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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 CO2 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 CO2. 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

- CO2 (the chemical abbreviation for carbon dioxide) is a gas naturally present in the air we breathe.
- Concentration of CO2 in the air is approximately **0.04%**.
- Concentration of CO2 in exhaled air (the "waste" of our breathing cycle) is around **4.5%.**
- **An atmosphere containing more than 5% of CO2 (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 **<u>Orinasal Pocket</u>**.

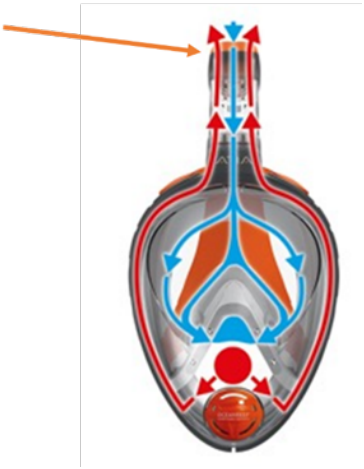
The FFSM shares this same design, which means that the breathing cycle of both products perform in the same manner (see graphics below):

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 **<u>our</u>** FFSM).

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

The benefit is to separate fresh air, containing only 0.4% CO2, from used, exhaled air with 4% CO2 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)

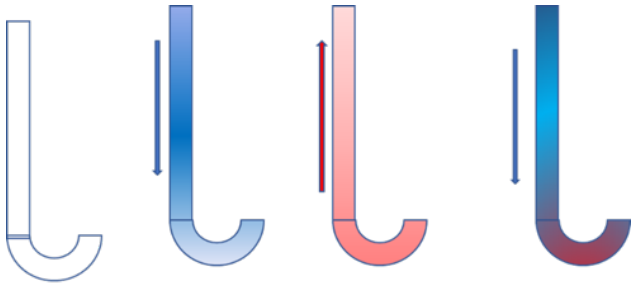
Further Tests and comparison with snorkel technology

A user snorkeling with a conventional snorkel will breathe through a "tube" placed in the mouth – inhaling fresh air at 0.04% CO2 and exhaling 4% CO2 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).

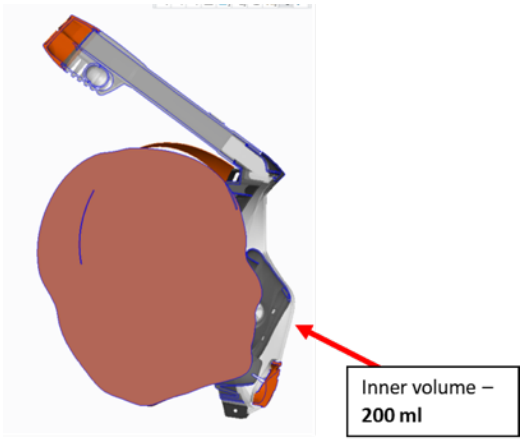
EN1972 CO2 percentage limit – follows the same parameters as EN136.



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.

ITALCERT

Notified Body n° 0426

TEST REPORT n° PPE125RP2602

1	**SCOPE**	*Measurement of the carbon dioxide content of the inhalation air and of the breathing resistance*
2	**STANDARD / TEST METHOD**	*EN 136:1998 - § 8.14 (with deviations), § 8.15 (with deviations)*
3	**APPLICANT**	*MESTEL SAFETY S.r.l.* *Via Arvigo, 2* *16010 S'Olcese (GE)*
4	**TESTING SAMPLE**	
4.1	Type	*Full face masks designed to be used in snorkeling activities.*
4.2	Identification of the product	*ARIA A1 (white), ARIA A2 (grey), ARIA A3 (blue)*
4.3	Sampling	*Made by the applicant: n° 3 masks, identified by ITALCERT with #A1, #A2 e #A3 (sizes L/XL)*
4.4	Preconditioning	*No. Samples tested as received.*
5	**DATE OF RECEIPT OF THE SAMPLES**	*2018-03-13*
6	**DATE OF PEROFORMING OF THE TESTS**	*2018-03-13*

Notes
1. *This test report is an English translation of the test report n° PPE125RP2602 issued by Italcert S.r.l. in italian language. In case of discrepancy it must refer to the test report in Italian language.*
2. *Every link to paragraphs (e.g.: link in the fields "Requirement" and "Test method") in every point of this Report, is anyway referred to the technical standard of which in point 2 of this Document. Would it become necessary to link other documents, than the complete references will be indicated.*
3. *Unless otherwise specified, the tolerances provided for in the reference standards apply to all values expressed in this Report.*
4. *The applicant has declared that the samples tested are new and that they have not been preconditioned.*

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7 PHOTOGRAPHIC DOCUMENTATION

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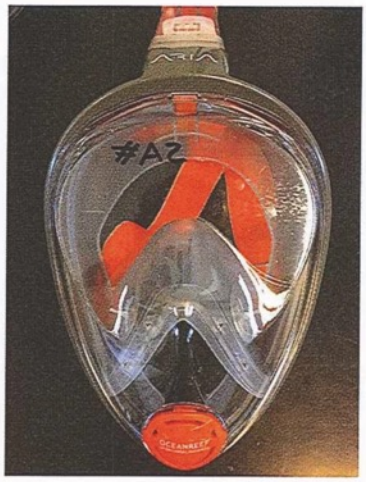

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8 LABORATORY TESTS

MEASUREMENT OF THE CARBON DIOXIDE CONTENT OF THE INHALATION AIR

Test method

For the type of mask being tested, no standards describing requirements and test methods are available. At the request of the client, ITALCERT has carried out an analysis of the available test methods for the measurement of the carbon dioxide content, identifying in the standard EN 136:1998, which applies to full face masks for industrial use, a possible valid reference.

The standard EN 136 has been used as reference for the test method, but not in order to evaluate the conformity or not of the mask to specific requirements; in fact there are no adequate data confirming that the acceptability requirement of the EN 136, equal to 1%, is also applicable to this type of mask.

The standard was followed in large part with the following exceptions:

a) The position of the testing head has been tilted, for greater similarity to the intended use of the mask
b) In addition to the breathing cycle required by the standard other breathing cycles have been performed, as below indicated.
c) Only one measurement was performed on each mask instead of the 3 required by EN 136.

The test was performed using the test equipment required by the standard EN 136: 1998 - § 8.14, testing the mask to a respiratory cycle by means of an artificial lung.

The masks were firmly fixed to a Sheffield-type test head using a suitable sealant to ensure they were hermetically sealed and were subsequently fed with air from an artificial lung adjusted to different breathing cycles (as specified below) and the air exhaled at the start of the test, it was characterized by a carbon dioxide content of 5% by volume.

During the breathing cycle a small amount of exhaled air is withdrawn continuously through a sampling line and subsequently fed back into the exhaled air through a CO2 analyzer.

In order to measure the content of CO2 in the inhalation air, the 5% of the volume of each cycle in the inhalation phase of the artificial lung is sampled in the point indicated by the standard by means of an auxiliary lung and sent to a CO2 analyzer.

The carbon dioxide content of the inhalation air has been measured and registered in continuous.

The tests have been performed till a constant content of carbon dioxide of the inhalation air is obtained.

The test has been performed at the following breathing cycles:

- 25 strokes/min and 2,5 l/stroke
- 25 strokes/min and 2l/stroke
- 10 strokes/min and 1,5 l/stroke

Such breathing cycles have been agreed with the applicant in order to simulate different breathing conditions considered as typical in the snorkeling activity.

Results

	Content of CO_2 in the inhalation air (% in volume) – average values		
Breathing cycle (strokes / l/min)	**Mask #A1 (size L/XL)**	**Mask #A2 (size L/XL)**	**Mask #A3 (size 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

BREATHING RESISTANCE

Test method

On request of the customer, ITALCERT has carried out a breathing resistance test, identifying in the standard EN 136: 1998, which applies to full masks for industrial use, a possible valid reference.

The standard EN 136 has been used as a reference for the test method, but not in order to evaluate the conformity or not of the mask to specific requirements; in fact, there are no adequate data confirming that the acceptability requirement of the EN 136 is also applicable to this type of mask.

The standard was followed in large part with the following exceptions:

a) The position of the test head was with the face facing forward (the measurements were not detected in five different positions / orientations as required in § 8.15 of the standard EN 136: 1998).

b) In addition to the standard breathing cycle (25 strokes / min and 2l / stroke) other breathing cycles were applied, as indicated below (the flow-rate breathing cycles of 10 / min, 30 l were not used / min and 95 l / min.)

The tests has been performed using the testing instrument described in the standard EN 136:1998 - § 8.15, subjecting the mask to a respiratory cycle by means of an artificial lung.

The masks were firmly attached to a Sheffield-type test head so as to guarantee a tight seal and were subsequently fed with air from an artificial lung, adjusted to different breathing cycles (as below specified).

The values of breathing resistance (inhalation and exhalation) were recorded continuously and are shown below

Results

Id.sample	Inhalation resistance ΔP (mbar)		Exhalation resistance ΔP (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

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