space where separation between exhaled and fresh air is not guaranteed.

**NOTE: MANY FFSMs on the world market DO NOT have this feature and, in fact, OCEAN REEF is one of the few manufacturers to have one-way valves on the three chambers of the snorkel and have an orinasal pocket designed to fully prevent mixing of used and fresh air.**

### **From Gas Mask & FFSM analogy to Safety Standards.**

In the USA, there are no specific safety standards related to the design or manufacturing of snorkeling equipment- neither 'traditional' equipment nor FFSMs. However, in Europe, some snorkeling products must meet specific safety standards - snorkeling masks and snorkels both have specific requirements. But because FFSMs are not just a mask or just a snorkel, it is necessary to consider other similar classes of products, to determine applicable safety standards in creating safe design and production.

**NOTE: To be able to sell a product on EU territory, a product must pass the EU NORM STANDARDS for the relevant class of products.**

Given the similarity between the 2 classes of products, when searching for applicable safety standards, we naturally arrived at Gas Masks, EU regulation: **EN 136**.

Though this standard was not created for FFSMs, it is the closest applicable safety standard for our product's class.

EN136, in fact, has a specific guideline regarding CO2 concentration in masks with orinasal pockets.

The MAX concentration of CO2 in the volume where the user will breathe must be 1% at a ventilation rate of 50 liters / minute.

This test is managed at ground level, with 2 liters volume ventilation at 25 breaths per minute.

**OCEAN REEF FFSMs have undergone such tests, conducted by an independent Certification Laboratory.**

OCEAN REEF masks were tested and maintained an average CO2 level lower than 1%, as per EN136.

**OCEAN REEF masks averaged a CO2 concentration of 0.8%, thus exceeding the test standard.**

**(Results Attached.)**

**Additional Tests:**

To further facilitate safety AND comfort during use, our masks were tested according to other EU standards that provide guidance for our class of product.

During engineering and production, we applied **EU standard EN 1972** – a standard created for **conventional snorkels**.

(Many consumers do not realize that poorly designed or manufactured traditional snorkels can be dangerous, if they do not have the correct length or bore.)

**Breathing effort** is one aspect considered in this standard. This test is aimed to quantify the effort needed for a normal person to safely breathe (inhaling and exhaling) through a snorkel.

EN1972 requires the manufacturer to perform both inhalation and exhalation testing: +/- 10mbar.

**These tests were also conducted by an Independent European Certification Laboratory.**

Tests for OCEAN REEF products resulted in an average effort of: **8.53** mbar inhalation and **7.26** mbar exhalation.

**Again, both values were well below the standard limit.**

(Results Attached)

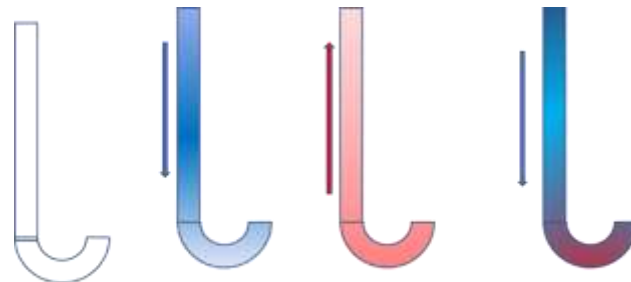
### Further Tests and comparison with snorkel technology

A user snorkeling with a conventional snorkel will breathe through a “tube” placed in the mouth – inhaling fresh air at 0.04% CO<sub>2</sub> and exhaling 4% CO<sub>2</sub> rich air → just like a gas mask user, or a FFSM user.

Typically, conventional snorkels do NOT have one-way valves to prevent the mix of used and fresh air.

As with FFSMs, a traditional snorkel has an inherent **dead air space** that must be considered. Therefore, the snorkel must be designed to meet EU safety standards (EN1972).

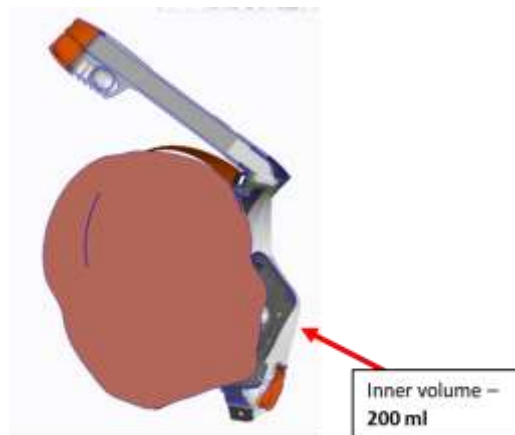
EN1972 CO<sub>2</sub> percentage limit – follows the same parameters as EN136.



Inhaling – exhaling, in normal snorkel.  
Red/blue shade indicates average dead space location.

EN1972 states that snorkels must have an inner volume not exceeding 230ml for adults and 150ml for children

To compare the inner volume of traditional snorkel and the orinasal pocket of OCEAN REEF FFSMs, measurements were taken using an EU standard ‘Sheffield Head.’ Testing showed our orinasal pocket has a volume of 200ml. Again, well within the EU standard established for even conventional snorkels.



### Third EU standard tested:

While we do not feel it is the closest comparison to our FFSMs, a third-party company tested our FFSMs using another related EU standard- **EN 250** which covers the safety of full face masks that are used for underwater breathing. This standard is not as strict as EN136 and, as expected, they reported that our masks also easily passed the relative **EN 250** criteria (those standards do not involve breathing at depth underwater.)

### Summary:

While we do not have a directly applicable standard to follow for FFSMs, OCEAN REEF has used its extensive experience to design and produce SAFE and COMFORTABLE products for the world market.

We have demonstrated our commitment to safety by designing products that meet or exceed 3 strict EU standards (**EN 136, EN 1972 and EN 250**) and by submitting our products to **independent third-party** testing laboratories for confirmation of that compliance.

Unfortunately, it seems that many FFSM Manufacturers worldwide are either unaware of or non-compliant with these safety standards.

Since there are no regulations governing the sale of these products, consumers may be exposed to uncomfortable and potentially harmful products, that might be confused with 'high end' and safely engineered products, like those produced by OCEAN REEF.

The most common deficiencies with these poorly designed masks are:

1) No one-way valves at the top of the snorkel (which is often hidden under the protective cap)

and

2) Orinasal pockets that do not completely seal

Both can result in a dangerous mixing of fresh and exhaled air.

#### **Conclusion:**

As mentioned, there has not been an opportunity to collect all equipment related to snorkeling fatalities. It has been reported that some of the deaths which occurred while snorkeling in Hawaii in 2018 involved the use of FFSMs. However, it is unknown if the incidents are related to equipment problems or health related issues, that could be caused by various human and/or environmental factors.

OCEAN REEF is confident in the safe design, development, and production of our FFSMs. However, we continue to test and look for ways to improve our products. Consumers should recognize that not all manufacturers follow the same safety standards as OCEAN REEF.

OCEAN REEF stands ready to participate and assist in lending our experience to those Agencies and consumer groups who seek more information about any connection between unsafe FFSMs and swimming accidents. We hope that by sharing the above information, it will help consumers make informed decisions and assist them in the purchase of FFSMs from manufacturers who are concerned with FFSM safety and comfort. Our goal is to provide FFSMs which consumers can trust while participating in one of the world's most exciting and enjoyable experiences – snorkeling.

**RAPPORTO DI PROVA PPE125RP2602**

<b>1</b>	<b>SCOPO</b>	<i>Misurazione del tenore di anidride carbonica dell'aria di inspirazione e della resistenza respiratoria.</i>
<b>2</b>	<b>NORMA / METODI DI PROVA</b>	<i>EN 136:1998 - § 8.14 (con modifiche), § 8.15 (con modifiche)</i>
<b>3</b>	<b>RICHIEDENTE</b>	<i>MESTEL SAFETY S.r.l. Via Arvigo, 2 16010 S'Olcese (GE)</i>
<b>4</b>	<b>CAMPIONE DI PROVA</b>	
4.1	Tipo	<i>Maschere intere progettate per essere utilizzate in attività di snorkeling.</i>
4.2	Identificativo del prodotto	<i>ARIA A1 (bianca), ARIA A2 (grigia), ARIA A3 (blu)</i>
4.3	Campionatura	<i>Effettuata dalla richiedente: n° 3 maschere, identificate da ITALCERT con #A1, #A2 e #A3 (taglie L/XL)</i>
4.4	Pretrattamenti	<i>Nessuno, campioni sottoposti a prova come ricevuti.</i>
<b>5</b>	<b>DATA RICEVIMENTO CAMPIONI</b>	<i>2018-03-13</i>
<b>6</b>	<b>DATA ESECUZIONE PROVE</b>	<i>2018-03-13</i>

- Note:
- Tutte le indicazioni di paragrafo, per esempio quelle contenute nei campi "Requisito" e "Metodo di prova" in ogni punto del presente Rapporto, si intendono comunque riferite alla norma tecnica riportata al punto 2 di questo Documento. Qualora si renda necessario riportare richiami a documenti diversi ne verranno chiaramente indicati i riferimenti completi.*
  - Se non diversamente specificato, a tutti i valori espressi nel presente Rapporto si applicano le tolleranze previste nella norma di riferimento.*
  - Il richiedente ha dichiarato che i campioni sottoposti a prova risultano essere nuovi e non essere stati sottoposti a preliminari cicli di condizionamento.*

Questo Rapporto di prova deve essere reso pubblico solo in forma integrale.

I risultati di prova ottenuti si riferiscono esclusivamente ai campioni sottoposti ad esame. Da essi non si può desumere una dichiarazione circa la conformità della produzione al campione di prova. E' vietata qualsiasi riproduzione parziale salvo autorizzazione scritta di ITALCERT.

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Per misurare il tenore di CO<sub>2</sub> dell'aria di inspirazione, il 5% del volume di ogni ciclo della fase inspiratoria del polmone artificiale viene prelevato nel punto indicato dalla norma per mezzo di un polmone ausiliario e inviato ad un analizzatore di CO<sub>2</sub>.

Il tenore di anidride carbonica dell'aria di inspirazione è stato misurato e registrato in continuo.

La prova è stata proseguita fino a ottenere un tenore costante di anidride carbonica nell'aria di inspirazione.

La prova è stata eseguita utilizzando i seguenti cicli di respirazione:

- 25 colpi/min e 2,5 l/colpo

- 25 colpi/min e 2l/colpo

- 10 colpi/min e 1,5 l/colpo

Tali ritmi respiratori sono stati concordati con il richiedente per simulare diverse condizioni di respirazione tipiche per l'utilizzo delle maschere in attività di snorkeling.

#### Risultati

Ritmo respiratorio (colpi / l/min)	Contenuto di CO <sub>2</sub> dell'aria di inspirazione (% in volume) - valori medi		
	Maschera #A1 (tg. L/XL)	Maschera #A2 (tg. L/XL)	Maschera #A3 (tg. L/XL)
10 X 1,5	1,1	1,1	1,0
25 X 2	0,6	0,9	1,0
25 X 2,5	0,7	0,7	0,8

#### RESISTENZA RESPIRATORIA

##### Metodo di prova

Su richiesta del cliente, ITALCERT ha effettuato una prova di resistenza respiratoria, individuando nella norma EN 136:1998, che si applica alle maschere intere per uso industriale, un possibile valido riferimento.

La norma EN 136 è stata utilizzata come riferimento per il metodo di prova, ma non come riferimento per valutare la conformità o meno della maschera a dei requisiti specifici; infatti non vi sono dati adeguati a conferma di poter ritenere che i requisiti di accettabilità previsti dalla EN 136:1998 siano applicabili anche per questo tipo di maschera.

La norma è stata seguita in larga parte con le seguenti eccezioni:

- La posizione della testa di prova è stata con il facciale orientato in avanti (le misurazioni non sono state rilevate in cinque diverse posizioni/orientamenti come richiesto al § 8.15 della norma EN 136:1998).
- Oltre al ciclo di respirazione previsto dalla norma (25 colpi/min e 2l/colpo) sono stati applicati altri cicli di respirazione, come di seguito indicato (non sono stati utilizzati i cicli di respirazione a flusso continuo pari a 10 l/min, 30 l/min. e 95 l/min.)

Questo Rapporto di prova deve essere reso pubblico solo in forma integrale.  
I risultati di prova ottenuti si riferiscono esclusivamente ai campioni sottoposti ad esame. Da essi non si può desumere una dichiarazione circa la conformità della produzione al campione di prova. È vietata qualsiasi riproduzione parziale salvo autorizzazione scritta di ITALCERT.

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La prova è stata effettuata utilizzando l'apparecchiatura di prova prevista dalla norma EN 136:1998 - § 8.15, sottoponendo la maschera ad un ciclo respiratorio per mezzo di un polmone artificiale.

Le maschere sono state fissate saldamente ad una testa di prova tipo Sheffield in modo da garantirne la tenuta ermetica e successivamente sono state alimentate con aria proveniente da un polmone artificiale regolata a diversi ritmi respiratori (come di seguito specificato)

I valori di resistenza respiratoria (inspiratoria ed espiratoria) sono stati registrati in continuo e sono di seguito riportati.

**Risultati**

Id.campione	Resistenza all'inspirazione $\Delta P$ ( mbar )		Resistenza all'espirazione $\Delta P$ (mbar)	
	25 x 2 l/min	25 x 2,5 l/min	25 x 2 l/min	25 x 2,5 l/min
#A1	6,4	9,2	5,8	7,2
#A2	6,3	8,3	6,0	7,4
#A3	5,7	8,1	5,4	7,2

Data di emissione: 2018-03-14

bocconi a monte 10 mbar

ITALCERT S.r.l.  
Settore Dispositivi di Protezione  
Individuale  
Dott. Andrea MONTESANTOITALCERT S.r.l.  
Settore Dispositivi di Protezione  
Individuale  
Ing. Flavio BANFI

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