



CMAS

CONFÉDÉRATION MONDIALE
DES ACTIVITÉS SUBAQUATIQUES

WORLD UNDERWATER FEDERATION

**Semi-Closed (SC-) Rebreather
Advanced SC – Rebreather**

**STANDARDS AND REQUIREMENTS
TRAINING PROGRAM**

(VERSION 2000/00)

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CMAS SEMI-CLOSED REBREATHER DIVER

Course Outline

PART 1 : STANDARDS & REQUIREMENTS

I. Course Classification

1. Classification

The CMAS REBREATHER COURSE (SEMI-CLOSED) is considered a **speciality** course. For each other type of unit an adoursement can be added .

2. Validity period

There is no specific period of validity for this certificate.

3. Benefits & responsibilities

Successful students will be qualified to dive using semi closed circuit – premixed nitrox .

II. Aims & Objectives of Course

0. To provide the diver with a good understanding of the techniques involved in the use of semi-closed circuit..
0. To make the diver aware of the additional physiological and technical problems encountered when using a semi-closed system.
0. To provide the diver with a good understanding of the special dive planning procedures appropriate to diving with semi-closed system.

III. Entry Requirements [prerequisites]

0. Student`s minimum age : 16 years
0. Certification Level : Certified CMAS Basic Nitrox Diver or equivalent of a recognised organisation.
0. Medical Certificate : current diving physical, according to member federation requirements.

IV. Maximum Student/Instructor Ratios

0. Equipment practical Ratio Instr./Student 1/6
0. Water Ratio : Instr./Student 1/2
0. First Dive Instr./Student 1/1

V. Instructor/Assistant Requirements

- 3 Instructor/Course Director
 - 3.0 Certificate Level: CMAS 2-Star Instructor
 - 3.0 Speciality: CMAS Rebreather Instructor or equivalent
 - 3.0 Proof of Experience: Instructor must be in active teaching status
- 3 Assistants
As required by the course director.

VI. Equipment

- 3 Semi-closed system being used must be of the same model
- 3 apparatus units used must to be approved by a third official party testing agency
- 3 Instructor will provide all additional supplies and equipment including audio visuals, support material, safety equipment, etc.
- 3 students will provide all personal diving equipment

VII. Special Course Requirements

1. Course outline: Must use the CMAS Training program (see Part 2)
2. Approval by the manufacturers of the semi-closed units used
3. Facilities: adequate classroom, according to the needs of the course and the students, normal open water diving site.
4. Depth limits according to qualification level of each diver [as a maximum under best conditions] and according to local circumstances. First dive should be in a shallow, sheltered water or pool – initially shoulder deep with a max depth of 4 m. Open water : progressively working to max depth 30 m- No decompressions dive recommended .
5. Minimum duration of any qualifying dive is 30 minutes .
6. All diving is to be done within a maximum oxygen partial pressure limit of 1.6 bar.
7. Supervision: During the course an authorised instructor as outline above, must always be present.

VIII. Student Performance Objectives

By the end of the course, students will be able to:

3 knowledge-related:

- 2.0 Explain the physiological and technical phenomena associated with diving semi-closed unit.
- 2.0 Explain emergency procedures
- 2.0 Explain proper procedures of use of tables
- 2.0 Demonstrate their knowledge of diving with semi-closed units

3 skill-related

- 5.0 Plan and execute dives within the limits of the breathing gas and apparatus used
- 5.0 Demonstrate all bail-out procedures
- 5.0 Demonstrate satisfactory safety maintenance and testing procedures for semi-closed units
- 5.0 Demonstrate proper buoyancy control and trim
- 5.0 Correctly use standard semi-closed Diving equipment

IX. Minimum Course duration :

- | | |
|---------------------------------------------------|----------------------------------------------|
| 1. Core knowledge : | 12 hours |
| 2. Practical Workshop : | 4 hours |
| 3. Swimming pool or shallow- sheltered water min. | 1 hour |
| 4. Open Water dives | 4 dives min ½ hour each max. 3 dives per day |

X. Quality assurance

CMAS strongly recommends and encourages all federations to use adequate system for quality assurance. A system in widespread use and of proven effectiveness is to send questionnaires to the student's , followed by an analyses of the feedback .

CMAS SEMI-CLOSED REBREATHER DIVER

PART 2 : TRAINING PROGRAM

I. Course Schedule

Minimum Duration

1. Classroom / Core Knowledge : 12 hours
2. Practical Workshop /Workbench : 4 hours
3. Swimming pool or shallow- sheltered water min. 1 hour
4. Minimum number of Open Water dives 4 dives min ½ hour each.

II. Course Content / Frame work

2 Theory Lessons

T 1: Theory Lecture 1/Generic

2.0 History of the rebreather

2.0 What is a rebreather / Schematic overview of:

pure O₂ rebreather
semi-closed rebreather
Closed circuit electronic rebreather

2.0 General concepts of the rebreather system

CCR & SCR
The Set-point of a CCR
Nitrogen narcosis and the SCR

T 2: Theory Lecture 2/Generic

1.4 Physics & Physiology

An introduction to:
hypoxia, hyperoxia, asphyxia and hypercapnia
Free radicals
Conservation of gas
CCR constant PO₂
Dalton's Law of Partial Pressure
Target PO₂
Changing PN₂ of the CCR during ascent
PN₂ drives the decompression obligation

1.4 Physiology

Reasons for causes of:
hypoxia
hyperoxia
anoxia
hypercapnia

1.4 Symptoms and signs

1.4 Common factors

T 3: Theory Lecture 3/Generic

1.5 Oxygen needs

oxygen metabolism
estimating oxygen needs
RMV method
converting RMV into O₂ consumption

1.5 Providing adequate oxygen

The inspired mix is NOT the same as in the tank
Assumptions
Setting the inspired oxygen value for the dive
Selecting the minimum flow rate (Qs) to provide at least a FiO₂ of 0.2
Dive cylinder duration

1.5 Dive planning

Using the FiO₂ concept in dive planning
Practical examples
work load and the FiO₂
safety-stop bottom time
cylinder duration
CNS clock
pulmonary toxicity
Class room practice FiO₂ / O₂ consumption (work rate) graphs

T 4: Theory Lecture 4/Generic

1.3 Rebreather functionality and design

1.3 Fundamentals of the rebreather:

mouthpiece

absorbents

the counterlung

hydro-static pressure (static lung load)

gas injection

1.3 Interaction between Rebreather and Diving Equipment f.I. Wet/Drysuit, etc

1.3 Bailout system

T 5: Theory Lecture 5/Generic

1.4 Practical constraints / Maintenance

gas choice and injector size (included also in planning session)

decompression

thermal constraints

buoyancy control

mask and leaks

PO2 monitoring

CO2 absorbent management

Cleaning and disinfecting

2 Practical Lesson

Workbench (SCR / semi-closed rebreather)

4 hours

P 1: System / Assembly and Functionality

1. Demonstration strip down, refill CO₂ stack and rebuild
2. Issue students their SCR for the course
3. Students, under supervision, strip down and rebuild their
4. Testing and recording

P 2: System Preparation and post dive maintenance

- 1 SCR cleaning, disinfecting and Dive Sorb replacement.
- 1 Fill HP cylinder and analyse gas mixture.
- 1 Reassemble SCR, test and record in readiness for next session/checklist use

P3: Shallow sheltered water Session

Min. 1 hours

1. RMV tests, Rest/work – collect results
2. Static weighting & trimming
3. Pre-breathe checks L-FIBBS checks =
Flow
Injection
Breathing Check
Bailout System
SCR expansion valve
4. Mouthpiece procedures : lock, remove, replace and open mouthpiece;
mouthpiece recovery and mouthpiece flooding and clearing
5. Manual gas injection – surface procedure
6. Bailout procedure

Post dive practical

- 3 SCR cleaning, disinfecting and Dive Sorb replacement.
- 3 Fill HP cylinder and analyse gas mixture.
- 3 Reassemble SCR, test and record in readiness for next session / Checklist

P4: Shallow open water dive practise (max 9 m)

1. Pre – dive checks L - FIBBS check (including gas choice and injector size)
2. Buoyancy trimming
3. Mouthpiece (MP) drill ; Close the MP & remove from mouth, replace and open ; MP recovery;
MP flooding and clearing
4. Surface procedure (gas injection)
5. Bailout drill

Post dive practical

- 1 SCR cleaning, disinfecting and Dive Sorb replacement.
- 1 Fill HP cylinder and analyse gas mixture.
- 1 Flow rate test
- 1 Reassemble SCR, test and record in readiness for next session.

P5: Open water dive practise (max 20 m)

- 1 pre-dive checks (including gas choice and injector size)
- 1 trim buoyancy
- 1 closing & removing MP; replacing & opening MP
- 1 recovering lost MP
- 1 clearing flooded tubes
- 1 surfacing procedure - gas injection
- 1 enjoy the dive
- 1 Log dive time & remaining dive sorb time

P6 / P7: open water dives (max depth 40 m)

Prepare, Plan and execute final dive (including gas choice and injector size)

1. Prepare SCR for deeper open water dive
2. Open water dive -
3. all skills (P 5 / 1- 6),
4. enjoy dive
5. Clean, disinfect, refill tank and analysis gas SCR.

SCR Rebreather examination / Final day

Prepare Safety-stop dive plans for

1. a maximum depth of 34 metres
2. a maximum depth of 20 metres
3. a maximum depth of 14 metres

Prepare the Rebreather for diving the above three dive plans for

- Dive No 1** - to Safety-stop plan
Debrief
Surface Interval – prepare SCR for next dive
- Dive No 2** - to Safety-stop plan
Debrief
Surface Interval– prepare SCR for next dive
- Dive No 3** - to Safety-stop plan
Debrief
Clean and prepare SCR for storage

This final day is about giving the student experience and having fun . The depths shown are indicative of the diving range. They are not meant to be absolutes. The local site and conditions should be used intelligently. Furthermore, the planning process should be done without the direct involvement of the instructor. The instructor is there to give advice and keep a watching brief.

III. Knowledge review & skills assessment

Theoretical knowledge :

4. suggested type : final evaluation
4. suggested form : written
4. suggested structure : 4 main topics , 5 questions for each , allotted time 45 minutes
4. question technique : multiple choice (not for planning questions and EAD/O₂Tables
4. allowed support material (for student) : decompression tables

IV. Awarding of certification material

May be given to successful students at end of course Only students who have attended the whole course (and /or successfully passed any required assessment /evaluation) may receive the corresponding recognition material :

- **CMAS Card**
- **Wallcertificate**

CMAS ADVANCED SEMI-CLOSED REBREATHER DIVER Course Outline

PART 1 : STANDARDS & REQUIREMENTS

I. Course Classification [type & level]

1. Classification

The CMAS AVANCED SEMI-CLOSED REBREATHER course is considered as a **speciality** course. As with all other secondary course types, this course can only be classified as an additional qualification.

2. Validity

There are no validity limits for this certificate.

3. Advantages and responsibilities

Successful students are qualified to decompress with double pneumatics in Semi-Closed-Systems and with a second pre-mixed gas mixture.

II. Aims & main focus of the training

8. To impart an extensive understanding of the equipment to the diver in connection with decompression procedures.
8. To bring the diver to the understanding of the additional physical technical problems that can arise in the use of a rigged Semi-Closed Rebreather.
8. To give the diver a sure knowledge of dive planning, as well as to impart the necessary hand signals, which are required for dives with extended SC-Systems.

III. Prerequisites

3. Minimum Age : 18 years
3. Certification level : certified CMAS Advanced Nitrox , Semi Closed Rebreather Diver or equivalent from a comparable Organisation.
3. Medical certification: actual medical examination, according to the requirements of the National Members Association.

IV. Maximum amount of participants

5. Theory/classroom : Ratio instructor / students 1/6
5. Practice/open water: Ratio instructor / students 1/2

V. Requirements of the instructors/assistants

3 Instructor/course leader

3.0 Dive instructor qualification: CMAS 2-Star dive instructor

3.0 Additional: CMAS Advanced SC-Rebreather Instructor

3.0 Practice Certification: The instructor must be active as a dive instructor, according to the requirements of his National Association.

3 Assistants

CMAS advanced SCR Diver and according to the requirements of the course leader.

VI. Equipment

- 3 The Semi-Closed-Rebreathers which are used must all be of the same equipment type.
- 3 All extended systems must be tested by an approved Inspection Institute (CE).
- 3 The instructor must provide all the necessary training aids, audio-visual learning means, course materials, lime, etc.
- 3 Course participants must bring their own personal equipment with them.
- 3 Units per course participant: Minimum 1 unit for 2 course participants.
The units must be disinfected between the dives if two divers use them.

VII. Minimum course requirements

1. Course profile: using the CMAS Trainings programs (see Part 2)
2. Infrastructure: An appropriate classroom for the course requirements and the amount of participants, as well as a suitable open water dive spot.
3. Dive limits according to the acquired certification levels of the diver (as the maximum under the best conditions) and corresponding to the local conditions. The first dive should take place in shallow, sheltered water or in a swimming pool, up to a maximum water depth of 5 meters.
Open water: up to a maximum depth of 40 meters. It is planned to do decompression dives.
4. Minimum duration of each dive: 60 minutes (surface to surface time).
5. All dives must be carried out with the maximum PO₂-limit of 1.5 bar.
6. Supervision: an authorised advanced SCR instructor must be present during the entire course.

VIII. Participants goals

At the end of the course, the participant should provide proof of their knowledge as follows:

2 Theory:

1. Describe the physical and technical special features in connection with diving with extended Semi-Closed-Rebreathers.
2. Explain emergency procedures.
3. Explain the correct dive planning taking into consideration the use of 2 gases and the appropriate tables.
4. Demonstrate your knowledge on dive preparations with extended SCR equipment including elaboration of runtime tables for the actual dives.

2 Practice

- 2 Planning and execution of dives within the limits for the breathing gas used.
- 2 Carry out all emergency procedures in practice.
- 2 Demonstrate equipment specific servicing/checks, as well as inspection procedures for Semi-Closed Rebreathers.
- 2 Demonstrate buoyancy abilities with reel and deco-balloon.
- 2 Correct use of extended Standard dive equipment with SCR.

IX . Minimum course duration:

- | | |
|----------------------------------------------|--------------------------------|
| 1. Theoretical lectures : | 6 hours |
| 2. Practical lectures : | 2 hours |
| 3. Swimming pool or flat, sheltered waters : | 2 hours |
| 4. Open water dives : | 4 dives (max. 2 dives per day) |

X. Quality assurance

In order to guarantee the quality assurance, CMAS recommends that all Associations use only high quality systems. A proven and widely used method is also to hand out questionnaires to course participants and then to analyse the replies.

CMAS ADVANCED SEMI-CLOSED REBREATHER DIVER

PART 2 : TRAINING PROGRAM

I. Course schedule

Minimum duration

- 0. Theory / Basic knowledge: 6 hours
- 0. Practical workshop: 2 hours
- 0. Swimming pool or flat, sheltered waters 2 hours
- 0. Minimum amount of dives in open water 4 dives (min. dive duration 60 minutes surface to surface)

II. Course contents

2 Theory

T 1: Theory lesson 1/ Introduction

2.0 Introduction to the course

2.0 History of mixed gas technology

2.0 The extended SC-Rebreather, general overview

Two parallel pneumatic systems in the same breathing loop.

Configuration and usage

Gas change between bottom gas and decompression gas

Reducing decompression obligation through the use of two different nitrox gasses in the system.

T 2: Theory lesson 2/ Equipment

5.0 Equipment function and design

Second pneumatic.

Gas change function and handling.

Absorber lime cartridge with reduction insert.

Monitoring of oxygen in breathing loop.

Redundancy of the system.

5.0 Equipment handling and testing

Filling and storage of gas mixtures.

Choice of the dosing nozzle and test of the flow.

Circulatory system evacuation and inflation (pressure tests).

Chemical reaction of the breather lime.

Controlling the swimming position.

Accessibility of the equipment.

Matching: underwater buddy pair check.

Working with reel and deco-balloon.

T 3: Theory lesson 3 / Physics and physiology

5.0 Repetition

➤ Molecular composition of the breathing gas.

➤ Oxygen

✓ Oxygen poisoning, CNS%.

✓ Oxygen shortage during ascent.

✓ Suffocation.

➤ Nitrogen

✓ PPN2 controls the decompression obligation.

✓ Nitrogen narcosis.

➤ CO2 poisoning

➤ Caustic cocktail

➤ Thermo-dynamics and hypothermia.

5.0 Deeper into physics and physiology

Decompression efficiency with use of high percentage oxygen nitrox.

The oxygen window.

Which deco-gas is the right one to choose?

Free radicals

Pulmonary oxygen toxicity OTU

5.0 Symptoms, signals and treatment

Hypoxia

Hyperoxia

Hypercapnia

Decompression illness

Inert gas anaesthetic.

T 4: Theory Lesson 4 / Oxygen logistics

1.3 The diver's oxygen demand

How to determine the divers oxygen demand during different workloads.

Connection between workload, supply gas composition, flow rate and breathing gas composition.

Choice of flow rate and consequences during hard work, during ascent, and in the surface, of a wrong choice.

Determination of maximum operating depth (MOD).

Choice of decompression gas.

Determining maximum depth for gas switch.

T 5: Theory Lesson 5 / Dive planning

0.0 Choice of gases

Choice of bottom gas for the actual dive.

Expected workload during the dive.

Choice of gas flow (nozzle) for the dive.

Choice of decompression gas.

Choice of gas flow (nozzle) for the decompression.

0.0 Decompression obligations

Choice of dive table.

Determination of required decompression stops.

Elaboration of run time table for the planned dive.

Elaboration of alternative run time tables for excessive depth and for excessive time.

The use of computer assisted dive planning.

The use of personal dive computers.

0.0 Gas management

Choice of size of bottom gas tank and calculation of maximum dive time.

Choice of decompression gas tank size and calculation of maximum decompression time.

Calculation of bail out gas requirement and choice of tank size.

2 Practice

P 1: Practice lesson 1/ Preparation before a dive

Composition and function

- Handing out of SCR's to the participants for the duration of the course.
- The course participants will dismantle and reassemble their SCR's,
- Check the functions and for leakage.
- Check the gas mix and flow and document the data.

P 2: Practice lesson 2/ Preparation after the dive

Preparation and provisions after the dive

- Clean and disinfect the SCR.
- Fill the pressure container and analyse the gas mixture.
- Reassemble the SCR, test it and document the data in preparation for the next dive.

P 3: Practice lesson 3 / maintenance of the SCR

User maintenance

- Preparing for storage.
- User maintainable parts
- Dealer maintainable parts
- Schedule for tests and replacements

P 4: Practice lesson 4/ Dive in a swimming pool ***Min. 2 hours***

0.0 Preparation

Optimise the weight distribution.

Check the pre-breathing control L-FIBBS.

Handling of the extended equipment (2nd pneumatic).

Gas change in the system, turning off the travelling gas, evacuating the circulatory system, opening the deco-gas and rinsing.

Setting of reel and balloon (shackle on and off).

Swimming with a set balloon.

0.0 Handling after the dive

Clean and disinfect the SCR and dispose of the absorber lime.

Fill the pressure container and analyse the gas mix.

Reassemble the SCR, test and document the data in preparation for the next dive.

Set the run time for the next dive.

P 5: Practice lesson 5/ Flat open water (max. 9 m)

1.1 Preparation

Pre-dive check L - FIBBS control.
Buoyancy control.
Handling before the dive (rinsing).
Wet-exercise check > matching.

1.1 Handling after the dive

Clean and disinfect the SCR and replace the absorber lime.
Fill the pressure container and analyse the gas mix.
Through-flow control with the flowmeter.
Reassemble the SCR, test and document the data in preparation for the next dive.
Set the run time for the next dive.

P6: Practice lesson 6/ Open water (max. 20 m)

Pre-dive check.
Rinsing.
Matching.
Buoyancy control.
Gas change with mutual control.
Introduction of the decompression procedures.
Setting of the reel and balloon.
Document the data on the dive time and remaining absorber lime time.

P7 / P8/ Practice lessons 7 + 8/ Open water dives (max. depth 40 m)

Preparation, planning and carrying out of the last dives

- Prepare the SCR for a dive in deeper, open water (lime container without reduction insert).
- Dive in open water - max. 40 m.
- All skills according to P 5 / implementation of 1- 6.
- Enjoy the dive.
- Clean and disinfect the system, fill the pressure container and analyse the gas mix.

III. Knowledge review & skills assessment

Theory:

1. Recommended methods : final assessment.
1. Recommended form : in writing.
1. Recommended structure : 4 main themes, allowed time 60 min.
1. Questioning technique : multiple choice & in writing.
1. Allowed support material (for course participants) : all tables.

IV. Awarding of certificate material

May be given to successful course participants at the end of the course. Only course participants who have attended the whole course, (and/or have successfully passed the required examination/assessments) may receive the corresponding recognition material :

- CMAS CARD
- WALL CERTIFICATE

CMAS SEMI-CLOSED (SC) REBREATHER INSTRUCTOR

Standards and Requirements

Definition :

An experienced Rebreather Diver (semi –closed) , who has the knowledge , skills and experience required to teach groups of Rebreather divers in the classroom, pool and open water.

I. Entry Requirements

Minimum Age :	19 years
Certification level :	CMAS 2 Star Instructor CMAS Basic Nitrox Instructor or equivalentCMAS Rebreather Diver (semi – closed)
Minimum number of hours in open water :	minimum 25 Dives , 25 hours bottom time in open water with semi – closed Rebreather
Experience :	Must have participated on at least one Rebreather Diver (semi closed) course in the role of Assistant Instructor

II. Assessment and certification

1. Pass a written examine
2. Demonstrate the ability to instruct a group of students in Rebreather techniques , theory and practical

III. Qualification

The CMAS Rebreather Instructor (semi-closed) is qualified to organise and instruct on CMAS Rebreather Diver courses and to evaluate and certify successful candidates .

CMAS ADVANCED SEMI-CLOSED REBREATHER INSTRUCTOR

Standards and Requirements

I. Entry Requirements

Minimum age :	18 years
Instructor qualification :	CMAS 2 star instructor CMAS Advanced Nitrox instructor CMAS SC-Rebreather instructor
Minimum open water dives as user:	50 hours
Proof of activities: Course	Must have participated in at least one Advanced SCR User- as an assistant trainer.

II. Assessment and Certification

1. The written examination must be passed.
2. Demonstrate the ability to instruct a group of course participants in practice and theory of advanced Rebreather-Technology.

III. Qualifications

The CMAS Advanced Semi-Closed-Rebreather instructor is qualified to organize and instruct CMAS-Advanced Rebreather dive courses and to evaluate and certify successful candidates.