

33. Mixed Gas Closed Circuit Rebreather Diver, Unit Specific

*** Discovery MK VI/SE7EN/Se7en must be equipped with full 60 M upgrades, including 60M-emodule and counter lungs with manual addition valves.**

33.1 Introduction

This is the intermediate level certification course for divers wishing to utilize a closed-circuit rebreather (CCR) for mixed gas diving. The objective of the course is to train divers in the benefits, hazards and proper procedures for mixed gas diving on the unit specific CCR, utilizing a mixed gas diluent containing 16 percent or greater oxygen, and to develop intermediate CCR diving skills appropriate to technical diving to a maximum depth of 60 Metres/200 Feet.

33.2 Qualifications of Graduates

Upon successful completion of this course, graduates may engage in technical diving activities utilizing the unit specific CCR to a maximum of 60 Metres/200 Feet, utilizing a mixed gas diluent containing 16 percent or greater oxygen provided:

1. The diving activities approximate those of training.
2. The areas of activities approximate those of training.
3. Environmental conditions approximate those of training.

Upon successful completion of this course, graduates are qualified to enroll in:

1. TDI Advanced Mixed Gas Closed Circuit Rebreather Diver, unit specific.

33.3 Who May Teach

An active TDI Closed Circuit Rebreather Instructor, with a unit specific TDI Mixed Gas Instructor rating.

33.4 Student to Instructor Ratio

Academic:

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

Confined Water (swimming pool-like conditions):

1. N/A.

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

1. A maximum of 3 students per active TDI Instructor is allowed.
2. The ratio should be reduced as appropriate due to environmental or operational constraints.

33.5 Student Prerequisites

1. Minimum age 18.
2. Provide a verified log of a minimum of 50 rebreather hours distributed over a minimum of 50 dives, with at least 25 dives and 25 hours on the specific rebreather unit and at least 10 rebreather dives to 30 metres/100 feet or deeper requiring staged decompression. If completing a unit crossover, provide proof of at least 10 logged CCR dives in the last 12 months.
3. Certified as a TDI Air Diluent Decompression Procedures Rebreather/ TDI CCR Helitrox Diluent Decompression Procedures Diver course or equivalent from agencies recognized by TDI.

33.6 Course Structure and Duration

Open Water Execution:

1. Open water drills practice air diluent dive and 50m fully equipped CCR diver surface tow must be completed prior to conducting mixed gas diluent training dives.
2. Minimum of 360 minutes open water training to be completed over a minimum of 6 dives including 1 equipment configuration and drills practice air diluent dive to a maximum 20 Metres/66 Feet.
3. A minimum of 5 dives must be conducted on mixed gas diluent.
4. All mixed gas dives are to be deeper than 40 Metres/130 Feet, utilizing a mixed gas diluent containing 16 percent or greater oxygen, to a maximum depth of 60 Metres/200 Feet.
5. A minimum of four dives must be decompression dives. At least two dives should be deeper than 50 Metres/165 Feet and at least one dive be to at least 55 metres/180 feet. Decompression must not exceed 60 minutes on a single dive.
6. No more than 3 in-water sessions per day and no more than 2 mandatory decompression dives per day.

Course Structure:

1. TDI allows instructors to structure courses according to the number of students participating and their skill level.
2. Oral examinations are permitted if the exam is not available in a language the student understands.

Duration:

1. Minimum of 6 hours for academic development and a further 2 hours for equipment configuration workshop.

Crossover:

1. If a student already qualified as a TDI Mixed Gas CCR Diver or equivalent wishes to qualify on another CCR recognized by TDI, the student must meet all crossover requirements for Air Diluent Deco or Helitrox Deco CCR, follow all unit specific course standards, and meet all skill performance requirements. The only changes during the unit crossover are:
 - a. Minimum of 120 minutes open water training to be completed over a minimum of 2 dives on mixed gas diluent to a maximum of 60 Metres/200 Feet.
 - b. Must demonstrate proficiency in all required skills at the Mixed Gas diluent level.

33.7 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.

33.8 *Training Material*

Required Material:

1. *TDI Diving Rebreathers* Student Manual and Knowledge Quest or eLearning.
2. *TDI Diving Rebreathers* PowerPoint presentation.
3. *TDI Extended Range and Trimix* Student Manual or eLearning.
4. *TDI Extended Range and Trimix* Instructor Guide.
5. *TDI CCR Preflight* Checklist.
6. Unit specific rebreather manual.
7. Unit specific rebreather examination if required by the manufacturer.
8. Manufacturer's Build Checklist.
9. Manufacturer's manual and updates.

33.9 *Required Equipment*

The following equipment is required for each student:

1. A complete closed-circuit rebreather configured within the manufacturer's recommendations; this should be the student's personal unit.
2. One (1) CCR mixed gas computer and 1 backup OC/CCR computer for bailout in the event of a system failure.
3. Bailout gas cylinders (minimum 2) with the appropriate capacity for the planned dive, each equipped with a first and second stage and SPG.
4. Mask, backup mask, fins, and a suitable line-cutting device.
5. Slate and pencil.
6. Reel with a minimum of 60 Metres/200 Feet of line.
7. Reel with a minimum of 30 Metres/100 Feet of line.
8. Two lift bags/delayed surface marker buoys (DSMB's) with adequate lift and size for the dive environment. Required for open water environments only.
9. Exposure suit adequate for the open water environment where training will be conducted.
10. Access to an oxygen analyzer.
11. Access to a helium analyzer.
12. Adequate weight.

Note: Instructor and students must all be on the same rebreather type (eCCR or mCCR) and no more than 3 different units of the same type on a given training dive.

33.10 Required Subject Areas

The TDI Diving Rebreathers Student Manual or eLearning is required for use as a review/recap document. The instructor may use any additional text or materials they feel will represent the topic in an educational manner.

The following topics must be covered during the course:

1. Gas Physiology:
 - a. Oxygen (O₂) toxicity.
 - b. Hypoxia.
 - c. Nitrogen absorption.
 - d. Helium absorption.
 - e. HPNS.
 - f. Carbon dioxide (CO₂) toxicity.
 - g. Gas consumption.
 - h. Gas mixing.
 - i. Gas density.
2. Formula Work:
 - a. Oxygen (O₂) metabolizing calculations.
 - b. Manually controlled closed circuit rebreathers.
 - c. Equivalent narcosis depth theory.
 - d. Central nervous system (CNS) tracking.
 - e. Oxygen tracking units (OTU).
 - f. Gas management.
3. Dive Tables:
 - a. Creation of custom dive tables appropriate to dive depths.
 - b. Creation of lower percentage of oxygen (PO₂) diluent to support loop flushing and bailout at depth.
4. Dive Computer:
 - a. Mix adjustable.

- b. Constant partial pressure of oxygen (PPO₂).
 - c. Oxygen (O₂) integrated.
 - d. Decompression conservatism/Gradient factor selection.
- 5. Dive Planning:
 - a. Operational planning.
 - b. Scrubber duration
 - c. Gas requirements including bailout scenarios.
 - d. Decompression on a CCR.
 - e. Oxygen limitations.
 - f. Nitrogen limitations.
 - g. Helium limitations.
 - h. Diving in mixed teams.
- 6. Unit-specific checklist.
- 7. Equipment Maintenance:
 - a. Fuel cell management:
 - i. Date stamps.
 - ii. Replacement.
 - b. Loop configurations.
 - c. Additional fitted equipment and modifications:
 - i. Auto diluent addition.
 - ii. Dual mode mouthpieces.
 - iii. Heads up display.
 - iv. Additional manual injectors.
 - v. Integrating oxygen monitors for dive computers.
- 8. Team Diving Considerations:
 - a. Purpose of dive
 - b. Use of pre-dive checklists
 - c. Buddy checks
 - d. Dive planning and setpoints
 - e. Bailout scenarios

33.11 Required Skill Performance and Graduation Requirements

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

1. No dives deeper than 60 Metres/200 Feet.
2. No dives shallower than 40 Metres/130 Feet, other than the 1 air diluent configuration dive are credited toward the dive requirements. Subsequent training dives in shallow water are permitted if necessary, during the course.
3. Calculate bailout gas at 50 litres /1.8 cubic Feet per minute usage for bottom mix and ascent phase including the first 10 minutes of decompression, and at 25 litres/0.9 cubic Feet per minute for decompression gas(ses) after the end of the first decompression stop.
4. 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. Equivalent narcotic depth not to exceed 30 Metres/100 Feet.
 - f. Breathing gas density of less than 6.3 g/l.
5. All dives to be completed within appropriate fixed PO₂ decompression tables or decompression planning software.
6. All dives to be completed within CNS percentage limits with a recommend maximum of 80 percent of the total PO₂ CNS limit.
7. Students to log all dives at the end of each diving day.

Land Drills:

1. Build unit based on manufacturer's specifications using manufacturer's manual/build checklist.
2. Demonstrate familiarity with basic and intermediate hand signals.
3. Select and prepare equipment suitable for soft overhead environment with long decompression obligations.

4. Conduct team-oriented drills for lift bag deployment and bailout procedures.
5. Drills for buddy rescue.
6. Properly analyze all gas mixtures to be used.
7. Demonstrate adequate pre-dive planning:
 - a. Limits based on system performance and scrubber duration.
 - b. Limits based on bailout gas requirements.
 - c. Limits based on oxygen exposures at chosen PPO₂ levels.
 - d. Limits based on manually controlled closed circuit rebreathers.
 - e. Limits based on nitrogen absorption at planned depth and PPO₂ (set-point) level.
 - f. Limits based on helium absorption.
 - g. Appropriate selection of decompression conservatism/gradient factors for planned dive.
 - h. Correct narcotic depth planning and diluent selection to allow cell flushing at target depth (diluent should not exceed a PO₂ of 1.2 at maximum planned depth).

Pre-dive Drills:

1. Conduct pre-dive checks using TDI Pre-flight checklist.
2. Use START * before every dive.
3. Stress analysis and mitigation.

* START is S-drill (OOA drill and Bubble Check), Team (buddy equipment checks), Air (gas matching), Route (entry/exit and planned path underwater), Tables (depth, duration, waypoints, and schedule).

Open Water Skills:

1. All skills must be demonstrated by the instructor on the unit specific CCR.
2. Show good awareness of team members through communications, proximity, and team-oriented dive practices.
3. Demonstrate buoyancy control; ability to hover at fixed position ($\pm$ 1m/3ft) in water column for at least 90 seconds without moving hands or Feet.
4. Mask removal and replacement/deploy backup mask while maintaining neutral buoyancy.

5. Properly execute a recovery from a system failure and conclude the dive and decompression on open circuit gases carried from a depth greater than 30 Metres/100 Feet.
6. Demonstrate ability to plug in and share off-board gas, including sharing/swapping of off-board bailout cylinders.
7. Properly execute a recovery from system failure and conclude the dive and decompression with the unit in manual mode.
8. Gas shutdowns and loss of gas, correct choice and switching to off board gases.
9. Broken hoses, catastrophic failure scenarios.
10. Flooded absorbent canister.
11. Cell errors.
12. SCR drill (minimum of 10 minutes).
13. Oxygen rebreather mode in depths less than 6 Metres/20 Feet.
14. Stop at 3 to 6 Metres/10 to 20 Feet on descent for leak bubble check.
15. Demonstrate competence managing 2 bailout cylinders, including drop and recovery while maintaining position in the water column.
16. Deployment of a lift bag/delayed surface marker buoy (DSMB) at depth and mid water.
17. Simulate failed lift bag/DSMB deployment.
18. On 2 of the dives, demonstrate an ascent with ascent reel and lift bag and perform staged decompression.
19. Electronics systems monitoring for PPO₂ levels.
20. Cell validation checks with appropriate use of diluent and oxygen.
21. Proper execution of the dive within all pre-determined dive limits.
22. Demonstration of decompression stops at pre-determined depths.

Demonstrate simulated rescue of a non-responsive rebreather diver to the surface from a depth of at least 6 metres/20 feet.

In order to complete the course and achieve the TDI Mixed Gas CCR rating the student must:

1. Complete to the instructor's satisfaction all confined and open water skill development sessions.
2. Demonstrate mature, sound judgment concerning dive planning and execution.
3. Satisfactorily complete the TDI Extended Range and Trimix examination with a minimum score of 80 percent.

4. Complete a refresher course following a period of inactivity greater than 6 months following the course.