CMAS

CONFÉDÉRATION MONDIALE DES ACTIVITÉS SUBAQUATIQUES

WORLD UNDERWATER FEDERATION

CONSTRUCTION STANDARDS FOR UNDERWATER SCOOTERS

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INTRODUCTION

The underwater scooter, as an electromechanical vehicle that drags a diving person underwater, must, in our opinion, have certain characteristics and features derived from precise design and construction so as to use all means to avoid any type of injury to the user and damages to property.
Currently, since there are no community regulations that address this type of machine, CMAS, in close cooperation with expert scooter manufacturers, has drafted some technical specifications useful in the design and construction of such underwater machines.
The use of a machine that drags a diver underwater during a dive includes a series of residual risks especially for personal safety, although the primary hazard remains the environment in which it operates, that is, the surrounding water.

CAUTION

The operation and handling of an underwater scooter, as well as the appropriate technical maintenance requires a certain minimum of technical understanding and knowledge, a certain minimum level of diving skills and competence and an appropriate equipment configuration. As any moving object may represent a potential danger to other persons in its vicinity, the driver must also have a distinctive feeling of responsibility for all his/her doing.

Therefore, CMAS does NOT endorse, promote or otherwise recommend the use of such devices, even at recreational diver course level, for

- *persons of less than 16 years of age*
- *divers not having at least a CMAS 2star diving certificate (or equivalent)*
- *divers without the proper training as received in a CMAS (or otherwise) sanctioned scooter diver course*
- *divers not meeting the minimum requirements for mandatory equipment and its configuration (ref. to standards and training program for CMAS scooter diver courses)*
- *diving beyond the limits as set by the diver's certification level or the operational limits set by the manufacturer of such a device (whichever applies first)*

Having appropriate private liability insurance with a minimum coverage of 2 Million Euros is absolutely mandatory.
By no means and under no circumstances, must scooters or any other towing devices be used as a substitute for the lack of physical fitness.

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I.
TECHNICAL CLASSIFICATION (SCOOTER CLASS DEFINITIONS)

1 Class 1 (Recreational)

Class 1 identifies all scooters with technical specifications that only meet recreational dive specifications with a single tank and within the limits of 2star CMAS or AOWD PADI (or comparable levels of other organisations).
Class 1 (or higher class) scooters are suitable for the CMAS level 1 (recreational) scooter diver certification courses.

2 Class 2 (Tec)

Class 2 identifies all scooters with technical specifications that meet class 1 dive specifications and technical diving specifications in non-overhead environments, and within the limits of a 3star CMAS diver in combination with technical diving certifications, such as Nitrox and Trimix (or comparable levels of other organisations).
Class 2 (or higher class) scooters are to be used for the CMAS level 2 (Tec) scooter diver certification courses.

3 Class 3 (Overhead environment)

Class 3 identifies all scooters with technical specifications that meet the previous two classes and are suited for all types of technical dives in natural or artificial overhead environments, such as cavern, caves, wrecks, mines, submerged buildings, under ice.
Class 3 scooters are mandatory for the CMAS level 3 (overhead environment) scooter diver certification courses.

II.
TECHNICAL TERMS AND DEFINITIONS

1. ***Buoyancy:***
   The resulting force exerted on the fully submerged, complete free floating scooter as defined by the law of Archimedes
2. ***Trim:***
   The position of the fully submerged, stationary, free-floating scooter's longitudinal axis relative to a horizontal plane
3. ***Drift:***
   The stationary, fully submerged and free floating scooter must not roll around its longitudinal axis and must come to rest with the operating handles perfectly aligned horizontally
4. ***Maximum operating depth:***
   The maximum depth at which the underwater scooter can operate.
5. ***Operating time:***
   The average operating time with the capacity to drag the diver with two 10 litre or 12 litre tanks, wetsuit, in correct hydrodynamic conditions and without currents, with intermittent use.
6. ***(Max.) Burn- or burning-time:***
   The time during which a defined current (Amps) may be drawn from fully charged batteries until reaching the low-charge limit
7. ***Static traction force:***
   The force exerted on the cord or handle with the scooter braked stationary in a position and with the propeller free of impediments or occlusions.
8. ***Water working temperature interval:***
   The minimum and maximum temperatures admitted for scooter use.

III.
REQUIREMENTS FOR CORRECT OPERATION

The scooter needs to meet the following navigability specifications in order to operate correctly:

1. Basically, it should be in neutral conditions, neither sinking nor floating. In open water, very slight positive buoyancy (max 50g) is acceptable whereas in overhead environment, similar negative buoyancy might be preferable.
2. In the idle position underwater and left free, the longitudinal axis of the scooter must stay perfectly horizontal.
3. It must have correct drift meaning that the handles must be perfectly aligned horizontally when idle underwater.
4. The steering (or driving) handle, the one incorporating the speed control device, must be ergonomic so as not to irritate hand joints.
5. Gradually distributing power must be possible without having to immediately accelerate at all costs.
6. Driving single handed must possible so as to leave the other hand free for compensation or to hold accessories such as flashlights or other.
7. It must have an automatic torque limitation system so that the introduction of any object in the propeller blade range of action does not damage the blade or associated parts, the scooter in its entity or, even worse, injure the diver.
8. The electrical motor must be equipped with a heat protection system so that any overload in highly autonomous models does not irreparably damage the electrical motor.
9. A safety fuse must be installed so that the circuit is cut off whenever the current required by the motor exceeds set limits, immediately stopping scooter operations.
10. It must have a system that timely warns the diver that the battery charge is low.
11. When using batteries particularly sensitive to overloads such as those with NiMh technology, a completely automatic battery overload current cut-off system must be used.
12. Even when using batteries with Pb (lead acid) technology, an overload current cut-off system may be required in the event of overload (also mandatory in overhead environment).
13. Suitable battery chargers, fully automatic, that maintain the batteries in fully charged status over unlimited time, must be supplied.
14. A user- and maintenance manual, written in the language of country where the scooter is sold (or at least in plain English), easy to understand and equipped with all the information required for scooter use, must be supplied.
15. All information stickers useful for correct use should be directly applied on the scooter body
16. Removing the propeller must be possible without having to dismantle its components.
17. Direct feed: In the event of use in extreme conditions, an emergency system that can bypass all controls (electronic or electromechanical) and manually connect the battery directly to the motor to permit fully manual use of the scooter should be included.
18. Varying the autonomy must be possible by changing only some of its parts such as, for example, the battery and external hull without fully replacing the scooter in its entity.
19. Adjusting drift must be possible by moving internal masses such as the battery or other ballast parts.
20. Adjusting buoyancy must be possible by varying the weight of the internal ballast without special tools.
21. Varying trim, or the tendency of the bow to rise or fall above or under the machine's horizon, must be possible without special tools.

IV.
GENERAL CONSTRUCTION FEATURES

General underwater scooter construction should meet the following essential requisites:

1. Construction materials must be resistant to corrosive water elements, especially those in salt water.
2. It must not be fragile and resist the normal collisions that may occur during transport and use.
3. If must not be deformable so as not to compromise scooter conditions and its resistance to compression due to external pressure.
4. It must not vary noticeably its volume and therefore its buoyancy when changing depth.
5. It must have good resistance to UV-rays since these are machines that are easily left exposed to sun rays over long periods of time.
6. It must resist to a pressure at least 1.5 times that stated as maximum operating pressure, in other words, the safety factor must be at least 50%.
7. All nuts and bolts must be made of stainless steel in order for the scooter to be dismantled even if flooded and with internal parts corroded.
8. Electrical wires must be highly flexible to prevent breaking due to the high number of bends they may sustain.
9. The ballast required for adjusting buoyancy in salt water must be easily removable and modifiable without special tools.
10. Gaskets and any other seals must be those readily available on the market. If O-rings are used, they must be compatible with any standard silicone grease.
11. External parts dedicated to hull closing that may get caught and consequently damage the scooter and cause hazards for the user should be avoided.
12. It must have specific handles or grasping points on the body that permit secure holds for transport.
13. Usage with tow behind type traction such as a tow cord and hook on a specific sling worn by the diver must be possible.
14. A main battery (cut-off) switch must be included to physically cut off at least one wire from the battery so as to cut off battery current to any service such as the electronic regulator or electrical motor or other components at any time.
15. Scooter speed must be adjustable by varying motor rpm (with set propeller step).
16. The propeller must have radial protection so that nothing can accidentally come into contact with the rotating blades.
17. If designed for use by minors, the propeller must be carefully protected to prevent the insertion of any object or finger into the path of the rotating blades.
18. Battery- and engine-compartment must be mechanically separated and hermetically sealed from each other (see below specific chapter on this key feature).

V.
DEVICE AND COMPONENT SPECIFICATIONS

MAIN SWITCH (on-off switch, power switch, cut-off switch)

The main switch (mandatory) must cut off the power supply to the engine immediately after the battery and upstream from any utility, electronic systems included.
The cut-off mechanism must be manually controlled by the user in any environment and in any conditions and must meet the following specifications:

1. Operate with sole finger force.
2. Mechanically separate the two contacts, not depending on servo-assisted systems.
3. It must be dimensioned to support the maximum peak current of the electrical motor activated without welding phenomena occurring in contacts.
4. Parts in contact must be made of specific alloys.
5. It must be placed in an easily reachable position for the diver.
6. It must not be protected in any way by guards or covers.
7. It must be robust and, in the event it breaks, must not permit the scooter to be flooded.
8. Inspections must be possible and it must be removable.
9. Instructions for use must be indicated next to it.
10. It must be easy to grasp and operated, even when wearing gloves.
11. It must not be able to confuse the operator by its shape with other scooter devices.

HERMETIC HULL CLOSING SYSTEM

The scooter's hermetic (water- and gas-tight) hull closing system must always be ensured because it is essential to avoid partial or full flooding and consequently the loss of neutral (or otherwise pres-set) buoyancy.
The underwater scooter hull closing system must be designed with the following specifications in mind:

1. The hull must be guaranteed fully gas- and watertight under all circumstances that normally apply for diving.
2. It must be easy to use and not induce errors in scooter closing.
3. It must always keep sealing surfaces in contact with gaskets.
4. It should not have any parts considerably protruding from the scooter shape that could, in some way, create hazardous situations for the diver or his/her environment during dives.
5. Inspections must be possible and it must be removable.

HERMETIC INSULATION OF THE BATTERY COMPARTMENT FROM THE ELECTRICAL MOTOR AND ELECTRICAL ENERGY CONDUCTION FROM THE BATTERY TO THE PROPULSION GROUP

The mechanical separation of the two compartments, one for the battery and one for the motor, is essential and mandatory since accumulators that do not generate gas during the chemical operating process (with convenient costs) are currently not used.
Any gas generated is mainly hydrogen, a highly flammable gas (explosive), which must absolutely be kept away from any sparks which could trigger gas combustion.
Generally, underwater scooters are made up of two fully hermetically separated chambers, one specifically for the motor and electrical control parts and the other for the batteries.
These compartments must have the following specifications:

1. Guarantee full hermetic separation.
2. They must be easy to remove for inspections and maintenance; sealants to be applied at every dismantling and reassembly are not permitted.
3. They must have good mechanical resistance and an ability to resist the temperatures generated by the electrical motor.
4. The electrical wire passage across the two compartments must be fully hermetic.
5. Contact connectors between battery wires and the motor must be suitably over-dimensioned and must not in any way generate sparks or overheating.
6. During outer hull closing, the hermetic features of the two compartments must not be compromised.
7. The battery mass must not in any way (even in the event of collision) compromise hermetic system integrity.

WATERTIGHT PROPELLER SHAFT

The propeller shaft, because the electrical motor is in a watertight container and the propeller is situated on the exterior emerged in water, must be perfectly watertight.

1. A system that provides the highest guarantees against water infiltration in the scooter must be designed and, therefore, a double seal is highly recommended.
2. Mechanical disk type seals are not recommended since they must be replaced whenever dismantled and do not fully prevent water leakage because, due to their nature, they operate with a thin layer of fluid between the two contact surfaces.
3. Seals must be readily available on the market and not custom made.
4. It must be very easy to dismantle the shaft water seal group for routine maintenance.
5. Seals must be protected as much as possible from any insertion of hooks or other objects that could wind around the shaft, consequently damaging the seal and flooding the scooter.

WATERTIGHT EXTERNAL CONTROLS

External controls on the scooter, such as the main switch, speed regulator and other control, must be watertight and sealed with multiple gaskets, suitably lubricated.
Gasket seals must be those readily available on the market.

GASKETS AND OTHER SEALING COMPONENTS

Gaskets and any other sealing components must be of standard types readily available on the market (dimensions, materials).
Especially O-Rings must be of a material that can be lubricated with any standard silicone grease on the market and readily available in any dive shop.
Whenever O-rings are used, sealing should be accomplished radially and not axially to a bore or a cylinder.

MOVING PARTS PROTECTION (PROPELLER)

To generate a propulsion drive in water, one of the systems used is a propeller as in our case.
The use of a propeller inevitably implies a rigid rotating body, emerged, in movement and at a close distance to the user which forces the manufacturer to review all the technical solutions (compatible with current technology and feasible physical implementation) to prevent injuring the user.
Especially if the underwater scooter is designed for minors, every moving scooter part must be isolated by a suitable protection so that no part of the user's body can come into contact with moving scooter parts.

The solution of fully isolating the propeller, especially with systems that do not let a child's finger pass, inevitably lead to a partial block of the water which, sucked in/out by the propeller, must pass through this protection.
In machines designed for adults who have received specific certificates, only the circumference of the propeller is normally protected for propulsion performance reasons.
This technical solution leads to possible contact with the rotating blades on both the suction and expulsion sides.
Therefore, special devices that limit damages caused by collisions between foreign objects and the propeller blades must be implemented and the user must be specifically informed of this potentially hazardous situation.
Essential devices that should be implemented include:

1. The propeller must be equipped with a transmissible torque limitation system.
2. The torque limitation system, once triggered, must not transmit motor torque to the propeller in any way.
3. Torque limitation value must exceed the torque transmitted by the motor for propulsion by at most 10%.
4. When torque limitation is triggered, the user must be immediately warned, better if the system warns the user by sound or vibration so that the speed control system is immediately released.
5. The torque limiter must not self-destruct when triggered and must resist at least one hundred interventions.
6. It must be easy to calibrate the torque limiter to compensate any shifts due to partial wear or other parameters.
7. Instructions on how to adjust the torque limiting device must be included in the manual.
8. The instructions manual must indicate the maximum setting values so as not to cause the torque limiter to malfunction.
9. A barrier must be created on the water suction side to prevent large objects from be sucked and ensure that hand insertion is not accidental.
10. From the expulsion side, the propeller blades must be placed at a distance from the protection so that the propeller does not touch the ground and surrounding objects in the event of accidental turning-on when the scooter is placed on the ground with the propeller facing down.

SPEED CONTROL HANDLE

The speed control handle (the device used once the main switch is turned on) is permanently used during a dive. For this reason and because it is the real device that triggers propeller rotation, it must meet the following specifications:

1. It must not be a retainer type; a direct, mechanical link which may work in both directions is to be preferred.
2. When released by the user, it must immediately stop the motor.
3. Delayed motor cut-off after releasing the device or gradual slowing down is not acceptable.
4. It must be suitably protected so that accidental turning-on is at least difficult.
5. Operation must only be possible by an intentional, distinctive hand- or finger movement, not by an unspecified, unintentional contact
6. It must be of a robust construction.
7. It must be integrated in the scooter steering system.
8. It must be usable with the same hand used to drive (steer) the scooter.
9. Operations must be inhibited when the main switch is off.

DOCUMENTS TO BE SUPPLIED

The underwater scooter must be equipped with an instructions manual that explains operations and informs the user on all possible hazards.
The subjects that must be included in the instructions manual are listed below.

1. general warnings
2. scooter use
3. routine maintenance
4. transport and storage
5. battery charging & maintenance
6. risks associated with incorrect battery use
7. risks associated with incorrect scooter use
8. residual risks
9. general risks during underwater diving
10. cutaway drawings / exploded views of major components
11. main spare parts list
12. customer service and the manufacturer’s addresses

VI.
CONSTRUCTION FEATURES AND CLASSIFICATION

pos.	Description of Feature	Class 1 (recreat.)	Class 2 (tec)	Class 3 (overhead environ-ment)
	Performance			
1	Maximum operating depth (required minimum)	**30 m**	**60 m**	**100 m**
2	Average Autonomy (required minimum)	**45 min**	**60 min**	**60 min**
3	Minimum static traction force	**120 N**	**180 N**	**220 N**
4	Water working temperature interval	**10 / 30°C**	**-5 / 35°C**	**-5 / 35°C**
	Requirements for correct operation			
1	Neutral conditions	**P**	**O**	**O**
2	Neutral trim	**P**	**O**	**O**
3	Drift	**P**	**O**	**O**
4	Ergonomic controls	**P**	**O**	**O**
5	Gradual start	**P**	**P**	**O**
6	Single handed operations	**P**	**O**	**O**
7	Propeller torque limitation system	**O**	**O**	**O**
8	Electrical and heat motor protection systems	**P**	**P**	**O**
9	Safety fuse	**O**	**O**	**O**
10	Battery low warning system	**P**	**P**	**P**
11	NiMh battery overload cut-off system	**O**	**O**	**O**
12	Pb battery overload cut-off system	**P**	**P**	**O**
13	Automatic battery charger	**O**	**O**	**O**
14	Use and maintenance manual in local language or in plain English	**O**	**O**	**O**
15	Warning and hazard stickers	**O**	**O**	**O**
16	Possibility of removing the propeller during the dive without losing parts	**P**	**P**	**P**
17	Emergency power supply bypass system for direct feed	**P**	**P**	**O**
18	Autonomy variation capacity by the user (modularity)	**P**	**P**	**P**
19	Drift regulation possibility	**P**	**P**	**O**
20	Buoyancy regulation possibility	**P**	**P**	**O**
21	Trim regulation possibility	**P**	**P**	**O**
	General construction features			
1	Rustproof construction materials	**P**	**O**	**O**
2	Overall durability	**P**	**O**	**O**
3	Non-deformable due to external pressure	**O**	**O**	**O**
4	Buoyancy consistency despite depth variations	**P**	**O**	**O**
5	UV ray resistant	**P**	**P**	**O**
6	Test pressure 1.5 times max operating pressure	**P**	**O**	**O**
7	Stainless steel nuts and bolts	**P**	**O**	**O**
8	Highly flexible electrical wires	**P**	**O**	**O**
9	Possible condition change from fresh to salt water	**P**	**O**	**O**
10	O-ring availability and compatibility to standard silicone grease	**P**	**P**	**O**
11	Hull closing system without protrusions	**P**	**P**	**O**
12	Transport handles	**P**	**O**	**O**
13	Tow behind drive	**P**	**O**	**O**
14	Main battery (cut-off) switch	**O**	**O**	**O**
15	Speed regulation	**P**	**O**	**O**
16	Radial propeller protection	**O**	**O**	**O**
17	Full propeller protection	**P**	**P**	**P**
18	Hermetically separated and sealed compartments for batteries and engine	**O**	**O**	**O**

Key

P = preferred, strongly recommended

O = mandatory