1. Bailout Closed Circuit Rebreather Diver

1.1 Introduction

This is an advanced level course for divers wishing to use a second closed circuit rebreather (CCR) for bailout / redundancy purposes in open water or overhead environment (wreck or cave diving). The objective is to train divers in the benefits, hazards and proper procedures for utilising a rebreather in back-up / bailout mode up to the level of their existing CCR qualification on both the unit planned to be the primary rebreather and the unit to be utilised as a bailout / back-up rebreather.

1.2 Qualifications of Graduates

Upon successful completion of this course, graduates may engage in technical diving activities utilizing the unit specific CCR as a bailout/back-up CCR to a maximum depth of their qualification on both primary and backup units and utilizing a diluent within the standards laid out in those qualifications 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

1.3 Who May Teach

An active TDI Instructor that has been certified to teach this specialty. The instructor must be certified as a TDI instructor on both the primary and back-up closed circuit rebreathers to be used at the level required for the course.

1.4 Student to Instructor Ratio

Academic

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

Confined Water (swimming pool-like conditions)

1. A maximum 3 of students per instructor

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

1. A maximum of 3 students per instructor; it is the instructor's discretion to reduce this number as conditions dictate

1.5 Student Prerequisites

1. Certified as a mixed gas diver on both the primary and the bailout / backup rebreather. It is recommended that this course be primarily for advanced mixed gas rebreather divers.
2. Minimum age 18
3. Provide a verified log of a minimum of 100 rebreather hours on both units over a minimum of 50 dives on each unit with that unit being used as the primary rebreather for those dives/hours. At least 20 dives on each unit should be mixed gas dives.

1.6 Course Structure and Duration

1. At least one skills dive in confined water or shallow open water to ensure
    a. Appropriate configuration of primary and backup rebreather
    b. Appropriate configuration of open circuit and offboard gases
    c. Demonstration by the student of the ability to monitor, manage and switch between primary and backup units and open circuit
2. A minimum of 240 minutes over at least 4 dives of open water execution dives are required with complete brief and debrief by the instructor including 1 skills, equipment configuration and drills dive, 1 simulated deco dive with switch to bailout CCR and 2 actual deco dives, each dives runtime to be divided between the two units, one dive with all units run manually, one simulated hypercapnia dive.
3. Maximum dive depth to be 20m for skills and drills dive, 40m for simulated deco dive and the student/instructors maximum certified depth for the final two dives. Diluents must be matched and meet student and instructors existing certification standards.
4. A minimum of 6 hours classroom / theory time suggested

1.7 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 this course the instructor must:

1. Download and retain a copy of the students dive logs of all training dives

2. Issue the appropriate TDI certification by submitting the Diver Registration Form to International Training Headquarters, the appropriate regional office or registering the students online through member's area of **www.tdisdi.com**

1.8 Required Equipment and materials

The following are required for this course

1. *TDI Extended Range and Trimix* Student Manual or eLearning
2. *TDI Extended Range and Trimix* Instructor Guide
3. TDI CCR Preflight Checklist
4. Unit specific rebreather manual for both units
5. Manufacturer's Build Checklist for both units
6. Manufacturer's manual and updates for both units

The following equipment is required for each student:

1. Two complete closed circuit rebreather configured within the manufacturers recommendations; these should be the student's personal units ***Rebreathers used on this course as bailout rebreathers must have a 'bailout mode' and be manufacturer authorised for use as a bailout unit.**
2. Two CCR mixed gas computer and 1 backup OC/CCR computer for bailout in the event of a dual system failure
3. Bailout gas cylinders with the appropriate capacity for the planned dive (30 minutes of OC gas at a sac rate of 60 lmin), each equipped with a first and second stage and SPG.
4. Mask, backup mask, fins and two cutting devices
5. Wetnotes/Slate and pencil
6. Reel with adequate capacity for planned dive
7. Backup reel or spool with adequate capacity for planned dive
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

1.9 Approved Outline

The TDI Diving Rebreathers and the TDI Extended Range and Trimix Student Manual or eLearning is required for use as a review/recap document. **Instructors may use any additional text or materials that they feel help present these topics.**

The following topics must be covered in review with additional time being allocated to academic if the student has any applied or theoretical knowledge gaps

1. Gas Physiology
    a. Oxygen (O_2) toxicity
    b. Hypoxia
    c. Nitrogen absorption
    d. Helium absorption
    e. HPNS
    f. Carbon dioxide (CO_2) toxicity
    g. Gas consumption
    h. Gas mixing
2. Formula Work
    a. Oxygen (O_2) metabolizing calculations
    b. Equivalent narcosis depth theory
    c. Central nervous system (CNS) tracking
    d. Oxygen tracking units (OTU)
    e. Gas management
3. Dive Tables
    a. Creation of custom dive tables appropriate to dive depths
        i. OC gas requirements
        ii. Use of TTS and max deco time plans
        iii. Limits of bailout/backup CCR
    b. Creation of lower percentage of oxygen (PO_2) diluent to support loop flushing and bailout at depth
4. Dive Computers
    a. Compatibility of primary and secondary units electronics
    b. PO2 control and monitoring on both units
    c. Safe loop pressure monitoring on both units
    d. Decompression conservatism/Gradient factor selection on primary and secondary units

5. Dive Planning
    a. Operational planning
    b. Scrubber durations on both units
    c. Gas requirements for both units and for OC including bailout scenarios and cross unit resources for offboarding
    d. Decompression on a primary and a bailout/backup CCR
    e. Oxygen limitations
    f. Nitrogen limitations
    g. Helium limitations
6. Unit-specific checklists
    a. Primary and secondary unit build and pre dive checklists
    b. Specific checklist for bailout mode on backup ccr
    c. Descent checklist for back-up / bailout unit
7. Equipment Maintenance
    a. Oxygen Sensor management
    b. Date stamps
    c. Replacement
    d. Loop configurations
    e. Additional fitted equipment and modifications
    f. Auto diluent addition
    g. Dual mode mouthpieces
    h. Heads up display
    i. Additional manual injectors v. Integrating oxygen monitors for dive computers

1.10 Required Skill Performance and Graduation Requirements

Students are required to successfully complete the following:

Land Drills

1. Build both units based on manufacturer's specifications using manufacturer's manual/build checklists
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. Descent and Verification Check Drills – see Appendix A
6. Drills for ***BOPP-TOPP*** switch to backup/bailout rebreather. **BOPP** (*Bail, Open Circuit, Pressure/PO2*) **TOPP** *(TTS, Off loop, Pressure/PO2)* protocol (all switches to back up rebreather happen via Open circuit bailout.
7. Demonstrate familiarity with switching and configuring both units electronics during the switching protocols.
8. Properly analyze all gas mixtures to be used
9. Demonstrate adequate pre-dive planning
    a. Limits based on system performance and scrubber duration
    b. Limits based on switching procedure to bailout rebreather based on Open circuit gas requirements. Suggest minimum of 30 minutes including decompression obligation
    c. Limits based on oxygen exposures at chosen PPO_2 levels
    d. Limits based on manually controlled closed circuit rebreathers
    e. Limits based on nitrogen absorption at planned depth and PPO_2 (set-point) level
    f. Limits based on helium absorption
    g. Appropriate selection of decompression conservatism/gradient factors for planned dive for both units
    h. Correct narcotic depth planning and diluent selection to allow cell flushing at target depth (diluent should not exceed a PO_2 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
4. Bailout CCR specific checklist

Confined or Shallow Open Water Drills

Note: the student should breathe roughly 50% of the dive on each unit

1. Complete all build and predive checklists for both units
2. Don both units and open circuit bailout and make a stride entry into the water.
3. Check and trim out all equipment in water and verify working
4. Complete bubble and equipment checks
5. Complete weight and trim checks

6. Breathe from either unit at will after verifying pressure and loop PO2
7. Bailout from either unit to OC
8. Conduct diluent flushes on and off loop on both units
9. Offboard gas on both units
10. Monitor and maintain setpoints on or off loop on both units.
11. Verify pressure and PO2 every 5 minutes on 'off loop' unit
12. Conduct Three ascents
    a. Ascent on the primary device with passive BO CCR
    b. Ascent to BO CCR with passive primary CCR
    c. Ascent to OC with both CCR passive (only for training reasons to practice control of both units, in reality it will be impractical as insufficient OC bailout would be available.)
13. Remove all but primary unit in water too deep to stand and then exit

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 the student and instructor certifications on both units
2. No dives shallower than 20 meters / 65 feet, other than open water dive 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. Equivalent narcosis depth not to exceed 30 metres / 100 feet (PPN2 less than or equal to 3.16)
4. Calculate OC bailout gas at minimum 45 litres /1.6 cubic feet per minute usage for bottom mix and at 30 litres/1.1 cubic feet per minute for decompression gas(ses)
5. PO_2 not to exceed manufacturer recommendation or a working limit of 1.3 bar during the bottom phase of the dive and 1.4 bar during the decompression phase of the dive.
6. Diluent PO_2 should not exceed 1.2 at maximum depth
7. All dives to be completed within appropriate fixed PO_2 decompression tables or decompression planning software
8. All dives to be completed within CNS percentage limits with a recommend maximum of 80 percent of the total PO_2 CNS limit
9. The student is only certified for CCR mixed gas diving on the rebreathers being used

Open Water Skills

1. All skills must be demonstrated by the instructor on both of the unit-specific CCRs
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 in water column without moving hands or feet
4. Mask removal, deploy backup mask and replace removed mask with backup
5. Conduct a switch to the backup/bailout rebreather following the following **BOPP** (*Bail, Open Circuit, Pressure/PO2*) **TOPP** *(TTS, Off loop, Pressure/PO2)* protocol (all switches to back up rebreather happen via Open circuit bailout.
    a. Bail to Open Circuit
    b. Check for Positive Pressure and PO2 on backup Unit
    c. Verify TTS/NDL limits 'in synch' on both units
    d. Appropriately close and prepare primary unit to be in 'off loop mode'
    e. Verify pressure and PO2 on backup unit and switch from Open Circuit as long as respiration level is appropriate
    f. End the dive
6. Properly execute a recovery from a simulated primary system failure and conclude the dive and decompression on the bailout rebreather from a depth greater than 45 metres/150 feet and repeat from at least 55m/180 feet
7. Demonstrate ability to plug in and share off-board gas, including sharing/swapping of off-board bailout cylinders or supply between rebreathers
8. Properly execute a recovery from system failure, switch to the bailout rebreather and conclude the dive and decompression with the bailout unit in manual mode
9. Demonstrate an appropriate response to the following failures in light of the choice to switch to a backup/bailout CCR
    a. BOOM Scenario - Gas shutdowns and loss of gas, correct identification of issues, appropriate choice of action and switching to off board gases if required. The instructor should cover likely scenarios at their discretion.
        i. BOOM on primary
        ii. BOOM on Bailout Unit
    b. Broken hoses, catastrophic failure scenarios
    c. Flooded absorbent canister
    d. Cell errors
    e. SCR drill (minimum of 10 minutes)
    f. Oxygen rebreather mode in depths less than 6 metres / 20 feet
10. Stop at 3 to 6 metres / 10 to 20 feet on descent for leak bubble check and pressure check / PO2 check of the 'off loop' unit, continue verification checks during descent and at maximum depth
11. Demonstrate competence managing 2 bailout cylinders and the backup rebreather, including drop and recovery while maintaining position in the water column

12. Deployment of a lift bag / delayed surface marker buoy (DSMB) at depth and mid water – required for OW environments only
13. On 1 of the dives, demonstrate an ascent with ascent reel and lift bag and perform staged decompression
14. Electronics systems monitoring both systems for PPO_2 levels
15. Cell validation checks with appropriate use of diluent and oxygen
16. Proper execution of the dive within all pre-determined dive limits
17. Demonstration of decompression stops at pre-determined depths

Open Water Dive 1 – max depth 20m

1. Complete START
2. Complete all build and predive checklists for both units
3. Test and check all equipment, i.e. depth gauges, bottom timers/watches and computers
4. Familiarization with area
5. Don both units and open circuit bailout and make entry into the water.
6. Check and trim out all equipment in water and verify working
7. Complete bubble and equipment checks
8. Descend to planned depth completing descent verification checks and do not exceed any pre-planned limits
9. Dive according to plan at a depth limited to 20 metres / 60 feet for first dive
10. Breathe from either unit at will after verifying pressure and loop PO2
11. Bailout from both units to OC
12. Switch to bailout CCR using BOPP-TOPP
13. Conduct diluent flushes on and off loop on both units
14. Offboard gas on both units
15. Monitor and maintain setpoints on or off loop on both units.
16. Verify pressure and PO2 every 5 minutes on ‘off loop’ unit
17. Run both units manually for at least 15 minutes
18. Ascend to safety stop

Open Water Dive 2 – min depth 20m max depth 40m

1. Complete START
2. Complete all build and predive checklists for both units
3. Test and check all equipment, i.e. depth gauges, bottom timers/watches and computers

4. Familiarization with area
5. Don both units and open circuit bailout and make entry into the water.
6. Check and trim out all equipment in water and verify working
7. Complete bubble and equipment checks
8. Descend to planned depth completing descent verification checks and do not exceed any pre-planned limits
9. Monitor and maintain setpoints on or off loop on both units.
10. Verify pressure and PO2 every 5 minutes on 'off loop' unit
11. Switch to bailout CCR using BOPP-TOPP
12. Breathe from either unit at depth after verifying pressure and loop PO2
13. Simulate at least 30 minutes of decompression with stops from at least 30m switching to the bailout unit for at least half the planned decompression time
14. Ascend to final stop
15. Surface and establish safe surface buoyancy and support

Open Water Dive 3 – min depth 40m max depth student and instructor certifications to no more than 60m

1. Complete START
2. Complete all build and predive checklists for both units
3. Test and check all equipment, i.e. depth gauges, bottom timers/watches and computers
4. Familiarization with area
5. Don both units and open circuit bailout and make entry into the water.
6. Check and trim out all equipment in water and verify working
7. Complete bubble and equipment checks
8. Descend to planned depth completing descent verification checks and do not exceed any pre-planned limits
9. Monitor and maintain setpoints on or off loop on both units.
10. Verify pressure and PO2 every 5 minutes on 'off loop' unit
11. Switch to bailout CCR using BOPP-TOPP
12. Breathe from either unit at depth after verifying pressure and loop PO2
13. Build up or simulate at least 45 minutes of decompression with stops from at least 39m switching to the bailout unit for at least two thirds of the planned decompression time.
14. Run the bailout unit manually for at least 20 minutes and for all of the 9m and 6m stops
15. Surface and establish safe surface buoyancy and support

Open Water Dive 4 – min depth 50m max depth student and instructor certifications to no more than 75m

1. Complete START
2. Complete all build and predive checklists for both units
3. Test and check all equipment, i.e. depth gauges, bottom timers/watches and computers
4. Familiarization with area
5. Don both units and open circuit bailout and make entry into the water.
6. Check and trim out all equipment in water and verify working
7. Complete bubble and equipment checks
8. Descend to planned depth completing descent verification checks and do not exceed any pre-planned limits
9. Monitor and maintain setpoints on or off loop on both units.
10. Verify pressure and PO2 every 5 minutes on 'off loop' unit
11. Breathe from either unit at depth after verifying pressure and loop PO2
12. Build up or simulate at least 70 minutes of decompression with stops from at least 48m
13. Bailout to open circuit as if in a CO2 (hypercapnia) event and breathe normally but post dive calculate gas actually used versus that which would have been used assuming a simulated high SAC rate for at least 30 minutes during the ascent
14. Switch to bailout CCR using BOPP-TOPP
15. Breathe the bailout unit at depth for the remaining ascent and decompression time.
16. Run the bailout unit manually with offboards for at least 30 minutes and for all of the 9m and 6m stops
17. Surface and establish safe surface buoyancy and support

In order to complete the course and achieve the TDI Bailout Rebreather 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. Course must be completed within 6 weeks from the starting date
4. Complete a refresher course following a period of inactivity greater than 6 months following the course

Appendix A – Descent and Verification Check Procedures

This procedure is necessary at least 3 times during the descent (in 5/6 meters, at half of the maximum depth, at the end of the descent)

The procedure of the drill during control and descent is:

1. Stop at a specific depth and compensate a buoyancy
2. Unclip the breathing hoses from the storage position to the ready position
3. Check by touch and visually that the counterlungs and corrugated hoses are in the correct shape and not excessively shrunk (if there is no vacuum in the system). In the case of Liberty, also compare the depth on the primary and backup rebreather. If they differ, it means that there is vacuum or overpressure in the BO CCR loop.
4. Check ppO2 in BO CCR
5. To inject a small dose of diluent into the BO CCR for safety (very short MAV press) and observe the hoses or counterlungs.
6. Close the mouthpiece of the primary device and go to BO CCR
7. Take two to three control breaths and observe ppO2 (ppO2 may change dramatically during control if, for example, there is a leak of oxygen into the loop but the gas in the loop does not circulate)
8. Close the BO CCR mouthpiece and go to the primary unit

We do not switch to OC during the bailout loop check, because it affects diver's buoyancy, consumes the gas from the bailout, which we may actually need later, and dilutes the gas in the primary unit loop unnecessarily, which results in wasting oxygen unnecessarily which has to be injected again.

Appendix B – BOPP-TOPP Emergency Bailout Procedure

The drill procedure in an emergency is:

BOPP (Bail, Open Circuit, Pressure/PO2)

TOPP (TTS, Off loop, Pressure/PO2)

In detail this procedure is

1. Go immediately to OC, the easiest and fastest way
2. In the event that a BOV is linked with off-board gas from BOV go to off-board gas, otherwise switch to an open circuit second stage with an appropriate gas closing the mouthpiece of the primary device.
3. Unclip the Bail Out CCR breathing hoses from the storage position to the ready position
4. Check by touch and visually that the counterlungs and corrugated hoses are in the correct shape and not excessively shrunk (if there is no vacuum in the system). Also compare the depth on the primary and backup rebreather. On a Liberty unit if they differ, it means that there is underpressure or overpressure in the BO CCR loop. Other units may vary.
5. Switch the BO CCR electronics to standard CCR mode (I listen for the solenoid to inject oxygen and observe the hoses and counterlungs)
6. Check ppO2 in BO CCR
7. Switch from open circuit bailout, either by closing the BOV mouthpiece of the primary device, or coming off an open circuit regulator and go to BO CCR
8. Take two to three control breaths and observe ppO2 (ppO2 may change dramatically during the check if, for example, there is a leak of oxygen into the loop but the gas in the loop does not circulate)
9. Only return to the primary unit if and when a safe loop on that unit can and has been verified.

***In case of hypercapnia stay on OC for as long as possible, as extremely increased ventilation can cause the scrubber to overbreathe.**