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Recreational diving services — Requirements for rebreather diver training — Decompression diving to 100 m

Services relatifs à la plongée de loisirs — Exigences concernant la formation des plongeurs à l'utilisation des recycleurs — Plongée avec décompression jusqu'à 100 m

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 228, *Tourism and related services*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 329, *Tourism services*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Rebreathers (i.e. breathing devices that recirculate some or all of the diver's exhaled breath and replenish any consumed oxygen to maintain a breathable mixture) are becoming much more widely available and popular among divers. The market for rebreather diving has been constantly growing in recent years and is now considered to be large enough that the need for standards for training organizations on minimum training requirements is evident. Rebreathers allow divers to dive for longer and to greater depths. Such depths can go beyond 30 m and can therefore require mandatory decompression stops. If rebreathers are used improperly, they can be hazardous; divers have had fatal accidents due to incorrect use of these devices. It is therefore important to specify training for diving with such devices.

Training organizations offering training that conforms with this document may exceed any of the requirements in terms of the volume or complexity of training but should at least ensure the students master all the skills and knowledge defined in this document.

Recreational diving services — Requirements for rebreather diver training — Decompression diving to 100 m

1 Scope

This document specifies requirements for rebreather diver training programmes which provide the competencies required to perform dives to 100 m with a rebreather using a breathing mixture containing helium and requiring mandatory decompression stops.

This document specifies evaluation criteria for these competencies.

This document specifies the requirements under which training is provided, in addition to the general requirements for recreational diving service provision in accordance with ISO 24803.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 24801-3, *Recreational diving services — Requirements for the training of recreational scuba divers — Part 3: Level 3 — Dive leader*

ISO 24802-2, *Recreational diving services — Requirements for the training of scuba instructors — Part 2: Level 2*

ISO 24803, *Recreational diving services — Requirements for recreational diving providers*

ISO 24806, *Recreational diving services — Requirements for rebreather diver training — Decompression diving to 60 m*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
rebreather
apparatus that has a supply of gas carried by the diver, allowing the diver to breathe under water which enables the diver to inspire gas from a facepiece connected to a counterlung and to pass exhaled gas through a carbon dioxide absorption material before it is re-breathed from the counterlung and inspired partial pressure of the gases within the apparatus remain within acceptable physiological limits so that gas is thus recirculated within the apparatus

Note 1 to entry: A rebreather can also be called a self-contained rebreathing apparatus.

Note 2 to entry: A facepiece can be a mouthpiece assembly, a half mask, a full-face mask or a helmet.

[SOURCE: EN 14143:2013, 3.1, modified — Note 1 to entry modified and Note 2 to entry added. This content has been reproduced with the permission of CEN. Copyright remains with CEN.]

3.2
rebreather type
primary rebreather design

EXAMPLE Closed-circuit rebreather (CCR), manually controlled closed-circuit rebreather (mCCR), electronically controlled closed-circuit rebreather (eCCR), semiclosed-circuit rebreather (SCR), manually controlled SCR (mSCR), electronically controlled SCR (eSCR), hybrid closed-circuit rebreather (hCCR).

3.3
rebreather unit
type of *rebreather* (3.1) having consistent controls, displays and configuration over several *rebreather models* (3.4), where the operation is essentially the same from rebreather model to rebreather model

3.4
rebreather model
specific individual design of *rebreather* (3.1) made by a manufacturer

3.5
breathing gas
gas present in the *breathing loop* (3.11) inspired by the diver

3.6
supply gas
gas present in a cylinder which can be added to the *breathing loop* (3.11)

3.7
bailout gas
gas present in a cylinder that can be breathed directly by the diver

3.8
PO_2
partial pressure of oxygen in a gas mixture

Note 1 to entry: This usually refers specifically to the breathing-gas mixture inhaled by a diver.

3.9
set-point
PO_2 set-point
PO_2 value that is used by a control system to determine when a solenoid valve injects oxygen into the *breathing loop* (3.11)

3.10
respiratory minute volume
RMV
product of the tidal volume and breathing frequency measured in litres per minute

[SOURCE: EN 14143:2013, 3.10]

3.11
breathing loop
portion of a *rebreather* (3.1) through which gas circulates, usually consisting of a mouthpiece, breathing hose(s), counterlung(s), non-return valves and a CO_2 absorbent canister

3.12
scrubber
canister in the *breathing loop* (3.11) containing CO_2 absorbent

3.13
confined water
swimming pool with a depth appropriate to the activity or body of water, offering similar conditions with regard to visibility, depth, water movement and access

[SOURCE: ISO 24801-2:2014, 3.5]

3.14
open water
body of water significantly larger than a swimming pool, offering conditions typical of a natural body of water

[SOURCE: ISO 24801-2:2014, 3.6]

3.15
limited open water
open water (3.14) no deeper than 20 metres with no appreciable water movement and visibility that is sufficient to allow effective student supervision and skill development

3.16
service provider
entity (individual or organization), including any individual acting on behalf of such an entity, which offers one or more of the following services:

— introductory diving activities;

— snorkelling excursions;

— provision of training and education;

— organized and guided diving for qualified divers;

— rental of diving equipment.

[SOURCE: ISO 24803:2017, 3.1]

3.17
safety stop
non-mandatory *decompression stop* (3.18) near the surface prior to surfacing

3.18
decompression stop
mandatory stop during ascent from depth prior to surfacing

3.19
decompression diving
diving with mandatory *decompression stops* (3.18)

3.20
delayed surface marker buoy
DSMB
surface marker buoy that can be deployed by a diver from underwater

4 Competencies

The training programme shall ensure that students are qualified to independently plan and conduct dives requiring mandatory decompression stops using the specific rebreather unit for which the diver has received training.

Divers qualified in accordance with this document are competent to dive with a suitably qualified buddy to 100 m using a rebreather with a supply gas containing:

— a minimum of 5 % oxygen;

— sufficient helium to control narcosis and to ensure a breathing gas density of less than 6,3 g/l.

In order to be deemed qualified to dive with a specific rebreather unit other than the one that the diver has received training for, a diver will need further unit-specific training.

The training programme shall ensure that the student has a full understanding of any theoretical concepts or skills applicable to the rebreather type, rebreather unit and rebreather model they will use. Students shall be provided with an overview of any information that is not specific to their rebreather, but this only needs to be informative in nature so that they are aware of the general possible configurations that other divers could use.

Student crossover training programmes shall be carried out in accordance with Annex B.

NOTE Following qualification in accordance with this document, a diver can incrementally build experience and competence to eventually be capable of diving to depths beyond 100 m using proper risk management protocols.

5 Prerequisites for training

5.1 General

The service provider shall ensure that the student fulfils the following prerequisites to take part in the training course envisaged.

In order to participate in a training programme in accordance with this document, students shall be qualified in accordance with ISO 24806.

5.2 Minimum age

The minimum age to participate in a training programme in accordance with this document shall be 18 years.

5.3 Diving experience

Students shall have logged at least 100 dives with a minimum of 100 hours using a rebreather. At least 50 dives and 50 hours shall have been made with the same specific rebreather unit to be used in the course. Concerning these dives:

— a minimum of 30 rebreather dives shall have been made to a depth deeper than 30 m;

— at least 10 of these 30 dives shall have been made to a depth deeper than 50 m using a gas mix containing helium and requiring decompression stops; these dives shall have been completed after qualification as a 60 m rebreather diver in accordance with ISO 24806.

The student shall have dived with the rebreather unit within the 6 months prior to starting the course.

5.4 Health requirements

Documented evidence shall be obtained that the student has been medically screened as suitable for recreational diving by means of an appropriate questionnaire or medical examination.

NOTE See Reference [3] for an example of a medical questionnaire and accompanying guidance to physicians.

In case of doubt, the training service provider shall refer students to proper medical resources. If the student is not examined by a physician, the student shall be obliged to confirm by signature that he or

she has understood written information given by the instructor on diseases and physical conditions which can pose diving-related risks.

Students shall be advised of the importance of appropriate regular medical examinations.

6 Introductory information

Information in accordance with ISO 24803 shall be made available to the students prior to or during the first class or meeting.

In particular, the students shall be informed of the limits of their training and qualification as specified in accordance with Clause 4.

7 Theoretical knowledge

7.1 Knowledge review

The training programme shall ensure that knowledge in accordance with ISO 24806 is reviewed by assessing the students (e.g. by means of an exam or quiz) before teaching new knowledge. Where knowledge gaps are identified, remedial training shall be carried out.

7.2 Risk management

The training programme shall ensure that students have knowledge concerning the identification, potential consequences and management of the following risks, specifically related to decompression dives to 100 m:

— risks associated with each phase of the dive, from dive planning to exiting the water;

— risks associated with hypoxic gas mixtures;

— use of bailout valve when using hypoxic gas mixtures at shallow depths or at the surface;

— risks associated with carrying multiple gases in multiple cylinders;

— failure to follow decompression model ascent rates;

— no direct or immediate access to the surface in an emergency due to decompression requirements and/or distance;

— inadequate bailout options;

— hypoxia, hyperoxia and hypercapnia, leading to unresponsiveness and drowning due to switching to the wrong gas, improper gas choice, failing to properly analyse the gas or rebreather system problems;

— inert gas narcosis;

— omitted procedures and errors caused by extensive equipment task overloading, high physical exertion and/or psychological loading;

— taking untried equipment and/or configurations on a deep dive without prior testing and familiarisation in shallow water;

— overweighting or loss of buoyancy;

— dive team members not adequately prepared or proficient;

— dive plan incomplete and without sufficient contingencies;

— inadequate surface support for the planned dive;

— loss of critical gases (breathing loop and supply gases);

— separation from dive team;

— separation of the dive team from surface support;

— remote dive site.

The training programme shall ensure that students have knowledge concerning the following means and measures to mitigate risks:

— dive team assessment and readiness;

— dive team proficiency;

— dive plan and roles;

— equipment preparation and testing;

— suitable surface support personnel, procedures and equipment;

— emergency evacuation plan.

7.3 Team diving

The training programme shall ensure that students have knowledge concerning the following potential risks of diving:

— in mixed teams using different rebreathers;

— in mixed teams using different breathing gases and/or equipment configurations;

— in mixed teams of open-circuit and rebreather divers;

— when team members use different dive and emergency procedures.

The training programme shall ensure that students have the following knowledge concerning diving in teams:

— team member selection, including considerations of physical and mental fitness;

— awareness of factors that can impact divers' ability to perform under stress;

— causes of stress (e.g. time pressure, peer pressure, task loading);

— the importance of having a non-judgmental team culture and a willingness to identify problems without fear or recrimination;

— team protocols and objectives;

— selection of gradient factors or decompression models;

— task assignments between team members;

— team gas analysing and cylinder-marking protocols;

— surface support and support divers;

— communication procedures between team members, surface support and support divers.

7.4 Project dives with specific objectives

Rebreather dives as deep as 100 m are complex operations and can involve situations in which a group of divers are diving with a particular purpose, especially exploration, that involves substantially more complex logistical and dive planning considerations than typical recreational dives. Rebreather divers at this level need the knowledge necessary to take part in such dives and function properly as part of a team.

NOTE This kind of diving can also be known as expedition diving.

The training programme shall ensure that students have the following knowledge concerning project dives:

— advantages and disadvantages of having standardised gases and decompression protocols;

— selection and duties of safety divers;

— surface support and logistics;

— decompression stations (e.g. trapeze, hang bars or habitats);

— ascent lines, descent lines;

— diver accounting procedures (e.g. by use of tags);

— emergency protocols.

7.5 Function of rebreather components

The training programme shall ensure that students have knowledge concerning the function of the following components of a rebreather, with emphasis on the specific features of the rebreather unit they will use during their training, specifically relating to decompression dives to 100 m:

— scrubber material suitability for deep diving and why it must be selected in accordance with the rebreather manufacturer's specifications, as scrubber performance becomes much more critical as depth approaches 100 m;

— the need to use a freshly filled scrubber canister for more extreme dives (e.g. dives approaching 100 m in depth or of extended duration);

— gas supplies (including, where applicable, oxygen, diluent or other supply gases);

— gas addition valves [including, where applicable, manual, automatic diluent valve (ADV) or other automatic gas addition];

— mouthpiece, dive surface valve (DSV);

— bailout valve (BOV);

— displays [including, where applicable, handsets, head-up display (HUD) or other];

— control modules;

— alarm and warning systems;

— firmware, software, including updates and downloads of dive profiles;

— suitability of regulator(s);

— access to gas cylinder valves;

— cylinder pressure indicators;

— PO_2 monitoring systems;

— CO_2 and helium monitoring systems.

7.6 Breathing performance using a rebreather

The training programme shall ensure that students have knowledge concerning the following factors affecting breathing performance using a rebreather, specifically relating to decompression dives to 100 m:

— choice of gases (see also Annex A), maximum and minimum depth of gases and advantages of helium;

— gas density (see also Annex A);

NOTE Limiting gas density will ensure that narcotic effects of breathing gas, often expressed as equivalent narcotic depth (END), remain within acceptable limits.

— ventilation rate and ventilation volume of the diver;

— rebreather design (e.g. rebreather type, rebreather unit, rebreather model), including the advantages and limitations of different types of rebreathers, in particular their gas control systems, with particular attention to the limitations of the rebreather used on the course.

7.7 Rebreather assembly and checks

The training programme shall ensure that students have knowledge concerning the following aspects of rebreather assembly and checks (as applicable to the specific rebreather unit used for training), specifically relating to decompression dives to 100 m:

— use of unit checklist(s);

— battery power;

— oxygen sensors (e.g. age, integrity and calibration);

— helium sensors, CO_2 monitoring systems;

— control systems and backup computer setup and function;

— PO_2 monitoring and control;

— set-point selection;

— set-point switch depths;

— set-point switch method (manual or automatic);

— on-board and off-board gases programmed into the control system;

— decompression conservatism settings (e.g. gradient factors) programmed into the control system;

— scrubber canister duration, proper preparation for diving, including filling and seals;

— mouthpiece valve operation, bite integrity and security, e.g. mouthpiece retaining strap (MRS);

— gas supplies (composition and pressure of all gases);

— gas connections and feeds to the system;

— bailout system, including multiple off-board cylinders;

— breathing loop integrity, including positive and negative pressure tests;

— displays and warning systems;

— buoyancy compensator fit, function and adequate lift capacity;

— harness assembly and adjustment with regard to additional off-board cylinders.

7.8 Gas supply duration

The training programme shall ensure that students have knowledge concerning the following factors affecting the gas supply duration, specifically relating to decompression dives to 100 m:

— frequent activation of gas addition valves;

— mask clearing;

— flushing the breathing loop;

— frequent changes in depth;

— inflating a drysuit and buoyancy compensation device (BCD) (if fed from the rebreather gas supply);

— the effects of system gas leaks.

7.9 CO_2 absorbent duration

The training programme shall ensure that students are knowledgeable about the importance of using the scrubber in accordance with manufacturer's instructions and factors that could adversely affect canister duration, such as:

— cold water temperatures;

— water ingress;

— depth and gas density;

— work rate;

— absorbent material and grain size.

7.10 Rebreather pre-water entry checks

The training programme shall ensure that students have knowledge concerning the following aspects of rebreather pre-water entry checks:

— use of manufacturer's rebreather unit checklist(s);

— recalibration of the rebreather unit (if required);

— gas supplies pressurized and on or off as appropriate;

— bailout and off-board cylinder access and operation;

— inflation and deflation systems access and operation (e.g. gas addition valves, BCD; dry suit, counterlung over pressure valve);

— electronics on;

— confirming inspired oxygen level (e.g. PO_2 or FO_2);

— pre-breathing the rebreather.

7.11 Advanced decompression dive planning

The training programme shall ensure that students have appropriate knowledge concerning the planning of dives using a rebreather, specifically relating to decompression dives to 100 m, including:

— operational planning, including contingency planning;

— supply gas selection, taking into account the addition of helium to the breathing gas, gas density, PO_2, narcotic effects;

— managing oxygen toxicity, including central nervous system (CNS) toxicity and oxygen toxicity units (OTU);

— absorbent canister duration;

— decompression planning, including knowledge of different decompression models and how to add conservatism (e.g. gradient factors);

— gas management, including gas consumption;

— safe use of dive planning tools (e.g. rebreather internal software or separate software) and risks associated with changing parameters;

— bailout considerations, including added decompression obligations, bailout gas selection and quantity of gases required to ensure bailout for the individual diver.

7.12 Dive conduct

The training programme shall ensure that students have an appropriate knowledge concerning the conduct of dives using a rebreather, specifically relating to decompression dives to 100 m, including:

— how to analyse and label cylinders, particularly with regard to clarity of oxygen percentage and depth range;

— how to manage at least three off-board gas cylinders (e.g. placement, trim, attachment);

— whether cylinders are carried with open or closed valves;

— options for preventing use of high-oxygen mixtures below their safe breathing depth;

— water entries using multiple off-board cylinders;

— safety precautions to be considered during surface swims with a rebreather and multiple off-board cylinders, including concerns regarding breathing gases with low oxygen levels;

— safety drills, bubble checks and descent procedures with a rebreather and multiple off-board cylinders;

— advantages and disadvantages of various in-water techniques for checking oxygen sensor linearity, including current limiting;

— ADV and/or manual addition valve (MAV) options for gas addition during descent and the dive;

— monitoring and controlling inspired oxygen levels (e.g. options for automatic or manual set-point changes);

— ascents and exits with a rebreather using multiple off-board cylinders;

— considerations concerning open-circuit gas supply mix connected to bailout out valves (BOVs);

— gas supply switching techniques, including the use of alternative bailout options, accessing gas from another diver;

— flushing of counterlungs;

— switching plug-in diluent during emergency use of rebreather in semi-closed mode;

— weight, buoyancy and trim when diving with a rebreather using multiple off-board cylinders;

— considerations concerning loss of primary buoyancy control device;

— need for redundant equipment, e.g. mask, delayed surface marker buoy (DSMB), cutting device, light, dive computer;

— maximum and minimum operating depth of different supply gas mixtures;

— effective gas switching during an open circuit bailout ascent;

— how to help an unresponsive rebreather diver at the surface and underwater, taking into account additional equipment and possible decompression obligations.

7.13 Identifying and reacting to potential issues

The training programme shall ensure that students have knowledge concerning the cause, anticipation and prevention of the following potential issues that could arise while diving with a rebreather so that they can recognize and properly react to these issues, with emphasis on the specific features of the rebreather unit students will use during their training:

— loss of supply gas;

— loss of breathing gas;

— loss of mouthpiece;

— battery depletion;

— failure of oxygen sensors;

— identifying incorrect PO_2 display (e.g. PO_2 display not reflecting gas or depth changes);

— failure of gas injection systems (e.g. oxygen solenoid, ADV or supply gas system);

— awareness of normal and abnormal sounds made by the rebreather (e.g. mouthpiece valves, gas addition, solenoid and water ingress);

— water in the breathing loop;

— caustic cocktail;

— loss of means to control buoyancy;

— subtle indicators of rebreather malfunctions (e.g. increasing buoyancy can indicate gas leakage into the loop, signs of unusual solenoid activity, changes to breathing rates).

The training programme shall ensure that students have knowledge concerning the following potential CO_2 issues with the rebreather and how to prevent or respond to them:

— scrubber malfunction or exhaustion;

— non-return valve failure;

— failure of CO_2 monitoring systems;

— unit assembly errors.

The training programme shall ensure that students have knowledge concerning the advantages and disadvantages of the following possible actions to be taken in the case of a rebreather issue where the diver is still able to breathe from the breathing loop:

— manual operation of an electronically controlled rebreather;

— manual operation in semi-closed mode;

— operation as an oxygen rebreather at a depth of 6 m or less.

The training programme shall ensure that students have knowledge concerning the advantages and disadvantages of the following possible actions to be taken in the case of a rebreather issue where the diver is no longer able to breathe from the breathing loop:

— switching to an open circuit bailout breathing gas supply;

— ascending to the surface following bailout decompression requirements;

— controlling buoyancy during ascent while breathing from a bailout source.

7.14 Hypercapnia, hypoxia and hyperoxia

The training programme shall ensure that students have knowledge of hypercapnia, hypoxia and hyperoxia, with particular regard to which of these become more likely during dives deeper than 60 m.

The training programme shall ensure that students have knowledge of:

— definitions;

— causes;

— signs;

— symptoms;

— associated rebreather warnings;

— actions to take if any of the above occur.

7.15 Buddy and team diving procedures

The training programme shall ensure that students are aware of the importance of following buddy-pair and team-diving procedures when diving with rebreathers. Considerations to be included are:

— agreeing on the purpose or mission of the dive;

— use of pre-dive check lists;

— pre-dive buddy checks monitoring the buddy during their pre-breathe;

— mutually verifying dive plan procedures throughout the dive (e.g. when switching gases or changing set-points);

— planning dives so that each diver can respond to emergencies independently, but so that buddies and/or team members stay in close proximity and are able to provide support if necessary;

— diving the same set-points and following the same plan in a team;

— being aware that any diver can bail out or end the dive at any time for any reason;

— always staying together as a buddy pair and/or in a team from entry to exit, in particular if a diver needs to abort the dive;

— asking for assistance from a buddy or a team member in case of an emergency, including bailout gas considerations.

7.16 Rebreather maintenance

The training programme shall ensure that students have knowledge concerning the necessity to clean and disinfect a rebreather and how and when to do so.

The training programme shall ensure that students have knowledge concerning the following consumables used in a rebreather and when and how to replace them:

— oxygen sensors;

— CO_2 absorbent;

— batteries;

— gas, including analysing and labelling.

The training programme shall ensure that students have knowledge concerning the importance of:

— staying up to date with user manual updates;

— performing required rebreather software updates;

— complying with the manufacturer's maintenance requirements;

— recognizing the risk associated with handling and contamination of oxygen systems.

7.17 Maintaining knowledge and skills

The training programme shall ensure that students are aware of the importance of:

— maintaining a high level of rebreather diving knowledge;

— regularly practicing routine and emergency skills, including rebreather unit-specific procedures.

8 Practical skills

8.1 Skills review

The training programme shall ensure that skills in accordance with ISO 24806 are reviewed by assessing the students (e.g. by means of performing skills on the initial dive) before teaching new skills. Where skills need improvement, remedial training shall be carried out.

8.2 General

New skills and skills being reviewed (in accordance with 8.1) shall be introduced or practised in limited open water.

All of the skills in accordance with 8.3 to 8.7 shall be completed unless the rebreather being used by the student does not include the specific features to allow the student to demonstrate a particular skill.

The programme shall ensure that students are aware of the importance of regular skill repetition to avoid skill-fade after qualification.

Multiple repetitions lead to muscle memory, which is beneficial in carrying out skills under stress. Hence, skills should be rehearsed frequently during and after the training course so that they become second nature.

8.3 Pre-dive procedures

The training programme shall ensure that students are able to demonstrate the following skills:

— planning time and depth for the dive, taking into account the limitations of gas supply and scrubber duration based on the rebreather manufacturer's specifications, the environment, decompression procedures, oxygen exposure, previous dives and other factors that could apply;

— confirming pressure and gas composition and that they are labelled correctly for all cylinders;

— assembling and setting-up the rebreather in accordance with the manufacturer's instructions (e.g. using the specified absorbent material and oxygen sensors) using a checklist (manual or digital), taking into account the aspects in accordance with 7.7;

— performing a complete rebreather pre-dive check in accordance with manufacturer's instructions using a checklist (manual or digital), taking into account the aspects in accordance with 7.10;

— donning and adjusting the rebreather and the bailout system for proper fit, including breathing hoses, mouthpiece, mouthpiece retaining strap (where fitted) and counterlung placement;

— performing a buddy check (see 7.15);

— ensuring proper weighting and trim-weight placement;

— pre-breathing in accordance with manufacturer's instructions.

8.4 Dive conduct

The training programme shall ensure that students are able to demonstrate the following skills:

— entering the water using a technique appropriate for the environment;

— establishing proper in-water weighting, buoyancy and trim;

— performing a bubble check and display checks (including cylinder pressure);

— demonstrating good awareness of the buddy or team members throughout the dive by means of communications, proximity and team-oriented dive practices;

— demonstrating awareness of system status by monitoring the rebreather's displays and gauges frequently throughout the dive, with particular emphasis on PO_2;

— demonstrating proper response to PO_2 deviation;

— monitoring of the remaining time of CO_2 absorbent;

— following procedures for retaining breathing loop integrity;

— removing and replacing mask or fitting back-up mask while maintaining neutral buoyancy;

— performing a controlled descent to the planned depth with a buddy and/or team members;

— demonstrating correct use of oxygen control selections and features of the control system;

— changing to appropriate set-point if not initiated automatically;

— if set-point changes are initiated automatically, confirming the set-point changes;

— checking oxygen sensors are not current-limited (linearity check) if not initiated automatically;

— demonstrating proper operation of mouthpiece closure mechanism;

— removing water from the breathing hoses;

— maintaining optimum breathing loop volume;

— maintaining neutral buoyancy when swimming in a horizontal position at a given depth;

— demonstrating buoyancy control by remaining at a given depth, ± 1 m, for at least 90 s, with minimum use of fins or arms;

— managing depth changes;

— switching rebreather gas supply to and from an off-board cylinder;

— performing manual gas addition (e.g. oxygen, diluent or other supply gas);

— performing a gas flush;

— removing and replacing an off-board cylinder while underwater;

— conducting decompression stops at multiple stop depths;

— deploying a DSMB;

— making a controlled ascent maintaining buddy and/or team member contact and ascending at the correct rate;

— at the surface, establishing positive buoyancy with the BCD, then closing the rebreather mouthpiece before removal;

— while carrying multiple stage cylinders unsupported at the surface, demonstrating oral inflation of the BCD.

8.5 Emergency situations

The training programme shall ensure that students are able to anticipate and recognize the rebreather issues listed in 7.13 and 7.14 and react to these situations by demonstrating the following skills:

— responding to a simulated rebreather emergency by performing a bailout ascent to the surface at a controlled rate accompanied by a buddy and/or team members and performing decompression stops switching bailout gases as appropriate;

— on signal of a simulated emergency, breathing from an open-circuit bailout gas provided by a buddy and/or team member and repeating as both donor and receiver;

— on signal of a simulated emergency, bailing out to an open-circuit source then returning to the breathing loop after the exercise following proper procedures;

— switching rebreather gas supply to an off-board cylinder and manually adding gas (e.g. oxygen, diluent);

— demonstrating manual control of the rebreather.

8.6 Response to rebreather malfunctions

The training programme shall ensure that students are able to demonstrate the appropriate responses to the following potential rebreather malfunctions (if applicable to the specific rebreather):

— hypoxia;

— hyperoxia;

— hypercapnia;

— oxygen sensor malfunctions;

— rebreather electronics malfunctions;

— rebreather solenoid malfunctions;

— loss of diluent;

— loss of oxygen;

— loss of any other supply gas;

— flooded breathing loop;

— loss of buoyancy;

— other rebreather warnings or alarms as applicable.

8.7 Post-dive procedures

The training programme shall ensure that students are able to demonstrate the following skills:

— removing at the surface any off-board bailout cylinders used;

— exiting the water using a technique appropriate for the environment;

— demonstrating appropriate post-dive care and disassembly of the rebreather, in accordance with manufacturer's instructions.

9 Instructors

Instructors shall be qualified in accordance with ISO 24802-2 and shall have been trained and assessed as a unit-specific rebreather instructor.

The instructor shall regularly practice using the specific rebreather unit and have current experience of the rebreather being used. In order to instruct a training programme in accordance with this standard, the instructor shall be qualified as a unit-specific 100 m rebreather instructor.

10 Training equipment and materials

10.1 Training equipment

On training dives, both the instructor and the student shall be equipped with at least the following:

— a rebreather that is in good working order that allows open-circuit bailout and decompression diving and is configured and used in accordance with the manufacturer's instructions;

— at least three off-board bailout cylinders, each with an open-circuit regulator fitted with a hose of sufficient length for sharing gas to which they can switch or share gas with another diver, with all off-board bailout cylinders being capable of supplying the breathing loop;

— an open-circuit bailout system which is separate from and not required for the normal operation of the rebreather and which is suitable for a safe return to the surface from the planned maximum depth, including all safety stops and decompression stops in the event of an emergency;

— a means of generating and providing an appropriate open-circuit bailout profile backup and means of determining depth and duration in the event of a system failure, such as a backup computer;

— an appropriate gas analyser(s).

NOTE The use of a DSMB, a cutting device and spool or reel can be appropriate or required in certain diving environments.

Bailout gas independent of the rebreather supply gases shall be selected so that the student can carry the simplest viable equipment configuration for the dive while providing a reasonable level of safety in case of an open-circuit bailout.

The breathing rate for bailout shall be calculated with a minimum respiratory minute volume (RMV) of 50 l/min for the bailout from maximum depth to completion of the first stop, then 25 l/min for all remaining decompression stops.

On training dives, the students and the instructor shall use the same rebreather type but may use different rebreather units, provided the instructor is qualified as a 100 m rebreather instructor for all rebreather units in use during the dive. Up to three different rebreather units may be used in a given training dive.

Instructors and students shall have a system of logging all the training dives with the following minimum information: depth, dive time, date of dive, gases used.

10.2 Training materials

The training programme shall ensure that students and instructors have at least the following materials available:

— the manufacturer's user manual (including updates) specific for the rebreather type, rebreather unit and rebreather model and associated electronics being used during training;

— specific student training materials;

— specific instructor training materials;

— rebreather-specific checklist(s) for the assembly and operation of the rebreather (rebreathers equipped with a built-in electronic checklist meet this requirement);

— if applicable, a manufacturer's record of training, to be completed by the instructor and the student.

11 Practical training parameters

11.1 Training dives or in-water sessions

The initial in-water training session shall take place in confined water or limited open water.

Initial open-water dives shall include planned simulated decompression stops and then progress to mandatory decompression stops. Students shall only progress to open-water dives including mandatory decompression stops after satisfactorily demonstrating competency of the required techniques to the instructor during simulated decompression dives.

Open-water dives shall be planned to have no more than 180 min of mandatory decompression stops on a single dive. The maximum depth for open-water dives shall be 100 m using a rebreather that supplies a breathing mixture containing helium.

Confined water and limited open-water sessions shall not be conducted in an overhead environment.

Open-water dives may only be conducted in overhead environments provided that:

— the instructor has proof of qualification to dive and instruct rebreather diving in overhead environments to the planned maximum depth of the dive;

— all students have proof of qualification to dive with a rebreather in overhead environments.

There shall be no more than three in-water sessions per day and no more than two open-water dives per day if any of these open-water dives require mandatory decompression stops.

11.2 Instructor responsibilities

11.2.1 General

All in-water skills shall be taught, directly supervised and evaluated by an instructor, who shall be in the water during each session. The instructor shall be in direct control of students throughout all in-water sessions.

During training, in particular when simulating emergency situations, the instructor shall ensure that the student's breathing gas is monitored by both the instructor and the student and maintained within the limits needed to support life.

The instructor shall ensure that all open-water dives are logged by the student at the end of each diving day.

11.2.2 Instructor-to-student ratios for dives of 60 m or less

The maximum number of students that may be accompanied by a single instructor on open-water dives of 60 m or less is three.

A fourth student may be taken by an instructor as long as the open-water dives are not being conducted in an overhead environment and if the instructor is accompanied by a qualified rebreather dive leader in accordance with 11.3.

11.2.3 Instructor-to-student ratios for dives deeper than 60 m

The maximum number of students that may be accompanied by a single instructor on open-water dives deeper than 60 m is three. The instructor may also be accompanied by a qualified rebreather dive leader but shall not take more than three students.

11.3 Rebreather dive leaders

In order to act as a rebreather dive leader, a diver shall be qualified as a 100 m rebreather diver in accordance with this document on the rebreather unit being used by the students and a dive leader in accordance with ISO 24801-3.

The dive leader shall have logged a minimum of 25 dives beyond 60 m with the rebreather unit being used by the students since qualifying as a 100 m rebreather diver.

The rebreather dive leader may use a rebreather on any open-water dive or open-circuit scuba on dives not deeper than 60 m, if qualified to 60 m with open-circuit.

For open-water dives in overhead environments, the dive leader shall have proof of qualification to dive in overhead environments to the planned maximum depth of the dive.

11.4 Breathing gas limits

11.4.1 Closed-circuit rebreather

The following requirements for breathing gases shall apply:

— the maximum planned set-point PO_2 shall be 1,4 bar,[1)] with a maximum of 1,3 bar for the bottom phase of the dive;

— the minimum oxygen percentage of any supply or bailout gas shall be 5 %;

— the breathing mixture and bailout gases shall contain sufficient helium to control narcosis and to ensure a breathing gas density of less than 6,3 g/l;

1) 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.

— END shall be ≤ 30 m, based solely on nitrogen content;

— the maximum breathing loop PO_2 shall not exceed 1,4 bar, except at depths of 6 m or shallower;

— the inspired PO_2 of the open circuit bailout gas shall not exceed 1,6 bar;

— diluent gas shall not have a PO_2 higher than 1,1 bar at the maximum depth.

11.4.2 Semi-closed rebreather

The following requirements for breathing gases shall apply:

— the maximum planned breathing loop PO_2 shall be 1,4 bar;

— the minimum oxygen percentage of any supply or bail out gas shall be 5 %;

— the breathing mixture, the supply gas and bailout gases shall contain sufficient helium to control narcosis and to ensure a breathing gas density of less than 6,3 g/l;

— END shall be ≤ 30 m, based solely on nitrogen content;

— the inspired PO_2 of the open circuit bailout gas shall not exceed 1,6 bar;

— if any supply gas could be breathed directly by the student, it shall have a maximum PO_2 of 1,6 bar at the maximum depth of the dive.

12 Evaluation

12.1 Knowledge

The training programme shall ensure that, in order to be qualified, students demonstrate to an instructor knowledge of rebreather diving by taking and passing an oral or written examination as prescribed by a training organization. This examination shall test theoretical knowledge in accordance with Clause 7 and knowledge of skills in accordance with Clause 8.

12.2 Skill evaluation

The training programme shall ensure that, in order to be qualified, students demonstrate to an instructor the skills in accordance with Clause 8.

The training programme shall ensure that students complete at least six in-water sessions, totalling at least 360 min.

The training programme shall ensure that students complete:

— a minimum of one confined water or limited open-water session;

— a minimum of five open-water dives totalling at least 300 min underwater;

— one open-water dive to at least 75 m;

— one open-water dive to at least 85 m.

12.3 Proof of qualification

The proof of qualification shall show at least the following parameters:

— name of card holder;

— rebreather type (e.g. CCR or SCR);