

32. Helitrox Diluent Closed Circuit Rebreather Diver Decompression Procedures Course, Unit Specific

32.1 Introduction

This is the second entry level certification course for divers wishing to utilize a closed-circuit rebreather (CCR) for mixed gas diving using a Helitrox diluent. The objective of the course is to train divers in the benefits, hazards and proper procedures for diving a CCR and to develop basic CCR diving skills, to a maximum of 45 Metres/150 Feet, using an air/nitrox/helium diluent for formal decompression diving. Students are permitted to utilize a diluent and bailout mix with no greater than a 35% helium content (+/- 5%) and no less than a 20% oxygen content and are permitted to use up to 100% oxygen for decompression.

32.2 Qualifications of Graduates

Upon successful completion of this course, graduates may engage in decompression diving activities utilizing a CCR without direct supervision provided.

The diving activities approximate those of training:

1. The areas of activities approximate those of training.
2. Environmental conditions approximate those of training.
3. Upon successful completion of this course, graduates are qualified to enroll in:
4. TDI Mixed Gas CCR unit specific course.
5. TDI Advanced Wreck Course.

32.3 Who May Teach

An active TDI Instructor with a TDI Helitrox Diluent CCR Decompression Procedures Instructor rating for the specific unit being used.

32.4 Student to Instructor Ratio

Academic:

1. Unlimited, so long as adequate facility, supplies and time are provided to ensure comprehensive and complete training of subject matter.

Confined Water (swimming pool-like conditions):

1. A maximum of 3 students per active TDI Instructor is allowed one additional student may be added if they are doing a refresher or unit crossover.

Open Water (ocean, lake, quarry, spring, river, or estuary):

1. A maximum of 3 students per active TDI Instructor is allowed. One additional student may be added if they are doing a refresher or unit crossover.
2. The ratio should be reduced as required due to environmental or operational constraints.

32.5 Student Prerequisites

1. Minimum age 18.
2. Provide proof of 50 logged dives. If completing a unit crossover, provide proof of 10 logged CCR dives in the last 12 months.
3. Minimum certification level of TDI Advanced Nitrox Diver, Deco Procedures Diver or Helitrox diver or equivalent from agencies recognized by TDI.
4. Provide proof of at least 5 logged staged decompression dives to a minimum depth of 30 metres/100 feet.
5. If the rebreather is a TDI approved Sidemount rebreather, the student must hold the TDI Sidemount Diver certification or equivalent, provide proof of 10 logged Sidemount dives, and any additional requirements the Sidemount rebreather manufacturer may have.

OR

1. Minimum age 18.
2. TDI Air Diluent CCR Diver certified or equivalent.
3. Minimum of 30 hours and 30 dives on the specific CCR unit.
4. Six months CCR diving experience.

32.6 Course Structure and Duration

Confined Water Execution:

1. Minimum of 60 minutes confined water training to a maximum of 9 Metres/30 Feet

Open Water Execution:

1. Equipment configuration session and confined water session must be completed prior to open water training dives.
2. Minimum of 420 minutes open water training to be completed over a minimum of 7 dives with a gradual increase in depth each day to a maximum of 45 Metres/150 Feet.
3. No more than 3 in-water sessions per day and no more than 2 dives requiring mandatory decompression per day.
4. Maximum decompression obligation of 10 minutes (while breathing from the CCR) on a single dive.

Course Structure:

1. TDI allows instructors to structure courses according to the number of students participating and their skill level.
2. The final exam may be given orally if not available in a language the student understands.

Duration:

1. Minimum of 6 hours academic development and 2 hours equipment maintenance workshop.
2. The duration of the entire course must be spread over a minimum of 5 days Crossover.

Crossover:

1. If a student has already qualified as a TDI Helitrox Diluent CCR Deco Procedures Diver or equivalent wishes to qualify on another CCR recognized by TDI, the student must follow all unit specific course standards and meet all skill performance requirements. The only changes during the unit crossover are:
 - a. Minimum of 60 minutes confined water training to a maximum of 9 Metres/30 Feet.
 - b. Minimum of 240 minutes open water training to be completed over a minimum of 4 dives to a maximum of 45 Metres/150 Feet with two dives deeper than 35 Metres/115 Feet. All open water dives to be conducted using helitrox as a diluent.
2. If a student already is qualified as a TDI Kiss Spirit Helitrox decompression diver or equivalent and is crossing over to the Sidewinder, the student must:
 - a. Complete an academic session covering unit build, hose routing, donning, and doffing.
 - b. A minimum of 180 minutes open water training over a minimum of 3 dives.

Upgrades:

1. If a student has the TDI Air Diluent, or equivalent, certification and wishes to do the Helitrox decompression part of this course:
 - a. Only 240 minutes of open water are required.
 - b. Students will complete a skills evaluation dive plus a minimum of 4 open water dives with two dives deeper than 35 Metres/115 Feet.
 - c. The student needs to have a minimum of 30 logged hours over 30 dives before enrolment on the Helitrox deco course.
 - d. Six months CCR diving experience.
2. If a student has the TDI Air Diluent Decompression certification and wishes to do the Helitrox decompression part of this course:
 - a. Only 120 minutes of open water are required over a minimum of two dives using helitrox as a diluent, with both dives deeper than 35 Metres/115 Feet.

32.7 Administrative Requirements

Administrative Tasks:

1. Collect the course fees from all the students.
2. Ensure that the students have the required equipment.
3. Communicate the schedule to the students.
4. Have the students complete the:
 - a. *TDI Liability Release and Express Assumption of Risk Form.*
 - b. *TDI Medical Statement Form.*

Upon successful completion of the course the instructor must:

1. Download and retain student's dive logs of all training dives.
2. Issue the appropriate TDI certification by submitting the *TDI Diver Registration Form* to TDI Headquarters or registering the students online through member's area of the TDI website.

32.8 Training Materials

Required Materials

1. *TDI Diving Rebreathers Student Manual and Knowledge Quest or eLearning.*
2. *TDI Diving Rebreathers PowerPoint presentation.*
3. Manufacturer's manual and updates.

4. Manufacturer's Build Checklist.
5. *TDI CCR Preflight* Checklist.
6. *TDI Decompression Procedures* Student Manual or eLearning.
7. *TDI Extended Range and Trimix Diver* Student Manual and Knowledge Quest or eLearning.
8. *TDI Advanced Nitrox* Student Manual and Knowledge Quest or eLearning.
9. Manufacturer's minimum training standards.

Optional:

1. Mel Clark- Rebreathers Simplified.
2. Skills prompt slates.
3. Richard Pyle - A Learners Guide to Closed Circuit Rebreather Operations.
4. Kenneth Donald - Oxygen & The Diver.
5. John Lamb - Oxygen Measurement for Divers.
6. Barsky, Thurlow & Ward - The Simple Guide to Rebreather Diving.
7. Bob Cole - Rebreather Diving.
8. Jeffrey Bozanic - Mastering Rebreathers.

32.9 Required Equipment

The following equipment is required:

1. A complete closed-circuit rebreather. Any modifications to the unit must be approved by the manufacturer.
2. Minimum of 1 CCR dive computer and 1 backup OC/CCR computer for bailout in event of system failure.
3. Mask, fins and a suitable line-cutting device.
4. Slate and pencil.
5. Reel with a minimum of 50 Metres/165 Feet of line.
6. Lift Bag/Delayed Surface Marker Buoy (DSMB) with adequate lift and size for the dive environment and a backup. Required for open water environments only.
7. Exposure suit appropriate for the open water environment where training will be conducted.
8. Access to an oxygen/helium analyzer.

9. Appropriate weight.
10. Bailout gas supply cylinder with appropriate capacity of gas for planned dive.

Note: Instructor and students must all be on the same unit for all portions of the course. The instructor and any certified assistant will also carry a bailout gas supply during all open water sessions. This redundant gas source must be greater than the instructor and any certified assistant's bailout requirements.

32.10 Required Subject Areas

The TDI Diving Rebreathers Student Manual or eLearning and the manufacturer's manual are mandatory for use during this course, but instructors may use any additional text or materials that they feel help present these topics.

The following topics must be covered during the course:

1. History and Evolution of Rebreathers.
2. Comparison of Open-Circuit, Closed-Circuit and Semi-Closed-Circuit Rebreather Systems and the Benefits/Problems with Each.
3. Practical Mechanics of the System:
 - a. Assembly and disassembly of the unit.
 - b. Layout and design of the unit.
 - c. Absorbent canister design and maintenance.
 - d. Proper packing of canister in accordance with manufacturers recommendations.
 - e. Breathing loop de-contamination procedures.
 - f. Manufacturer supported additional items (bailout valve, automatic diluent valve, etc.)
 - g. Loop volume – minimum/optimum.
4. Gas Physiology:
 - a. Oxygen (O₂) risks: Hyperoxia, Toxicity, Hypoxia.
 - b. Nitrogen absorption.
 - c. CO₂ toxicity, Hypercapnia.
 - d. Gas consumption.
 - e. Gas density.
5. Electronic and Manual Systems Design and Maintenance:
 - a. O₂ metabolizing calculations.

- b. Fuel cells:
 - i. Maintenance.
 - ii. Replacement.
 - iii. Manufacturing date.
 - c. System electronics functionality and calibration procedures.
6. Dive Tables:
- a. Constant partial pressure of oxygen (PPO₂) theory.
 - b. Central nervous system (CNS) and awareness of oxygen tracking units (out).
7. Dive Computers:
- a. Mix adjustable.
 - b. Constant PO₂.
 - c. O₂ integrated.
 - d. Decompression conservatism/Gradient factor selection.
8. Dive Planning:
- a. Operational planning.
 - b. Gas requirements including bailout scenarios.
 - c. Scrubber duration.
 - d. Oxygen limitations.
 - e. Nitrogen limitations.
 - f. Diving in mixed teams.
9. Emergency Procedures:
- a. Use of B.A.D.-D.A.S. - Bail out, Anxiety breaths, Decide – Diluent flush, Always know your PO₂, Skills to overcome problem.
 - b. Three H's problems.
 - c. Flooded loop.
 - d. Cell warnings.
10. Battery warnings and electronic failures. Bailout gas requirements. Helium Considerations:
- a. Helium absorption and elimination.
 - b. Advantages of hyperoxic mixes for decompression.

- c. Advantages of helium for bottom gas.
- d. Hypoxia.
- e. HPNS.
- f. Effects on respiration.
- g. Effects as an insulator.
- h. Helium limitations.

11. Team Diving Considerations:

- a. Purpose of dive
- b. Use of pre-dive checklists
- c. Buddy checks
- d. Dive planning and setpoints
- e. Bailout scenarios

32.11 Required Skill Performance and Graduation Requirements

All standards set by both TDI, and the rebreather manufacturer must be met, while maximum limits of neither may be exceeded.

The following open water skills must be completed by the student during open-water dives with the following course limits:

1. All open water dives must be between 6 Metres/20 Feet to 45 Metres/150 Feet using helitrox as a diluent on at least 4 open water dives.
2. All skills must be demonstrated by the instructor on the unit specific CCR.
3. Two dives using helitrox as a diluent must be deeper than 35 Metres/115 Feet.
4. Satisfactorily complete any additional skills required by the unit specific manufacturer.
5. Breathing gas limits:
 - a. Maximum planned PO₂ setpoint not to exceed 1.3 bar
 - b. Maximum breathing loop PO₂ of 1.4 bar except at 6m/20 ft or less for a maximum of two minutes
 - c. Open circuit bailout not to exceed a PO₂ of 1.6 bar at the maximum depth of the dive
 - d. Onboard diluent not to exceed a PO₂ of 1.1 bar at the maximum depth of the dive

- e. Recommended maximum END of 30 metres/100 ft
- 6. All dives to be completed within CNS% limits with a recommend maximum of 80% of the total PO₂ CNS limit.
- 7. Safety stops to be conducted with a minimum 3 minutes at 6 Metres/20 Feet.
- 8. Where the user opts for an automatic diluent valve (ADV) fitted by the manufacturer additional skills such as regular diluent gauge monitoring and addition control must be emphasized.
- 9. Calculate bailout gas at 50 litres /1.8 cubic Feet per minute usage for deep mix and at 30 litres/1.1 cubic Feet per minute for decompression gas if a separate deco gas is carried.
- 10. All dives to be completed within appropriate fixed PO₂ decompression tables or decompression planning software.
- 11. The student is only certified for Helitrox decompression diving on the specific CCR unit.
- 12. Students must do one bailout from depth on o/c to include simulated or actual decompression.
- 13. Students to log all dives at the end of each diving day

Open Water Skills:

- 1. Pre dive checks:
 - a. Unit build-up using manufacturer's unit build checklist.
 - b. Scrubber packing.
 - c. Positive and negative checks.
- 2. Verify diluent and O₂ cylinder contents using O₂ analyzer.
- 3. Demonstrate correct pre dive planning procedures including:
 - a. Limits based on system performance.
 - b. Limits based on oxygen exposures at chosen PPO₂ levels.
 - c. Limits based on nitrogen absorption at planned depth and PO₂ set-point.
 - d. Appropriate selection of decompression conservatism/gradient factors for planned dive.
 - e. Thermal constraints.
- 4. Emergency procedures:
 - a. Mouthpiece familiarity drills.

- b. Bailout drills.
 - c. Gas shutdowns and loss of gas.
 - d. Broken hoses.
 - e. Flooded absorbent canister.
 - f. CO₂ breakthrough.
 - g. Semi-closed mode.
 - h. Low oxygen drills.
 - i. High oxygen drills.
 - j. Flooding Loop.
 - k. Electronics and battery failure.
 - l. Demonstrate simulated rescue of a non-responsive rebreather diver to the surface from a depth of at least 5 metres/16 feet.
 - m. Oral inflation of BCD at the surface
- 5. Use of BCD/suit and effective management of loop breathing volume for buoyancy control. Demonstrate ability to hover at fixed position ($\pm 1\text{m}/3\text{ft}$) in water column for at least 90 seconds without moving hands or feet.
 - 6. Stop at 3-6 Metres/10 – 20 Feet on descent for leak bubble check.
 - 7. Electronics systems monitoring for PO₂ levels (SETPOINT) and switching set-points.
 - 8. Manual control of set-point if electronically controlled CCR is not used.
 - 9. Use and adjustment of Heads Up Displays and computers.
 - 10. Mask removal and replacement.
 - 11. Use of lift-bag/delayed surface marker buoy and reel.
 - 12. Proper execution of the dive within all pre-determined dive limits
 - 13. Constant-loop volume management.
 - 14. Cell validation checks with appropriate use of diluent and oxygen.
 - 15. Post dive clean of unit to avoid contamination and spread of disease.

If this is the first CCR course taken on the unit, the following must be included:

- 1. Post dive clean of unit:
 - a. Mouthpiece and hoses.
 - b. Clean and disinfect unit.

- c. Inspect components of unit.
- 2. Dive maintenance of unit:
 - a. Cell remove and replace.
 - b. Mouthpiece strip and rebuild.
 - c. Replacing batteries/recharging.

Decompression related in water skills:

- 1. Demonstrate comfort swimming on surface and at depth carrying 1 bailout/decompression cylinder.
- 2. Demonstrate ability to drop and retrieve one bailout/decompression cylinder while maintaining position in the water column.
- 3. Demonstrate ability to deploy SMB or lift-bag solo and as a member of a team.
- 4. Demonstrate appropriate reaction to gas hemorrhage from manifold or first stage, SPG and primary regulator.
- 5. Demonstrate appropriate reaction to simulated free-flowing deco regulator.
- 6. Buddy breathing deco gas for at least 1 minute.
- 7. Oxygen rebreather mode at less than 6 Metres/20 Feet stop.
- 8. Complete 1 bailout scenario at depth to include decompression obligation on open circuit.

In order to complete the course and achieve the TDI Helitrox Diluent Decompression Procedures CCR rating the student must:

- 1. Satisfactorily complete the written examination with a pass mark of 80% and 100% remediation.
- 2. Complete to the instructor's satisfaction all confined and open water skill development sessions.
- 3. Demonstrate mature, sound judgment concerning dive planning and execution.
- 4. Complete a refresher course following a period of inactivity greater than 6 months following the course.