ESDP Best Practice for using Closed-Circuit Rebreather for Occupational Scientific Diving at work

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And
European Scientific Diving Panel (ESDP)

Version 2.0 - April 2024

A CCR scientific diver deploying an underwater sound recorder in shallow water. Photo VLIZ – Sven Van Haelst

About this document

This document is addressed to all managers, health and safety officers responsible for research laboratories or research vessels, and scientific divers. They may not be specialists in using rebreathers for work operations but are willing to better understand what is going on in that field. It is developed as a living document to provide a best practice guide for using Closed-Circuit Rebreathers for occupational scientific diving at work.
The development of this 'living' document will be iterative, starting with the first version of November 2021, resulting from the brainstorming organised 'online' during the COVID-19 pandemic. The composition of the working group can be found in Annexe 1.
The first revision presented here is based on my willingness to include more material, such as a paragraph giving some basic information on gradient factors and another on human factors. It also considered the few remarks received, including changing some illustrations.

Alain Norro April 2024

A CCR Scientific diver at work. Photo: Brett Seymour, Tulsamerican Project 2017

Contents

A draft standard including two levels of qualification for scientific diving at work was issued at the end of the Banyuls sur Mer (France) meeting held in October 2000. A final version was issued by ESDP as an ESF Marine Board consultation document in September 2009 with the name "Common practices for recognition of European competency levels for scientific diving at work. European Scientific Diver (ESD) Advanced European Scientific Diver (AESD)". It was revised in 2017 and published by the European Marine Board using the same name. (Féral and Norro, 2023)
Today, there is a need to include into the 'standard' the use of Closed-Circuit Rebreather (CCR) when conducting scientific diving.

This document is added to the ESDP's Common Practices for the recognition of European competency levels for scientific diving at work. European Scientific Diver (ESD) Advanced European Scientific Diver (AESD)' edition 2017. It addresses the specific use of CCR as a breathing apparatus when performing occupational scientific diving activities.
A note on specific training for rebreather diving will be added to the document based on the ISO standards today under development for CCR diving. (ISO, 2020)

Consideration of scientific methods that could be further used and/or deployed using CCR shall be part of the document. Such methods may include underwater positioning, data transmission, transport means (Diver Propulsion Vehicles) for transect, survey, underwater transport of equipment, etc…

The Redline for CCR use during scientific diving activities at work is the *safety of the activity*. Therefore, how can CCR *add value* to the sciences and/or to the safety of the dive/diver?

Why use CCR for occupational scientific diving work?

The use of the CCR breathing apparatus for occupational scientific diving work is relevant for all depth zones depending on the targeted objectives (to approach the wildlife in the river, for behavioural studies of ichthyofauna, to implement sensors or perform core sampling, for eDNA sampling by pumping in the MCE…). The recommendations will have to encompass all the profiles of divers, with differentiated parts according to the level of engagement[1]. Underwater sound measurements of marine life (fishes) used rebreathers for a long time (Lobel, 2009), while the exploration of the twilight zone by R. Pyle (Pyle, 1999) highlighted the deep occupational scientific diving work using CCR.

[1] Engagement can be defined as P*SQRT(t) with P the pressure and t the time of the exposition

Best practice

In this part, we address numerous points of attention/questions concerning the best practice of using CCR for occupational scientific diving. Those items are not ranked and will be extended in successive editions of this document. It is not intended to rewrite existing procedures for technical diving but to highlight what is essential for the sector of occupational scientific diving.

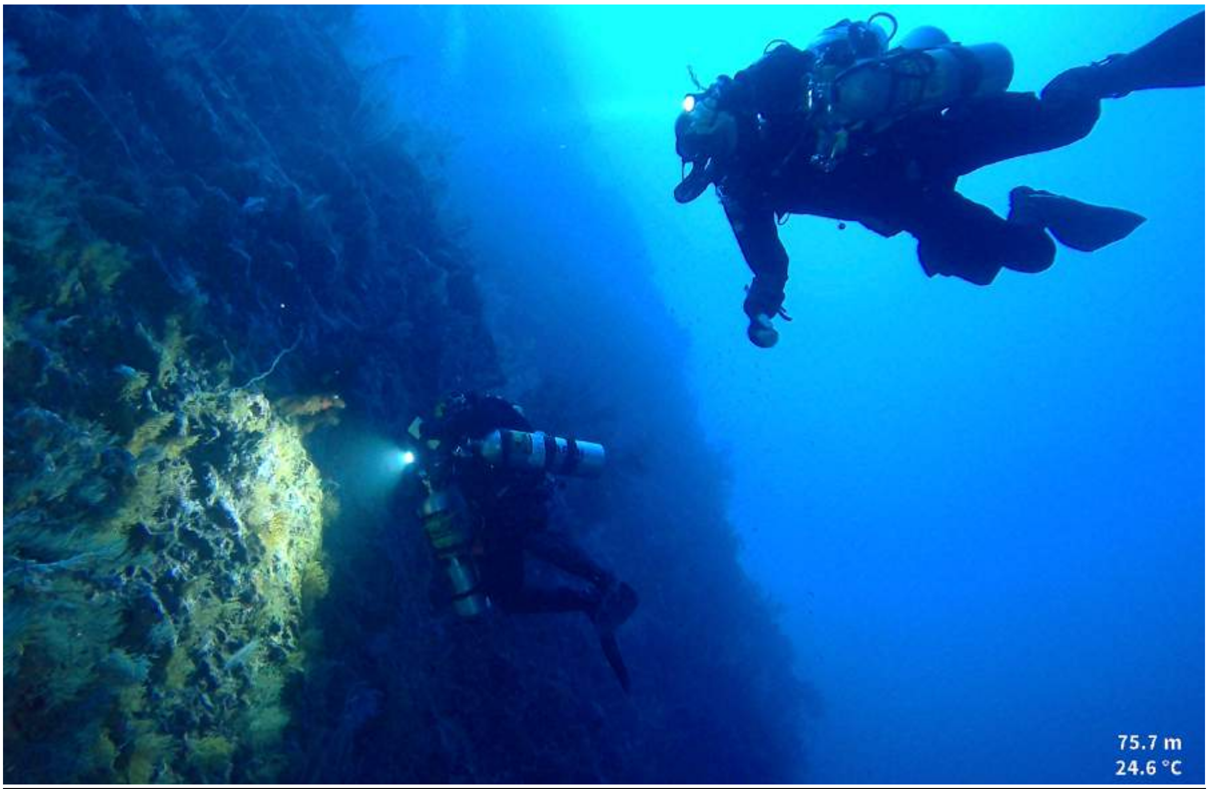
-Does the planned use of CCR for occupational scientific diving increase the risk of the activity?

Using CCR decreases risk and increases safety for scientific diving activity (Norro, 2016). The gas efficiency of CCR breathing apparatus is a notable advantage over open circuit systems. Another advantage is the breathing of warm, humid gas to increase comfort and to reduce hypothermia risk in cold water conditions. The gas efficiency of CCR reduces the stress of monitoring the limited supply of open circuit SCUBA. CCR divers can hear ambient noise better than open circuit divers because of the reduced self-generated noise and the absence of bubbles. This is particularly important in some special situations, such as under a ceiling or in the presence of particles. CCR allows optimised decompression by taking advantage of constant oxygen partial pressure, etc.… (Anonymous 2015, Hocdé 2015, Hocdé et al. 2017).

The reduction of risk is only attainable through high-quality and repetitive CCR training. In the CCR sector, contrary to the OC scuba diving sector, the CCR manufacturers are involved in the training programs/cerification organisations. If shortcuts are taken in the training of technical CCR divers, accidents result. CCR manufacturer Martin Parker highlighted that there were 24 rebreather diving fatalities in 2019, making that year one of the worst from the start of the use of CCR by the technical diving sector. Parker suggested that poor training might account for the casualties. Similarly, Fock (2013) demonstrated the inverse relationship between the quality of the training and the level of risk taken (accepted ???) by the diver. It is known that for the occupational scientific diving sector (Dardeaux et al., 2012, Sellers 2016), the diving accident rate is lower than that of recreational or commercial diving. This is likely due to the high level of education of the participants as well as their willingness to follow existing safe procedures included in strict training.

-Diving as a pair

“Buddy pair” diving increases the safety of occupational scientific diving using CCR. Adding a third diver when the pair are busy gathering data is an added safety. The task of the third diver is then only to take care of the execution of the dive planning. (S)He is also in charge of the overall safety of the team during the dive. The team can exchange the roles on the next dive. Occupational diving legislation of some European countries requires a minimum team of three persons: diver, standby diver, and dive supervisor.



CCR Scientific and support diver during a black coral inventory on a mesophotic zone drop-off of the Red Sea. Photo: Alain Norro

-Group of divers with different CCR equipment

The utilization of multiple CCR models within the same dive team may increase the risk of the activity, and this factor should be included in the risk analysis. Preferably, all dive team members should dive the same type of CCR unit. When this is impractical, risk could be mitigated by requiring cross-over training on all varieties of CCR to be used during the hyperbaric operations or expedition. If that risk mitigation measure is employed, additional training must occur before the first project dive.

-Configuration

Some divers like to have the bailout tank attached 'direct 'on the side of the CCR box/frame, while others prefer to carry the bailout tanks in side-mount configuration (high or low). As a basic recommendation, the configuration is left at the discretion of the diver as long as it can be proven safe and efficient for the proposed scientific task.

- Safety person (team) at the surface

It is essential to highlight that the safety team must have experience/skills/qualification equal to or exceeding those of the working divers. The safety person must be ready to act before the first diver enters the water. As a reminder, in many, if not all, legal texts concerning occupational diving, a safety person/team must be present on-site during the dive.

- Composition and quality of the breathing gas

a/ recommendation of trimix diluent below the depth of 40 m to increase safety (nitrogen decompression, reduction of gas density (see below) and narcosis for sensitive people).

b/Use a few standard diluents mixes according to the main depth zones to gain experience and avoid making several different mixes. This simplifies logistics and may reduce the risk of error and decompression differences inside a dive team.

c/Compose your blends using breathable-quality gases and avoid industrial-quality mixes. The EN12021 norm exists for air/gas quality and must be strictly followed.

d/ Do not delegate the verification of your mixes (diluent & bailout) to anybody else. Every diver MUST verify him(her)self the gas composition of all cylinders used before signing the blender book and analysis tags on tanks. Never rely only on a check made by another person (e.g. Blender)

-Gas density

Very often today, CCR divers do not take enough care of the gas density of their breathing mixture. This parameter is essential for CCR diving. The maximum gas density that must be used is 6,3 g L^{-1} with a recommended value at 5,2 g L^{-1} (6,7 g L^{-1} and 5,7 g L^{-1} for Norro 2016)

-Decompression strategy & decompression procedure and dive computers

Most of the time, occupational diving national legislation relies only on the dive tables and based on the rules accepted for a sector of activity. Dive tables to be used for CCR diving are scarce and need greater availability. The US Navy developed some dive tables for Heliox mixes (Johnson & Gerth, 1999; Johnson et al., 2000 and Gerth & Johnson, 2002), but in the sector of occupational scientific diving, divers using CCR generally rely on 'decompression software' and dive computers. Reliable and 'validated only' software must be used. Several plans must be computed, and total decompression time must be compared to existing decompression tables and/or sector experience. The software includes adjustable conservatism, and that should not be seen as added safety, nor as an exact science; it is just a smart, or not, way to increase decompression at the given stage or for the complete decompression plan. Conservatism is used during the challenging/comparison phase introduced earlier. Several plans must be computed for a deeper excursion or longer bottom time and bailout purposes. Multi-level diving may be planned as well. ***But always plan the dive and dive the plan!***

-Decompression strategy & comments on gradient factors (GF) setup

The principle of gradient factors (Erik Baker) was introduced in the 1990s to modify dissolved gas decompression models (Bühlmann ZHL16c). The goal was to allow these models to obtain decompression profiles similar to those obtained by bubble models (VPM family) in technical deep diving using mixed gas.

The parameterization introduced by Erik Baker included two parameters, the so-called GF Low and GF High. These percentages are applied to the maximum allowable gas tension of each of the 16 compartments used in the ZHL16c model. Current dive computer manufacturers implement this type of parameterization to adjust the computer's conservatism. The user (diver) can vary the two parameters, GF Low and GF High, and it is necessary to guide him/her in his/her choices.

It appears today that it is not wise to introduce/use the low gradient factor when diving with air or nitrox. It might even be detrimental to safety (De Ridder et al. 2023)

Implementing these parameters (GF) in current computers does not make it possible to have a low GF greater than the high GF. If the low GF determines the depth of the deeper stop, the high GF is used to artificially lengthen (conservatism) the last decompression stops. A high GF factor equal to 100% represents the maximum admissible gas tension as predicted by Bülhmann (in this case, ZHL16 c). The comparison of the decompression profiles carried out at the tables, and those carried out with the computer introduces, most often, a high gradient factor of between 80 and 100%.

It is, therefore, appropriate to set the low GF to the same value as the high GF (twin factors), for example, 85/85 (see (De Ridder et al.2023).

For the case of trimix dives, in the early days of GF model usage in the 1990s, it was common to have GF set up like 20/75 or even lower GF low values, imposing the first stop to be taken very deep.. Nowadays, this practice has changed. Keeping the diver too deep for too long is counter-productive for the latter decompression stage. An interesting analytical method is proposed by D.Doolette (2019). It is possible to use that method to compute a value for the parameter ‘GF low’ as soon as the diver sets the value for the parameter ‘GF high’. In that method, the GF low is about 70 % of the ‘GF high’

- Back-up decompression procedure or computer

It is advisable to have a backup decompression procedure when diving. The simplest is a printed copy of the decompression schedule(s) agreed upon during planning, but it is usually a redundant dive computer. Almost every CCR includes a decompression computer linked to the online PpO_2 measurement system. The backup computer capable of managing constant PpO_2 diving should be unlinked to the CCR. Setting up that backup computer to a lower setpoint than the CCR is advisable to build a safety margin. Use of a dive computer must be authorised by National/ regional laws or sector rules. As soon as CCR diving is foreseen, a backup plan must include ‘normal’ CCR plan(s) as well as bailout plan(s)

Note: - We carry a backup computer with harsher GFs and a lower safety margin. It is still higher than Bühlmann’s original idea, but it allows quicker deco if you need to get out of the water. If you have to bail out, you bailed out for a valid reason, and doing extra deco doesn’t make sense. You can always add deco safety if you have the gas available and there are no other risks.

-Bailout strategies

Bailout strategies may encompass complete autonomy where each diver carries all necessary bailout gas mixes and volumes to ascend safely through all decompression stops at any point in an aborted dive, sharing bailout gases within the team, or even a riskier strategy of carrying sufficient gas to reach the shot line where other gas cylinders are cached. The three solutions could be part of the plan and will be discussed when establishing the risk analysis for the dive. Risks associated with the various strategies include failure to locate the shot line, managing cases of gas loss, or hitting a decompression ceiling before reaching the gases. The standard gases within the groups or for the complete expedition must be considered when completing the risk analysis.

-Man-Machine Interface (MMI)

MMI is a critically important component of any CCR. The CCR diver must completely and deeply understand it before any dive is conducted. Maintenance of this knowledge is to be verified as often as possible during drill exercises that can be integrated into any dive. Suppose logging information is included with the possibility of being downloaded by the MMI. In that case, it must be used during the debriefing phase of the dive, helping to review the dive together with the log file of the dive computer if available. It is advisable to keep track of those data with respect to GRDP.

-Mouthpiece strap

The French Navy sees this strap as an important part of the rebreather equipment. It increases the safety of the activity, so it is advisable to use one for occupational scientific diving. More recently, at the Rebreather Forum RF4 (April 2023, Malta), it was again highlighted that a mouthpiece strap was a great addition to the CCR diver safety configuration. Some manufacturers are today fitting the mouthpiece strap as a standard on all their new units.

-OC Bailout valve

This piece of equipment is available today on the market. Some divers consider this device as increasing their safety; others see this as an unnecessary complication of their rig and therefore as an additional failure point better avoided. If the diver chooses to employ CCR with OC Bailout valve, this equipment must conform to the existing EU norm (EN250) by itself but also when used inside the loop of the CCR (EN14143).

-Wired or wireless underwater communication systems

Communication diver-to-diver and diver-to-surface strategies or diver recall procedures are part of the risk analysis.

Traditional line signals to the surface or wired communication is impossible for deep, fully autonomous diving using CCR.

Wireless communication systems with or without full-face masks (FFM) may be used in some situations to maintain a link between the diving team and the diving supervisor at the surface or underwater. Adding devices into the loop of the CCR may alter the EU Norm, which should be verified. Some models can be used to a depth of 100m and a horizontal range of a few hundred meters. They can use a waterproof microphone positioned on the CCR mouthpiece and require no modification to the CCR loop. (no risk of losing CE norm of the rebreather)

A drop camera or ROV can also be used to ensure communication and/or verify the work/safety of the occupational scientific diver. Hand or light signals can be used in front of the ROV video camera.

If FFM is used, the divers must have completed specific training before the first dive of the expedition. The CE norm must also be verified to determine whether the CCR norm remains valid.

An Ultra-Short BaseLine (USBL) acoustic system can also track the diver. In this case, the occupational scientific diver will have a transponder attached to the side of the CCR. In any case, completing the risk analysis must include reviewing the communication systems options.

- *Human factors*

Human factors in occupational scientific diving encompass the psychological, physiological, and sociotechnical aspects of human performance and behavior that influence safety, decision-making, and performance during underwater activities. Issues such as stress, anxiety, communication breakdowns, decision-making errors, and inadequate teamwork can contribute to accidents underwater (Lock, 2012. ILO, 2021).

Physical fitness, equipment familiarity, and experience levels are critical factors that influence a diver's ability to respond to emergencies and navigate challenging conditions. Buoyancy control and awareness of the underwater environment also play crucial roles in ensuring the safety and well-being of scientific divers.

Diving is inherently risky, and the underwater environment poses unique challenges. Failure to understand, manage, or mitigate these human factors can lead to potentially life-threatening situations and accidents. This topic aims to ensure that human factors are adequately considered in occupational scientific diving and to give you the best chance of enjoying your working dive without unexpected and dangerous surprises. In other words, it’s about making it easier to do the right thing and harder to do the wrong thing.

If you think safety considerations negatively impact your budget and operational effectiveness, try having an accident … Managing human factors is essential to preventing occupational accidents, injuries, and mishaps, which can cost businesses money, reputation, and potentially their continued existence.

Therefore, recognising and addressing human factors typically covers various topics to equip divers with the knowledge and skills needed to navigate the challenges of underwater environments. This is crucial for creating a safe occupational scientific diving environment. In the next paragraph, we illustrate one of those human factors: task loading.

-The concept of task loading

The occupational scientific diver is not only diving, but (s)he is 'working' underwater. In addition to the 'normal' tasks relevant to rebreather diving, the scientific working tasks may be unique or multiple, repetitive or sequential with a simple sequence or even including conditional links. The tasks should be discussed with the diving team during the risk analysis and the dive briefing. If too many tasks pop up simultaneously, the diver may become "task overloaded" and experience difficulties in completing the dive safely, with the possibility of shortcutting some vital actions. Hence, correct gas choice is essential to reduce the chance of narcosis, which may increase task loading, causing earlier "task overloading".
Generally, when developing an experiment that must be conducted underwater, the task load of the diver must be considered. Most often, one task or one combined task must be planned per dive. Trying to do too much often results in no data return at the end of the dive due to the diver's brain being task overloaded; furthermore, that may induce new risks. One may remember that diving CCR already generates numerous tasks by itself. For instance, during the initial descent, the CCR diver is busy monitoring the unit. When complex tasks may be undertaken, it is advisable to include in the dive team one extra diver whose responsibility is only managing the dive safety and who will strictly respect the dive plan and decompression procedure.

CCR Scientific diver at deco: photo Michel Lafontaine

Advice on general planning for a CCR based scientific diving expedition/ Element of risk analysis and structure of the work method statement document.

Besides the basic information required for the organisation of a scientific diving expedition[2], we highlight items specific to planned use of CCR by a group of occupational scientific divers.
Gas planning regarding the scientific objective of the expedition is paramount.
Moreover, for CCR-based scientific diving expeditions, experienced personnel with good CCR diving experience are needed. The selection of divers is a critical task for the expedition leader.

The complete team must have dived, preferably together, for a minimum number of dives asked by the dive leader, preferably before the expedition starts (knowing the equipment and procedures used during the expedition).

To reduce loss of dive time due to equipment failure, sufficient planning for and procurement of spares should consider the possible variety of breathing apparatus used during the expedition.

[2] Not the purpose of this document

Strategies to reduce risk during the scientific diving expedition are part of every project's general and specific risk analysis planning, including the scientific diving activities to be undertaken. Again, this document is intended to address only specific points of attention regarding CCR diving aspects.

CCR diver exploring a deep wreck using DPV. Photo Alain Norro

-Work Method Statement document

For every work planned underwater like expedition or local underwater work, a general document presenting all aspects of the planned work need to be provided by the scientific diving work leader to the administration in charge of authorizing the work. That could be National authorities, Health and safety department of scientific institution, concessioner of energy production zones, etc…
This general document must include the following chapters.

- Executive summary
- Task list: a description of *all* the tasks you plan to conduct during the project, the equipment you will use, and how it will be employed…
- Scientific diving procedure: this part explains the selection of your team, which procedures you apply for the scientific dives, …
- The operational risk management (ORM). ORM is a decision-making tool that helps to systematically identify risks and benefits and determines the best courses of action in any situation. Like other safety risk management processes, the risk management process is designed to minimise risks, reduce mishaps, preserve assets,

and safeguard health and welfare. The whole approach is pre-emptive rather than reactive. It identifies risk mitigation measures you take to reduce any identified risk.

- The specific procedures you apply in special conditions, if any, and the safety equipment consideration.

- The Emergency plan

-Among others *not ranked but specific to CCR diving, all those aspects must be discussed inside the work method statement document.*

- Certification of the diver, national/international recognition of certification as well as local rules considering CCR diving.
  This includes verification of medical clearance/ insurance in respect to national, international and local law/rules/considerations for the use of CCR

- Authorisation to dive on the given site cultural/natural heritage, including sample collection authorization, etc…

- Gas filling: Specific consideration when diving CCR is the use of a gas booster. Specific training is required for the operator, and increased fire risk must be considered, and other strategies developed to mitigate the risk.

- Availability of gases. When using a CCR, smaller quantities of gases are used than for an equivalent expedition using OC Scuba. Nevertheless, gases of suitable quality must be available, their quantity carefully planned, and quality assessed. It is good to verify prior to arrival on site the type of valves or cylinders sizes and pressure available/ordered.

- Wrong gas situation (diluent and/or bailout) for the planned dive. Here, it is advised to have a double verification strategy, including at least a gas verification made by the diver himself before assembling the CCR bailout.

- A bailout plan must be discussed and assessed before any dive. Having to bail out in the worst-case scenario during the dive (end of the bottom time) must be planned for. A realistic RMV of the concerned diver must be taken into account. Every team diver must assess dive team bailout or 'solo' bailout strategy before any dive starts. If team bailout is used, the worst-case RMV must be considered for the entire concerned group.

- Failure of equipment: failure of any system of the CCR is unacceptable before the dive. In case of failure before the dive, back up equipment must be used or the dive must be cancelled. If the dive team is reduced in numbers the Bailout strategy must be reviewed, particularly when the bailout plan was for “team bailout”.

- In case of failure underwater, the dive must be terminated quickly according to the foreseen plan and/or according to the 'what if' situation planning.

- ‘What-if’ planning. Series of questions to reply about any exception that may occur before, during and after the dive.

- CCR equipment consideration in the group

- Use of DPV

- Vessels/speedboat/surface support/platform used including CCR support like bailout gases, agreed signal with SMB (colors, sign/etc…), communication, ROV, etc…

- Getting lost underwater may increase due to the absence of bubble and risk analysis must provide strategy(ies) to mitigate that risk.

- Identification of "high risk" situations for scientific diving using CCR and the strategies applied to mitigate the level of risk. e.g. deployment of a heavy or cumbersome instrument (risk of breathlessness) or working in areas with strong currents must be addressed in the specific risk analysis.

- Evacuation of injured diver/team must be planned according to local/national/international standards.

- …
- TO BE CONTINUED

CCR scientific diver at work: photo provided by Régis Hocdé

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Terminology

CCR : Closed Circuit Rebreather

ESDP: European Scientific Diving Panel, under the umbrella of Mars

MARS: The European Network of Marine Stations

MCE: Mesophotic zone

MMI: man-machine interface

RBINS: Royal Belgian Institute of Natural Sciences, 29 rue Vautier, B-1000 Brussels

RMV: Respiratory minute volume

…/…

Annexe 1

Composition of the ESDP working group on occupational scientific diving using CCR (First edition)

Sweden
Dr Brandon Foley Lund Univeristy, Sweden

France
Ing. Régis Hocdé is research engineer working in the 'MARine Biodiversity, Exploitation and Conservation' research unit (MARBEC Univ Montpellier, CNRS, Ifremer, IRD, Montpellier, France). His expertise lies in marine biodiversity, observatory systems and data science. He is currently involved as PI or co-PI in different international programs. He is also a scientific diver and a deep diver expert with a closed-circuit-rebreather. For scientific diving, he is a national expert for his institute (IRD - French National Research Institute for Sustainable Development) and French authorities (Ministry of Research/MESRI, Ministry of Labour/DGT). He is the secretary of the French National Scientific Diving Committee (CNPS). He also teaches diving and scientific diving methods.

United Kingdom
Martin Parker is a diving equipment manufacturer specializing in CCR. A diver since 1974, a technical diver since 1993, and the first diver to use the Inspiration CCR on Trimix (1996). He has been a member of BSI and CEN creating European standards for diving equipment for 30 years and is currently part of the ISO Committee creating rebreather training standards.

Finland
Dr Juha Flinkman is a marine scientist and a scientific diver currently working at Finnish Environment Institute (SYKE), Marine Research Center. He was involved in the development of the ESC standards and the Finnish national scientific diving system. Flinkman has been diving since 1982, and a IANTD technical diver OC Full Trimix since 1997, and JJ-CCR Full Trimix since 2015. Flinkman has undertaken historic wreck research for over 30 years with his team Badewanne (www.badewanne.fi). Participated on the first edition of the document.

Italy
Dr Lorenzo Bramanti is a marine ecologist working as a senior researcher at CNRS (France) on conservation, ecology and restoration of Mediterranean and tropical corals. He practices scientific diving since his master Thesis at University of Pisa (Italy) in 1997 working at on the Mediterranean red coral (*Corallium rubrum*). Lorenzo Bramanti is certified in Italy as Advanced European Scientific Diving since 2006. He started diving with CCR in 2010. Since 2020 he is class IIIB professional French diver.

Belgium
Dr Alain Norro, the working group organiser, is a physicist at the Natural Sciences Institute in Brussels who works in oceanography, underwater acoustics, and mathematical modelling. He is also in charge of the sector of scientific diving in Belgium (managing & training

responsible) and is a founding member of the ESDP; he has been diving from 1975 and is an occupational diver using and teaching the CCR diving technique (all levels) for more than 17 years, including its use in the occupational scientific diving sector in Belgium

Valerie Woit, AESD from Belgium (ABSD), CCR diver, diving instructor trainer and instructor for scientific diving methods (revised 2024 edition)

Meetings composition

At the first meeting of the 16th September 2020 were present Régis Hocdé(FR), Juha Flinkman(FI), Lorenzo Bramanti (IT), Brandon Foley (SE) Martin Parker (UK) and Alain Norro (BE)
At the second meeting of the 17th December 2020 were present Juha Flikmann(FI), Lorenzo Bramanti (IT), Brandon Foley (SE) Martin Parker (UK) and Alain Norro (BE)
Apologies: Régis Hocdé(FR)

Updated edition, prepared in April 2024 by Alain Norro and Valerie Woit and reviewed by Brandon Foyley

Annex 2

Situation of using CCR for occupational scientific diving in Europe (first edition)

Finland: Finland: No law exists in Finland that may restrict the use of CCR for scientific diving. In addition to national occupational scientific diving certification, the ESDP-recognised certifications ESD & AESD are used. National certification is compatible with AESD. There is no limitation to diving methodology or equipment. Surface supplied, mixed gas, CCR, etc., can be utilised by a scientific diver, provided proper and recognised training and adequate experience have been received. Recognised training agencies may be professional or recreational, but they must be internationally recognised and accepted. Under development is an academy of scientific diving.

Sweden: OC and no deco were the base of scientific diving before technical diving emerged. In Sweden, ESD and AESD are recognised. The employer can propose any kind of diving equipment and will be responsible for permitting the use of, for instance, CCR at work.
However, any part of common legislation(rules) may help in the evolution of Sweden's rules.

Italy: Apparently, no one is using CCR at work for scientific activities in Italy; some, of course, use it aside from working activities but for research linked to their professional activities. More information should be gained from the Italian National Committee (Massimo Ponti)

United Kingdom: Some code of practice exists (L107,2014) and CCR can be used

Belgium: There is no limitation on the CCR use in Belgian rules/legislation. The use of CCR is encouraged in Belgium as soon as there is an advantage for the diver or the scientific purpose of the dive. CCR is used in Belgium inside that framework during training and operations

France: In France, legislations exist including CCR, for science and archaeology, recreational activities and other sectors. More and more research programs are dedicated today to the exploration of the mesophotic zone where the use of CCR take advantage on any other scuba diving technique and often over other exploration methods (ROV, AUV, dredges...). Since 2019, many academic scientists are currently training to be able to work in diving beyond 50 m and use CCR.