Dräger Ray Semiclosed Rebreather Specialty Course Instructor Outline

Product Number 70253 Version 1.0

Legend

Note to instructors:	Required information. Read to student divers as printed.
Note to students:	Important information. Read to student divers.
By the end of this session, you will be able to: • *Objective* • *Objective* • *Objective*	Objectives always precede individual Academic Topics and open-water dives.
	Points for the instructor to consider that give additional qualifying information about conducting the course. Not intended to be read to students.

PADI®
Ray Specialty Course Instructor Outline

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Please read this first.

Qualifying To Teach PADI Specialty Diver Courses

To apply for a Specialty Instructor rating, an individual must be certified as a PADI Underwater Instructor or higher. There are two ways to qualify to teach PADI Specialty Diver courses: 1) Attend a Specialty Instructor Training Course conducted by PADI Course Directors, or 2) apply directly to PADI.

Specialty Instructor Training Course attendance is *highly recommended* and *encouraged*. These courses provide hands-on training, technique demonstrations, course marketing information, current PADI Standards information and, when applicable, instructor-level open-water training.

Application made directly to PADI requires either: 1) use of a PADI standardized Specialty Course Instructor Outline (this document), or 2) the submission of a self-generated specialty course outline for review. To speed outline approval, reduce liability exposure and ensure educational validity of your specialty courses, it is highly recommended that PADI standardized Specialty Course Instructor Outlines be used for courses they have been developed for.
The Specialty Course Instructor Application is to be used whether attending a Specialty Instructor Training Course or applying directly to PADI.

> *Important Note: Prior to promoting or teaching a PADI Specialty Diver course, written confirmation of instructor certification in that specialty must first be received from PADI.*

For more information on certification as a PADI Specialty Instructor, please refer to the "General Standards and Procedures" section of the PADI *Instructor Manual*. If you still have questions after reading this section, call the Training and Education Department at your PADI Office.

Introductory Information
Ray Specialty Course Instructor Outline

For specific PADI Standards on teaching a Ray Specialty course, please refer to the "Specialty Diver Courses" section of the PADI *Instructor Manual.*

Heading IV in the outline provides information that student divers master prior to the conclusion of the course. At your discretion, students may cover topics in this section through independent study, reviews and informal sessions as appropriate.

Heading V, the Confined-Water Dive, provides information on conducting the required confined-water dive in the course.

Heading VII, IX,X and XI provide information about conducting the open-water dives in the course.

I. Course Overview

The purpose of the PADI Semiclosed Rebreather – Ray specialty course is to familiarize divers with the skills, knowledge, planning, organization, procedures, techniques, problems, hazards and enjoyment of diving with a Ray semiclosed rebreather. The Semiclosed Rebreather – Ray specialty course is intended to serve as a training program that emphasizes adventure and fun while establishing the benefits of Ray semiclosed rebreather diving and developing the skills required. The goals of PADI Ray semiclosed rebreather training are:

A. To develop the student's knowledge of Ray semiclosed rebreathers — when to use Ray semiclosed rebreathers, types of semiclosed rebreathers available, Ray semiclosed rebreather accessories, their maintenance, and how to make minor repairs.

B. To develop the student's ability to perform the skills needed, or that may be needed, when diving in a Ray semiclosed rebreather.

C. To enable the student diver to plan, organize and conduct dives using a Ray semiclosed rebreather.

II. Semiclosed Rebreather – Ray Course Requirements

A. Prerequisite certification: PADI Advanced Open Water Diver, Advanced Plus or equivalent (for this program, equivalcency is proof of certification beyond entry level with experience in deep diving and underwater navigation), or PADI Open Water Diver (or equivalent) with proof of at least 10 dives logged beyond training dives for Open Water Diver certification.

B. Prerequisite certification: PADI Enriched Air Diver or equivalent. The term equivalency is defined as proof of enriched air certification that qualifies the diver to use any blend of enriched air up with up to 36 to 40 percent oxygen. Certifications that permit only the use of EANx32 and EANx36 are not considered equivalents. If accepting equivalent certification, ensure that students know how to use the DSAT Enriched Air RDPs, Equivalent Air Depth Tables and Oxygen Exposure Table.

C. Minimum age requirement: 15 years.

D. Student diver-to-instructor ratio: 6:1.

E. Completion of a confined-water Ray semiclosed rebreather training session is required. This confined-water session must be completed prior to making the first open water training dive of this specialty course. Additional confined-water training may be added at the discretion of the instructor conducting the specialty course.

F. Dive data.

1. One confined water dive
2. Three open water dives.
3. The maximum depth for training Open Water Divers 18 metres/60 feet, or the depth at which the supply gas oxygen partial pressure reaches 1.4 ata, whichever is shallower. The maximum depth for training Advanced Open Water during this course is 30 metres/100 feet (using optional EANx32 upgrade). The depth will never exceed that at which the supply gas oxygen partial pressure reaches 1.4 ata.
4. Student divers will be directly supervised by instructor during all open water dives.

III. Student Diver and Instructor Equipment Requirements

A. Student diver equipment.

1. All personal standard diving equipment including:
   a. Mask, snorkel and fins. (Snorkel does not have to be worn on mask the entire dive.)
   b. Ray semiclosed rebreather with bailout system and integrated BCD.
   c. Exposure suit and accessories appropriate for local diving environment and depth. Accessories may include hood, boots and gloves (wet or dry) or mitts if needed.
   d. Instrumentation, including a means to monitor depth, time and direction.

Note to instructors: Depth and time monitoring may be accomplished through use of electronic dive computers, although student divers should be encouraged to carry additional depth and time monitoring instrumentation as backup in case of computer failure.

   e. Recreational Dive Planner, Enriched Air RDPs, DSAT Equivalent Air Depth Table and Oxygen Exposure Table.
   f. Diving tool or knife.
   g. Slate with pencil.
   h. Whistle.
   i. Log book
   j. Ray Instructions for Use manual

2. Specialty equipment/supplies
   a. DiveSorb®.
   b. Spare Ray components that are appropriate for replacement by end user (hoses, breathing bag, etc.)
   c. Antiseptic and maintenance equipment
   d. Oxygen analyzer

B. Instructor equipment.
1. All personal standard and specialty equipment required by the local environment. Note: The instructor may use open circuit scuba during open water training dives.
2. Recommended safety equipment.
   a. Boat or surface float with reference line

      (12 mm/.5 in line recommended) for descents/ascents as appropriate for conditions or activity.
   b. First aid supplies/equipment. Recommended: First aid kit, pocket mask and emergency oxygen system.
3. Specialty instructor equipment.
   a. Additional weights — in small increments to help student divers trim their buoyancy.
   b. Tool kit.
4. PADI materials that may be used to teach this course.
   a. General materials and teaching aids:
      1. Log Book (Deluxe Diver's Log Book recommended).
      2. PADI Instructor Manual.
      3. Student Record File.
   b. PADI reference materials.
      1. PADI Enriched Air Diving video, diver and professional editions.
      2. PADI Enriched Air Diver Manual
      3. The Encyclopedia of Recreational Diving book and Multimedia CD-ROM.
   c. Recognition materials.
      1. PIC envelopes.
      2. Specialty Diver wall certificates.

IV. Knowledge Development Presentation
The following is a formal classroom presentation. Directions to or comments for the instructor are enclosed in [brackets].

This outline is written so that you give this single classroom presentation at the start, with all subsequent knowledge integrated into detailed confined water and open water dive briefings.

By having student divers read the Instructions for Use independently, you may find it effective to integrate this presentation into briefings, with little or no need for a formal "classroom" setting.

A. Introductions, course overview and welcome to the course.

1. Staff introductions.

a. [Introduce yourself and assistants.]

b. [Have student divers introduce themselves and explain why they're interested in Ray semiclosed rebreather diving — break the ice and encourage a relaxed atmosphere. Some students may mention they want to make technical dives — exceed recreational limits, make decompression dives, etc. Explain that this course and the Ray were not intended for that type of diving, but that students will learn important skills for more technical rebreather diving if they desire to go that direction after gaining more experience.]

2. Course goals.

a. To develop your practical knowledge of Ray semiclosed rebreather diving.

b. To dispel some of the myths regarding Ray semiclosed rebreathers.

c. To increase your dive skills.

d. To enable you to plan, organize and make dives using a Ray semiclosed rebreather.

e. To provide you with additional supervised experience.

f. To encourage you to participate in other PADI continuing education courses.

3. Course overview.

a. Presentations. [You may hold reviews and discussions as predive briefings. If you will use more

formal classroom presentations, give the times, dates and locations.]

b. Open-water training dives. There will be at least three Ray semiclosed rebreather dives during this course during which you'll practice Ray semiclosed rebreather diving techniques and gain experience in using a Ray semiclosed rebreather.

c. Confined water dives: There will be one confined-water Ray semiclosed rebreather dive prior to making the open-water dives. This session will be on _____ (date) at _____ (location).

4. Certification.

   a. When you successfully meet the performance requirements for the course, you will have earned the PADI Semiclosed Rebreather – Ray Specialty certification.

   b. Certification means that :

      1. You have been trained to plan, organize, conduct and log open-water dives using a Ray semiclosed rebreather in conditions generally comparable to, or better than, those you were trained in.

      2. You may apply for the rating of Master Scuba Diver if: 1) you are a PADI Divemaster or higher certification with certification in four other PADI Specialty ratings (in addition to Semiclosed Rebreather – Ray), or 2) you are a PADI Advanced Open Water Diver and a Rescue Diver with certification in four other PADI Specialty ratings in addition to Semiclosed Rebreather – Ray.

      3. You are qualified to dive with a Ray semiclosed rebreather, and obtain fills and carbon dioxide absorbent for it without further instructor supervision.

5. Class Requirements.

   a. Cost of course. [Be sure to explain all course costs.]

   b. Equipment needs [Be sure students understand what they must supply and what the course includes].

   c. Course materials.

   d. Attendance requirements.

6. Administration.
    a. Complete paperwork — Enrollment, Standard Safe Diving Practices Statement of Understanding, PADI Medical Statement, Liability Release and Express Assumption of Risk. [The PADI Student Record File contains all of these forms. Using it makes completing course paperwork easy and convenient.]

B. Benefits and Drawbacks to Using a Semiclosed Rebreather

Learning Objectives: By the end of this section, you will be able to answer the following questions:

1. *What are meant by "rebreather," "semiclosed rebreather," "closed circuit," "semiclosed circuit" and "open circuit" scubas?*
2. *How does a semiclosed rebreather differ from a fully closed rebreather and open circuit scuba?*
3. *What are five advantages to using a semiclosed rebreather versus open circuit scuba?*
4. *What are three disadvantages to using a semiclosed rebreather versus open circuit scuba?*

1. Types of scuba — we call the equipment we use as recreational divers "scuba," but it is only one of several types of scuba. By definition, scuba is any self-contained device that permits you to breathe underwater.
    a. open circuit scuba — the type of scuba you're used to. You inhale air or enriched air from the cylinder and exhale into the water. Your exhaled gas is not reclaimed — hence, the circuit is "open."
    b. closed-circuit scuba or closed-circuit rebreather — commonly used by military divers and by some technical/research divers. You inhale gas (usually enriched air) from a breathing bag (counterlung). Your exhaled breath goes through a chemical scrubbing process to remove waste carbon dioxide, then returns to the breathing bag. You only use a small portion of the oxygen you inhale, so the unit adds a small amount of oxygen to replace what your body consumed. You rebreathe the oxygen you didn't actually use. The circuit is "closed" because it reclaims all your exhaled gas. This type of scuba typically requires extensive training because it is complex.
    c. semi-closed circuit scuba or semiclosed circuit

rebreather — this is what the Ray is. You inhale enriched air from a counterlung. Your exhaled breath goes through a chemical scrubber to remove waste carbon dioxide, then returns to the breathing bag. A slow, continuous flow of enriched air enters the breathing bag to replace used oxygen, and an exhaust valve permits a small amount of gas to escape. The circuit is "semiclosed" because part of your exhaled gas is reclaimed, part is lost. Semiclosed circuit offers some of the advantages of closed circuit with much less complexity (requires no electronics) and simplified training.

2. Advantages of using a semiclosed rebreather compared to using open circuit scuba.
   a. fewer and smaller bubbles, and quieter — easier to get close to shy wildlife
   b. same diving in a smaller package — you can have the same bottom time with one small cylinder and canister of scrubber as with two or three scuba tanks
   c. duration independent of depth — there's no practical change in how long your gas lasts between a deeper dive and shallower dive
   d. warm, moist air — your breath's moisture recirculates, and the scrubbing process generates some heat; hence you may stay warm longer, and you tend to dehydrate less than when breathing with open circuit
   e. in case of a problem, you usually have some time — rebreathers have gas in their counterlungs even if the cylinder shuts off; with some problems, this gives you more time to think and react
3. Disadvantages of using a semiclosed rebreather compared to using open circuit scuba.
   a. setup, disassembly and maintenance are more time consuming and require attention — not as simple and straightforward as open circuit
   b. you must use EANx50, or EANx32 with the optional upgrade, and you must have scrubber — you cannot use air if enriched air isn't available, and there's no way to use the unit at all without chemical scrubber
   c. you have to look for problems — when open circuit has a problem, there's no doubt and you know

right away; with semiclosed (and closed) rebreathers, you can have a problem and not know until it's too late, unless you're trained for and watch for such problems.

C. Using EANx 40 to EANx60

Learning Objectives: By the end of this section, you will be able to answer the following questions:

1. *What are the equipment considerations for using enriched air with more than 40 percent oxygen?*
2. *How do you determine your oxygen exposure for enriched air with more than 40 percent oxygen?*
3. *How do you determine your equivalent air depths for enriched air with more than 40 percent oxygen?*
4. *What are your maximum depth and contingency depths when using the Ray?*

[Note to instructor: If student divers are certified with a technical nitrox rating that covers the use of Enriched Air with up to 60 percent oxygen, you may omit the portions of this presentation that cover objectives 1 through 3.]

1. You'll be using EANx50 in the Ray. Although you'll learn some differences between open circuit enriched air diving and semiclosed rebreather enriched air diving, you'll follow essentially the same procedures. However, your training to this point may be limited to EANx40.
2. Equipment considerations with EANx40 and up
   a. While there's some debate about whether all equipment needs to be cleaned and compatible to oxygen service standards for enriched air with less than 40 percent oxygen, when the oxygen percentage exceeds 40 percent, the need for oxygen service standards is accepted unanimously.
   b. Besides assuring that all equipment that will be used with EANx40 or a blend with higher oxygen, follow all equipment manufacturer recommendations.
3. Oxygen exposure — with EANx40 and up, you use the same procedures you've already learned. However, the Equivalent Air Depth Table doesn't list oxygen partial pressures for these blends, so use the oxygen partial pressure formula in the Enriched Air Diver Manual.

You use the partial pressure to determine your oxygen exposure and oxygen exposure time remaining on the DSAT Oxygen Exposure Table the same as with any enriched air blend. [Make up one or more problems proving a depth, time and blend with 50 percent oxygen and have students determine their oxygen partial pressure and oxygen exposure. Have them determine oxygen exposure time remaining for a planned repetitive dive. This should go quickly, but be sure all students understand before moving on.]

4. Equivalent air depths — similarly, you use the EAD formula to determine equivalent air depths because they don't appear on the Equivalent Air Depth Table. [Make up one or more problems proving a depth, time and blend with 40 to 60 percent oxygen and have students determine their EADs. This should go quickly, but be sure all students understand before moving on. For review, you can continue on and have students calculate one or more repetitive dives using the formulas to find EADs and oxygen exposure.]
5. Maximum and contingency depths — As you recall, you don't plan dives to a depth that would make your oxygen partial pressure exceed 1.4 ata, with 1.6 ata the contingency limit. With the Ray, your maximum depth is 18 metres/60 feet, and your contingency depth is 22 metres/70 feet. If you're using EANx32 with the optional upgrade, your maximum depth is 30 metres/100 feet and contingency depth 40 metres/130 feet. You can find maximum and contingency depths for any oxygen blend using the formulas in the Enriched Air Diver Manual.

Important Note: The most current manual supplied with the Ray and revised procedures issued by Draeger supercede the material in this outline. Revise the material you present to student divers based on the most current information available. Advise students that Draeger may send owners updates, revisions and other information that may change the recommended procedures, which should be followed.

D. Ray Semiclosed Rebreather Components and Function

Learning Objectives: By the end of this section, you will be able to answer the following questions:

1. *How does the Ray work?*
2. *What are the basic components to the Ray?*
3. *What are the purposes and functions of each of the basic components?*
4. *What variables affect the oxygen content of the counterlung?*
5. *What seven problems/hazards can you have with the Ray that you wouldn't have with open circuit scuba?*
6. *How does buoyancy control differ using a rebreather compared to using open circuit scuba?*

1. Ray operation and component overview

[Note to instructor: Have a unit open and point to each component and indicate the gas flow path as you describe the operation. Don't go into a lot of detail at this point — the idea is to give students the basic picture of how it works, what each component looks like and where it fits. Details on component use come later.]

a. Let's look at the unit operation beginning with when the diver exhales (you have to start somewhere). The exhaled breath flows through the mouthpiece and exhaust hose (one-way valves control the flow direction) to the exhalation bag. Excess gas escapes from the pressure relief valve (also called the exhaust valve). You set the pressure relief valve to control the desired breathing volume in the unit. (More about this later.)

b. From the exhalation bag, the gas passes through the CO_2 scrubber, which holds the dry chemical DiveSorb® that removes waste carbon dioxide.

c. From the CO_2 scrubber, the gas goes into the inhalation bag (also called the counterlung). The oxygen sensor (optional) tells you the oxygen partial pressure of the gas you're breathing.

d. The supply cylinder feeds enriched air to the regulator, which injects a continuous small stream of enriched air into the inhalation bag. This continuous flow assures a stream of oxygen to replace the oxygen you consume. (More about this later.)

e. The regulator has a bypass valve, which provides extra gas from the cylinder if the inhalation bag

volume drops below what you need when you inhale, such as when you descend. The submersible pressure gauge tells you how much gas you have in the cylinder, just as when using open circuit scuba.

f. The BCD operates just like those you're used to with open circuit scuba. The extra second stage coming off the regulator is the bailout system, which is a compact open circuit scuba unit supplying gas directly from the supply cylinder in case you have a problem with the Ray.

g. From the inhalation bag, the gas returns to you when you inhale through the inhalation hose (which has one-way valves) and the mouthpiece. Note that mouthpiece closes — [!] You must close the mouthpiece before taking it out of your mouth underwater or at the surface in the water, or the system may flood, which can make it unoperational and cause any of several serious problems.

h. The total path from the mouthpiece, through the unit and back to the mouthpiece is called the breathing loop.

2. Unlike with open circuit scuba, the oxygen content in the gas you inhale varies depending on how fast your body uses oxygen. It will also vary if you use EANx32 with the optional upgrade. This varying oxygen content is discussed shortly.

3. Ray problems/hazards that don't exist with open circuit scuba

   a. Scrubber depletion — DiveSorb® can absorb a limited level of carbon dioxide. If you exceed this limit, or get the chemical wet, waste carbon dioxide stays in your breathing gas, with potential for headache, nausea, with unconsciousness and drowning in the worst case. This is called hypercapnia. You'll learn to change the scrubber well within its capacity to absorb CO_2.

   b. Channeling/ bypassing scrubber — If you don't pack your scrubber properly, gas can form a "channel" through the DiveSorb® rather than flowing smoothly through the entire scrubber material. This quickly depletes the scrubber in the channel, after which the scrubber canister absorbs little carbon dioxide. Improper assembly or damage to the scrubber can allow circulating gas to go around it. Either creates the same problems as scrubber deple-

tion. You'll learn to pack, inspect, assemble and check the scrubber properly to avoid these.

c. Water in the breathing loop — Water, aside from normal condensation, in any part of the breathing loop causes tremendous breathing effort. If DiveSorb® gets wet, it no longer absorbs carbon dioxide. Although rare, water mixing with the chemical can cause a caustic cocktail, which is when scrubber dissolved in water returns to the mouthpiece, potentially causing chemical burns in the mouth and breathing passages. You'll learn how to keep water out of the breathing loop.

d. Hypoxia — It may seem strange that you can have too little oxygen when you're using enriched air, but it can happen several ways:

   1. Hypoxia (insufficient oxygen) is possible if you exceed your planned exertion rate and consume oxygen from the recirculating gas faster than planned.

   2. The flow rate can be set too low for your exertion level and/or the enriched air blend you're using.

   3. Hypoxia can cause unconsciousness without warning due to too low oxygen if you run out of supply gas, or if your exertion rate is too high. In these cases, the oxygen partial pressure may drop below the threshold needed to stay conscious. This can happen at any point in the dive, but particularly while ascending because the inspired oxygen partial pressure drops as pressure lessens. This can lead to drowning. You'll learn several steps and procedures for avoiding hypoxia.

e. Decompression sickness – If your oxygen consumption exceeds the level you planned for, you'll have more nitrogen in the breathing gas than you planned for. You'll absorb nitrogen faster, shortening your no decompression limits, creating DCS risk if you're not aware of it.

f. Narcosis – Similarly, higher than planned oxygen consumption will elevate nitrogen, creating more potential nitrogen narcosis at a given depth.

g. Sensor failure — The oxygen sensor can stop giving you oxygen information. This removes a safe guard you have for avoiding hypoxia, DCI and narcosis problems. You'll learn what to do if this happens.

4. Buoyancy control with the Ray
    a. You'll learn to control your buoyancy by controlling the inhalation bag volume, and by adjusting the BCD.
    b. With open circuit scuba, your changing lung volume as you inhale and exhale allows you to fine-tune your buoyancy. With a rebreather, as you inhale the counterlung contracts, and your overall volume and buoyancy remain the same.
    c. Therefore, you can't use breath control and lung volume to fine-tune your buoyancy when rebreather diving.
    d. As you ascend, gas in the counterlung and breathing loop expands. If you ascend faster than it escapes through the over pressure valve, reduce the loop volume by inhaling through your mouth and exhaling through your nose.
    e. Bag purging (discussed in detail later) is the process of refreshing gas in the counterlung. Your buoyancy drops significantly for a moment while doing this.

E. Planning Dives with the Ray Semiclosed Rebreather

Learning Objectives: By the end of this section, you will be able to answer the following questions:

1. *What are the two basic parts of planning a dive with the Ray semiclosed rebreather?*
2. *How do you calculate your oxygen exposure when using the Ray semiclosed rebreather?*
3. *How do you plan for the amount of oxygen in your breathing gas when using the Ray semiclosed rebreather?*
4. *How do you set a dive computer or use dive tables when using the Ray semiclosed rebreather?*
5. *How does the oxygen sensor assist you in determining the content of your breathing gas?*
6. *What is the approximate cylinder duration with the Ray semiclosed rebreather?*
7. *What is the approximate scrubber duration with the Ray semiclosed rebreather?*

1. There are two basic steps to follow when planning a dive with the Ray semiclosed rebreather:
    a. determine your oxygen exposure and oxygen exposure limit for the planned dive

b. determine the EAD to use with dive tables, or what enriched air blend to set in an enriched air computer, and determine your no decompression limit

2. Determining oxygen exposure and oxygen exposure limits

   a. The oxygen content in the inhalation bag fluctuates with your exertion level, but can be as high as the oxygen content of the supply gas (EANx50, or EANx32 with the optional upgrade).

   b. Using the DSAT Oxygen Exposure Table, calculate your oxygen exposure and oxygen exposure time remaining as though you were using EANx50 (optional EANx32) for the entire dive just as you would with open circuit enriched air.

   c. If using an enriched air computer, you have to determine oxygen exposure manually. This is because you'll be setting your computer based on the inhalation bag oxygen content, NOT the supply gas content.

3. Determining your EAD and using dive tables/computers.

   a. The nitrogen content in the counterlung varies depending on your exertion level because you consume oxygen from the recirculating gas. Therefore, the gas you breathe is higher in nitrogen/lower in oxygen than the supply gas.You determine the EAD/set an enriched air computer based on the highest nitrogen/lowest oxygen expected during the dive.

   b. Oxygen consumption varies with your activity level. Average is 1 l/min. (litre per minute) 2 l/min is considered high and .75 l/min. low. A conservative number for all-round diving with moderate exertion is 1.5 l/min. When in doubt, for conservatism, use a higher rather than lower oxygen consumption rate.

   c. Dive the Ray assuming your oxygen consumption is 1.5 l/min, or 2.0 l/min if you are big or will be working hard during the dive.

      1. For 1.5 l/min, plan use the RDP/set your computer as though using EANx35.

      2. For 2.0 l/min, plan use the RDP/set your computer as though using EANx30

3. If using EANx32 with the optional upgrade, for 1.5 l/min, plan use the RDP/set your computer as though using EANx24.
4. If using EANx32 with the optional upgrade, for 2.0 l/min, plan use the RDP/set your computer as though using EANx22.

d. See the tables in the Ray Instructions For Use manual.

e. Use the oxygen sensor to verify that the inhalation bag contents have the oxygen percentage you planned, or higher, throughout the dive. By noting the lowest point reached over several dives and comparing it to the oxygen contents table, you may fine-tune the oxygen consumption rate used for dive planning.

4. Supply gas cylinder duration

a. Flow rate may be treated as a constant:

1. Flow actually varies as much as 11 percent from the average rate (used as the constant); this variation is within the allowable tolerance range.
2. Flow is = 7.3 l/min, .26 cf/min
3. With optional EANx32 upgrade, the flow when using EANx32 is 15.5 l/min, .55 cf/min

b. With the standard 4 litre Ray cylinder, the approximate duration starting with a full cylinder is 96 minutes.

c. Using EANx32 with the optional upgrade, the approximate duration starting with a full 4 litre cylinder is 45 minutes.

d. The following will reduce the cylinder duration because they exhaust gas from the breathing loop and activate the bypass valve:

1. Clearing and equalizing your mask — you exhale through the nose, venting gas from the breathing loop. Bypass valve replaces lost gas.
2. Descending/frequent depth changes — as you descend, counterlung volume begins to drop due to gas compression. Bypass valve activates to maintain counterlung volume. You exhaust gas from the loop as you ascend by exhaling through your nose, and automatically through the overpressure valve

3. Bag purging — you inhale through your mouth and exhale through your nose to empty the inhalation bag completely; bypass valve replenishes the volume.
4. Excessive use of the BCD (usually caused by overweighting).

5. Frequent tripping of bypass valve due to high exertion or overpressure valve set too low.
6. Scrubber duration
   a. The CO_2 scrubber will last approximately one hour when properly packed with DiveSorb® and used at temperatures between 0°C/32°F and 30°C/85°F.
   b. This is approximate only — if it gets wet, it will exhaust much faster.
   c. If you plan to dive in water below 10°C/50°F, or if DiveSorb® has been stored below freezing, see the Instructions for Use manual for special scrubber packing procedures.

   d. Drager recommends refilling the scrubber with fresh DiveSorb® after every dive to avoid exceeding one hour use. Never exceed one hour use on a single fill of DiveSorb®. Doing so may cause unconsciousness and drowning due to scrubber exhaustion and excess carbon dioxide.
   e. To ensure fresh DiveSorb® when diving:
      1. Store DiveSorb® tightly closed in its airtight container.
      2. If in doubt about whether DiveSorb® has been stored properly, replace it with fresh DiveSorb®.
      3. Do not pack the CO_2 scrubber more than a few hours in advance of use. Don't store the CO_2 scrubber with DiveSorb® in it.
      4. Dispose of used DiveSorb® immediately to avoid confusion with fresh.

F. Handling Problems and Emergencies with the Ray Semiclosed Rebreather

Learning Objectives: By the end of this section, you will be able to answer the following questions:

1. *What are the causes, prevention, signs and action to take for CO_2 scrubber depletion, channeling or bypass?*
2. *What are the possible causes, prevention, signs and actions to take for carbon dioxide buildup?*
3. *What are the causes, prevention, signs and action to take for water in the breathing loop?*
4. *What are the causes, prevention, signs and action to take for low oxygen in the inhalation bag and/or hypoxia?*
5. *What are the causes, prevention, signs and action to take for oxygen sensor failure?*
6. *What should you do if you accidentally lose your mouthpiece while it's open.*
7. *What should you do any time you don't "feel right" when diving with a semiclosed rebreather?*

1. Scrubber depletion, channeling or bypass
   a. Causes (depletion) — overuse of cartridge, improperly stored DiveSorb®, water in scrubber.
   b. Causes (channeling or bypassing scrubber) — improper packing of scrubber, damaged scrubber, improperly assembled scrubber, failed one-way valves.
   c. Prevention — don't use scrubber more than two hours, replace DiveSorb® before each dive, store DiveSorb® properly, keep water out of the breathing loop and pack the scrubber properly. Inspect scrubber before use, assemble properly and perform predive check of scrubber and one-way valves.
   d. Signs — Headache, nausea, shortness of breath, any feeling of not being well, breathing resistance, gurgling sound while breathing, water coming into mouth with inhaled gas, burning sensation or "slick" feeling in mouth (caustic cocktail).
   e. Action to take — Immediately switch to bailout system, terminate dive. Do not use unit again until you determine the cause and have it serviced as necessary.
2. Carbon dioxide buildup (hypercapnia)

a. Causes – Include scrubber depletion, channeling/ scrubber bypass, water in breathing loop (discussed shortly), skip breathing, insensitivity to carbon dioxide, high breathing rates/workload, nonreturn valve failure (you rebreathe the same gas before it passes through the scrubber.

b. Prevention – See scrubber depletion/channeling/ bypass and water in breathing loop (next). Breath normally at all times and avoid exertion levels higher than planned. Perform predive equipment check to confirm proper valve and other part operation.

c. Signs – Headache, excessive breathing resistance, high breathing rate, shortness of breath, not feeling well.

d. Action to take – Immediately switch to bailout system if you suspect mechanical problem or are unsure, and end the dive. If you're breathing excessively due to high exertion, perform a bag purge(inhale through mouth, exhale through nose until you trigger bypass valve two or three times).

3. Water in the breathing loop.

a. Causes — Failure to close mouthpiece before taking out of mouth while in the water, unit components not properly drained before assembly, hole in exhalation bag, inhalation bag, hose or other portion of breathing loop, CO2 scrubber damaged or not assembled properly, excessive condensation buildup

b. Prevention — Close mouthpiece before removing from mouth, inspect and assemble unit correctly and perform predive leak checks, between dives, inspect exhalation bag and inhalation bags for accumulating moisture.

c. Signs — Excessive breathing resistance, gurgling while breathing, caustic cocktail, bubbles coming from unit, unit noticeably heavier.

d. Action to take — Immediately switch to bailout system, terminate dive. Do not use unit again until you determine the cause.

4. Low oxygen/potential hypoxia

a. Causes — exertion level too high, partially clogged flow nozzle reduces flow rate, failure to open

supply cylinder, running out of supply gas, incorrect use of optional EANx32 upgrade.

b. Prevention — Avoid overexertion. Personally analyze supply gas before using it. Perform predive checks including flow rate checks. Perform GGG step before entering water (more about this shortly). Monitor SPG and end dive with ample reserve. Watch oxygen sensor closely.

c. Signs — Heavy exertion with heavy breathing, oxygen sensor (if used) reads oxygen percent too low, gas flow lower than expected (based on SPG readings). SPG reads zero. **It is very important to carefully plan your underwater exertion rate when planning your dive, and to stay within that rate.**

d. Actions to take:

   1. If overexertion, immediately perform bag purge to replenish inhalation bag with fresh supply gas (inhale through mouth, exhale through nose until you trigger bypass valve two or three times).

   2. If oxygen sensor readings are too low without excess exertion, or you suspect too low gas flow, switch to bailout system and ascend immediately. Make a safety stop as long as bailout system permits (but don't run out of gas). Confirm flow rates and oxygen content — if off, your EADs were wrong and you must recalculate or discontinue diving until the next day to clear residual nitrogen. If flow is off, do not use unit again until serviced.

   3. If SPG reads zero, switch to your buddy's bailout system and ascend immediately to the surface. If your buddy is too far away, ascend immediately to the surface. At the surface, you may check the supply cylinder valve if you suspect you forgot to open it. If it is closed, open it and check SPG. If you have gas, stay on bailout system a minute or so for fresh gas to enter inhalation bag before switching back; perform bag purge after switch. If you're out of gas, end the dive.

e. Some divers perform a bag purge prior to all ascents. Although not required, this is an easy added safeguard against low oxygen accidentally causing unconsciousness during ascent.

5. Oxygen sensor failure
    a. Causes — battery failure, impact damage, improper calibration, beyond useful life.
    b. Prevention — check/replace batteries, protect from damage, calibrate according to mfg. procedures and compare periodically with other analyzer, replace sensor as recommended by mfg.
    c. Signs — readout blank or gibberish, readout absurd.
    d. Action to take — Not considered an immediate emergency unless you have a reason to suspect low oxygen (Many divers don't use oxygen sensor.) If low oxygen possible, treat as low oxygen, switch to bailout system and end dive. In normal operation, the inhalation bag should have a comfortable margin between the calculated oxygen and the actual (higher) content. Perform bag purge and ascend using Ray, and end dive. After dive, replace battery or have serviced as needed.
6. Lost mouthpiece
    a. If you accidentally loses your mouthpiece in the water while it's open, the breathing loop may or may not flood, depending on conditions.
    b. Be ready for sudden buoyancy loss. If underwater, switch to your bailout system.
    c. Immediately come to an upright position, which will make an water that does enter the unit run away from the mouthpiece. Retrieve the mouthpiece and close it. Surface staying in the upright position, exit the water and check the unit for flooding.
    d. If underwater when retrieving the lost mouthpiece, it will likely be over your head freeflowing. Keep it slightly elevated and freeflowing as you close it — this may keep the unit from flooding and may, profile permitting, allow you to resume the dive after you've checked it.

7. Anytime you don't feel right, whether it's breathing resistance, an ill sensation or just something you can't "put your finger on," immediately switch to your bailout system and end the dive. Inspect the unit and/or have it checked over by a professional if in doubt.

G. Ray Semiclosed Rebreather Assembly, Predive Check and Maintenance Overview

Learning Objectives: By the end of this section, you will be able to answer the following questions:

1. *Why are predive checks and proper maintenance important to diving safely with the Ray semiclosed rebreather?*

1. Predive checks
   a. Predive checks are important with all scuba gear. With a semiclosed rebreather, it takes on extra importance because some problems, such as a partially obstructed flow nozzle or a failed one way valve, are not readily apparent without performing the special checks.
   b. Therefore, perform all the checks as specified by Drager in the Instructions For Use manual.
2. Maintenance
   a. Maintenance is important for safe diving with any equipment. With rebreathers, an added concern is that microorganisms, some of which can be harmful, can grow inside breathing bags and other parts of the breathing loop.
   b. For reliable function and to avoid health concerns, maintain your unit as specified by Drager in the Instructions for Use manual.

[Note to instructor: Using a disassembled unit, assemble the unit to provide an overview. This should go quickly, while describing (but not actually doing) the methods for checks, scrubber packing, etc., when you do them, and why they're important. Refer to the checklist packaged in the unit. Next, disassemble the unit, similarly describing the maintenance procedures.

The purpose is to give students a broad picture of assembly, predive checks, disassembly and maintenance. They will learn the detail during Practical Application as they assemble their units while you demonstrate and confirm their work.]

V. Confined Water Dive

[Note to instructor: The Confined Water Dive precedes all open water dives. It's recommended that you have the Ray units set up and ready to go. However, at your discretion based on logistics and student needs, you may have students assemble and check their units (see next section, VI. Unit Setup and Check) for the confined water dive. In either case, this section begins with all units assembled and checked according to Drager's recommendations.

The Predive Briefing portion contains material to present to student divers prior to starting the dive.]

A. Predive Briefing

1. This confined water dive will begin developing skills unique to diving with semiclosed rebreathers in general, and the Ray in particular. You'll practice each of these during the open water dives, but begin by being introduced to them and practicing them in the controlled conditions of confined water.
2. The GGG step and assembled unit one way valve check
   a. Because gas flows when the supply cylinder valve is open, you don't open it until right before the dive, and you close it immediately after diving. Get in the habit of the GGG step every time you enter the water so you don't forget to open the valve. [!] Forgetting to open the supply cylinder can lead to hypoxia, unconsciousness and drowning. GGG stands for Gas, Gauge and Gag (mouthpiece).
   b. Gas — Open supply cylinder valve one turn.
   c. Gauge — Check the SPG for ample suppl. Close the supply cylinder valve and watch the SPG needle fall — this confirms gas flow through the nozzle. Open the supply cylinder valve all the way and leave it open; watch the SPG rise.
   d. Gag — ("Gag" is a term used to help you remember in that it refers to having something in your mouth, even though it's not really a gag.) The unit mouthpiece should be closed. Put it in your mouth, exhale to blow out any water, then open the mouthpiece. Get in the habit of always putting it in your mouth before opening, and closing before removing from your mouth. Inhale through your mouth and exhale through your nose until you hear the bypass valve activate two or three times. This replaces air in the inhalation bag and your lungs with enriched air. (Do this whenever you switch to the unit).

e. One-way valve check — Block the inhalation hose by squeezing it and attempt to inhale. You should not be able to. Block the exhalation hose and attempt to exhale. You should not be able to. Close the mouthpiece and remove it from your mouth. If you can inhale/exhale with hose blocked, do not dive with the unit until the one way valves have been serviced.

3. Exhalation bag overpressure valve setting and proper weighting

   a. In addition to the weight considerations you're used to (exposure suit, body composition, salt versus fresh water, etc.), you have to offset the weight of the counterlung, keeping in mind that you no longer use breath control to fine-tune your buoyancy.

   b. The counterlung buoyancy depends on the overpressure valve setting. You want it set so that it holds just enough gas to accommodate your breathing volume. Set too low, you will exhaust gas and trigger the bypass valve on every breath and waste gas; set too high and you have excess breathing resistance and buoyancy. Setting clockwise increases the volume; counterclockwise reduces the volume.

   c. Drager recommends setting the valve all the way open (counterclockwise/anticlockwise), which is optimum for most people. Allow breathing loop to fill until you hear gas exhaust from the valve, then while breathing through the unit (remember GGG step) set your weight so you float at eye level. If not wearing a compressible exposure suit, you may elect to add about one kg/two pounds. Weights go in the unit's integrate weight system, and/or a separate weight system as you prefer. Assure that you can obtain adequate buoyancy by ditching one part of your weight.

   d. After swimming underwater for a few minutes at a constant depth, if you find you're tripping the bypass valve on every breath, close the valve one half a turn. Swim a few more minute, readjusting again as necessary and until you don't trip the bypass valve while breathing normally at a constant depth. You may need to readjust your buoyancy as you readjust the breathing loop volume.

4. Underwater bubble check

   a. When you and your buddy first descend, immediately check each other for bubbles leaking from the breathing loop, hoses or other areas.

b. If you find leaks, surface and inspect the unit to find the problem. Don't dive with a leak.

5. Switching to and from the bailout system

   a. Switching to your bailout system is the primary step if you have a problem, so you'll practice a lot during the dives. However, you want to make the switch without flooding the Ray so you can switch back and continue the dive. It's also important in a real emergency because flooding the unit decreases your buoyancy.

   b. To switch to bailout, secure the bailout second stage and close the Ray mouthpiece while it is still in your mouth. Take the second stage, clear it and breathe from it as with any open circuit scuba.

   c. To switch back, secure the Ray mouthpiece (it will be floating over your head). Put it in your mouth and exhale to blow water out of it, then open it.

   d. This is the signal for "switch to your bailout system." [Demonstrate signal.]

6. Bag purge

   a. Use a bag purge any time you want to replace the inhalation bag gas with fresh gas from the supply cylinder (low oxygen concern, before ascending, when switching to unit after breathing air).

   b. Inhale through your mouth from the unit and exhale through your nose. Your buoyancy will become more negative. Do this until you hear the bypass valve trip; continue for two or three breaths.

   c. Resume breathing through your mouth only. Your buoyancy will return as the inhalation bag returns to normal volume.

   d. Use a bag purge when necessary, but excessive bag purging will shorten your dive by diminishing your gas supply.

   e. This is the signal for "bag purge." [Demonstrate signal.]

7. Underwater buoyancy control

   a. Since breath control has little effect on buoyancy, you control it almost exclusively with your BCD. This means you use your BCD a bit more than you're used to with open circuit scuba.

   b. When ascending, the breathing loop volume expands. It vents through the exhaust valve, but may not vent fast enough to maintain buoyancy control. To prevent

excessive buoyancy, you can eliminate expanding gas from the loop by inhaling through your mouth and exhaling through your nose.

B. Confined Water Dive

Discover Rebreathers Option

You can use this confined water dive as the basis for a Discover Rebreathers experience using the Ray. In conducting a Discover Rebreathers experience, include and cover the following in addition to the points/objectives listed in this section.

1. Prerequisites: To participate in the Discover Rebreather experience, participants must be certified divers.
2. Participant to instructor ratio: 6:1
3. Participants must complete the PADI Medical Statement, Statement of Understanding (Certificate of Understanding) and Express Assumption of Risk, and any other paperwork required by your PADI Office.
4. Describe (briefly) how the Ray works. This doesn't have to be detailed, but gives participants a basic understanding of how the units work.
5. Units should be set up and ready to go. Go over the unit's components, again briefly. Give participants an overview of how semiclosed circuit scuba differs from open circuit scuba mechanically.
6. Be sure participants understand:
   a. The signs of water in the breathing loop and caustic cocktail.
   b. To switch to the bailout system and/or surface immediately if anything doesn't seem right.
   c. The GGG step and the importance of keeping water out of the system.
   d. How buoyancy control with semiclosed circuit scuba differs from with open circuit scuba, and how to control buoyancy.
7. Begin the Discover Rebreather experience by covering the material to meet objectives 1 through 7, and 10. If participants meet all ten objectives during the experience you may, at your discretion, credit this experience as the required confined water dive for participants who enroll in the course.

Learning Objectives: By the end of this confined water dive, the student diver will be able to:

1. *Demonstrate the GGG step prior to entering the water.*
2. *Demonstrate the assembled unit one way valve check.*
3. *Set the exhalation bag overpressure valve (exhaust valve) for the desired gas volume in the unit.*
4. *Establish proper weighting using the Ray semiclosed rebreather.*
5. *Perform an underwater bubble check for a buddy.*
6. *Switch to the bailout system while underwater without flooding the breathing loop.*
7. *Switch from the bailout system to the Ray without introducing water into the breathing loop.*
8. *Perform a bag purge.*
9. *Demonstrate proper buoyancy control while swimming underwater.*
10. *Reduce counterlung volume underwater by exhaling through the nose.*

1. Predive check — BWRAF as usual
2. GGG step — have everyone perform steps as you demonstrate/guide
3. Assembled unit one way valve check — have everyone perform steps as you demonstrate/guide
4. Weighting — everyone begins with over pressure valve all the way open and adjusts weight. Have more weight at hand for fine-tuning as dive progresses.
5. Breathing underwater with the Ray
   a. Student divers descend to bottom. Allow a moment to adjust, then have buddies perform bubble checks for each other.
   b. Allow ample time before moving on to exercises to get used to the breathing characteristics of the unit, adjust buoyancy etc.
   c. Allow divers to swim around a bit and get the feel of swimming and moving.
6. Use of bailout system. Have students switch to and from their bailout systems. Pay close attention to properly closing and opening mouthpiece to avoid introducing water into breathing loop.
7. Bag purge. Have students practice purging their inhalation bags.
8. Underwater buoyancy control. Have student divers establish neutral buoyancy and swim around. Include ascending

and descending, with students releasing gas through their nose to control breathing loop volume during ascents.

9. Free time for skill development and experience. Allow ample time for divers to get familiar with their semiclosed rebreathers. As they become comfortable, periodically have them switch to their bailout systems.
10. Surface, exit appropriate for environment. Remind divers to close the mouthpiece before removing from mouth, and to close cylinder valve after exiting water.

C. Debriefing

After students remove and secure their gear, debrief them on their performances, offer tips and suggestions.

[Note to instructor: Based on logistics and student needs, you may have students disassemble and maintain their units at this time (see section, VIII. Unit Disassembly and Maintenance), or after Ray Dive One.]

VI. Unit Setup and Check

[Note to instructor: This section takes student divers through setup, following the checklist on the CO2 scrubber and the instructions in the Instructions for Use manual. It's recommended that you demonstrate as you go, checking each student's work at each step.

The outline provides the steps as prompts for content and sequence. See and refer students to the Instructions for Use manual for detail and further specifics.

Drager can add or modify the suggested assembly and test procedures. Teach and use the current procedures Drager recommends.]

Learning Objectives: By the end of this session, the student diver will be able to:

1. *Prepare and check the supply cylinder for use.*
2. *Set the regulator for the correct flow rate (if using the optional EANx32 upgrade).*
3. *Test the flow nozzle for proper flow rate.*
4. *Properly fill and prepare the CO2 scrubber cartridge for use.*
5. *Check the breathing hoses for leakage and operation of one way valves.*
6. *Properly assemble the unit components.*
7. *Test the unit for leaks with negative pressure.*
8. *Check the bypass valve for correct operation.*
9. *Check the oxygen sensor.*
10. *Test the unit for leaks with positive pressure.*
11. *Check the BCD for proper operation.*

A. Preparing the Supply Cylinder

1. Check the cylinder pressure for adequate supply. The standard Ray cylinder is full at 200 bar/3000 psi. If it needs filling, remember it must be filled with EANx50, (or 32 with the upgrade) from a proper enriched air source.
2. Analyze the enriched air oxygen content. As in open circuit enriched air diving, you must do this personally, marking the contents on the cylinder tag or decal.
3. Screw the regulator to the cylinder valve.
4. Don't attach to unit yet — you'll use the cylinder for a few predive checks.

B. Setting and Checking the Gas Flow

1. Setting the gas flow — only if EANx32 upgrade is used
   a. Disconnect the MP hose from the bypass valve housing.
   b. Connect the EANx32 u grade housing to the MP hose.
   c. Store the EANx50 housing in a clean, dry location.
2. Checking the gas flow — per Drager, do this before all dives
   a. Connect the flowmeter to the b ypass housing.
   b. Have the regulator attached to a cylinder with at least 50 bar/700 psi, but leave the cylinder valve closed for now.
   c. Put on an even surface.
   d. Open the supply cylinder valve and watch the flowmeter for the proper reading indicated on the meter.
   e. If the unit fails this test, repeat to be sure you didn't do something wrong. If still fails, do not dive with the unit until it has been inspected/serviced by an authorized Ray repair technician.
   f. Close cylinder valve after test to save gas and remove flowmeter. SPG pressure should drop evenly and continuously; otherwise have it serviced.
   g. Remember that cylinder valve, regulator, and bypass housing need to remain oxygen clean to avoid fire/explosion hazard. Keep them away from oil and contaminants, fire or other combustion sources.

C. Preparing the CO2 Scrubber Cartridge

1. Cautions: Drager endorses only DiveSorb® soda lime for use in the Ray. Soda lime is caustic if it becomes moist, and can cause chemical burns. Do not let DiveSorb® come in

contact with your skin or eyes. Improper cartridge packing may lead to scrubber failure and personal injury — pack the cartridge properly according to Drager's instructions.

2. Open cartridge and fill one-third with fresh DiveSorb®.
3. Shake and tap sides with hands to settle contents. Do NOT tap bottom or bang against an object.
4. Fill another third and repeat process.
5. Fill cartridge rest of way to filling line. Shake and tap so then when filled, the DiveSorb® is between the upper and lower fill lines marked in the cartridge.
6. Attach and secure lid.
7. Blow into both cartridge openings alternately to clear out dust, being cautious to avoid contact with DiveSorb® or its dust.
8. Set aside for assembly.

D. Checking the Breathing Hoses for Leaks

1. Open the mouthpiece and inhale/exhale through it. Confirm that air comes in the inhalation side and goes out the exhalation sides only.
2. Close the mouthpiece and blow into the hose end on the inhalation side. Air should flow through. Inhale; there should be no flow or leakage.
3. Open the mouthpiece and put it in your mouth. Block the inhalation hose and inhale. There should be no air flow or leakage.
4. If you have leakage, disassemble and reassemble the mouthpiece and hoses, then recheck. If you still have leakage, don't dive the unit until it has been serviced.

E. Assembling and Testing the Unit

1. Put the CO2 cartridge in place and connect it to the breathing bags.
2. Attach the bypass valve housing to the inhalation bag. Calibrate the oxygen sensor and attach to the CO2 cartridge.
3. Connect the breathing hose, being careful to match the hoses for correct gas flow. Double check the mouthpiece connection.
4. Put the supply cylinder in the cylinder strap and reconnect the regulator. Cinch down the strap securely. Attach the low pressure hose from the regulator to the BCD low pressure inflator.

5. Leak test with negative pressure.
   a. With supply valve closed, inhale bags completely flat through mouthpiece.
   b. Shut mouthpiece.
   c. Bags should not reinflate for about 30 seconds.
   d. If bags reinflate, confirm the supply cylinder valve is closed. If so, there is a leak — do not use unit until it has been properly serviced.
7. Check the bypass valve
   a. Open supply cylinder valve.
   b. Open the mouthpiece and inhale from it until the inhalation bag collapses. It should trip the bypass valve, and you should get enough gas to breathe easily.
   c. If the valve doesn't trip or you get insufficient gas, have the unit serviced before further use.
8. Check the oxygen sensor
   a. With the supply cylinder valve open, close the mouthpiece allow the inhalation bag to inflate.
   b. Check the oxygen sensor reading. The partial pressure should match the 50 percent (or 32 percent) reading you got directly from the supply cylinder by reading .50 (or .32).
   c. If not, recalibrate the oxygen sensor and try again. If it's still off, have it serviced.
10. Positive pressure leak test.
   a. Lay unit on its back, close mouthpiece and set overpressure valve to full clockwise position.
   b. Fill bags and breathing loop completely and close cylinder valve.
   c. Place a two kilogram/five pound weight on inhalation bag and watch. The bag should not deflate noticeably within 30 seconds.
   d. If it does, have the unit serviced before further use.

VII. Ray Dive One

Learning Objectives: By the end of this dive, with instructor guidance, the student diver will be able to:

1. *Prepare the Ray for use by correctly assembling it and performing all predive checks.*
2. *Plan an open water dive with the Ray including determining the NDL, and oxygen exposure limit.*
3. *Demonstrate the predive bag purge and GGG step before entering the water.*
4. *Adjust weight and breathing loop volume (over pressure valve setting) for diving in open water.*
5. *Descend in a controlled manner using the Ray.*
6. *Perform an underwater leak check with a buddy.*
7. *Monitor the SPG throughout the dive so the diver reaches the surface and ends the dive with at least 20 bar/300 psi remaining.*
8. *Monitor the oxygen sensor (if used) to be sure inhalation bags stay at or above the planned oxygen content.*
9. *Switch to and from the bailout system on signal without introducing water into the breathing loop.*
10. *Perform a bag purge on signal and before beginning an ascent to the surface.*
11. *Control buoyancy throughout the dive, remembering to exhale through the nose as necessary during ascent to control breathing loop volume.*
12. *Determine the residual nitrogen (pg) on the RDP and the oxygen exposure after the dive.*
13. *Demonstrate appropriate post dive maintenance/care of the Ray unit.*

1. Briefing.
    a. Evaluation of conditions.
    b. Facilities at dive site.
    c. Entry technique to be used — location.
    d. Exit technique to be used — location.
    e. Bottom composition and topography around training site.
    f. Depth range on bottom — maximum, 18 metres/60 feet.
    g. Ending tank pressure — when to terminate the dive.
    h. Interesting and helpful facts about the dive site.
    i. Sequence of training dive
        1. Suiting up

2. Predive bag purge
3. Gas/Gauge/Gag step
4. Enter water — adjust buoyancy. Remember to close mouthpiece before removing from mouth, put in mouth and clear before opening.
5. Descend, leak check.
6. Switch to bailout and back on bottom.
7. Bag purge just over bottom (so divers experience how much buoyancy drops during bag purge.
8. Tour for fun and experience — divers monitor gauges and control buoyancy. Instructor has them switch to bailout on signal periodically.
9. Preascent bag purge.
10. Ascent, maintain buoyancy control— safety stop at 5 metres/15 feet for three minutes.

j. Special communication underwater and topside.

k. Emergency procedures.

2. Predive procedures.

a. Prepare personal dive equipment and set up/check Ray (see VI. Unit Setup and Check)

b. Perform inhalation bag, oxygen exposure, maximum depth, no-decompression and cylinder duration calculations.

c. Don gear and semiclosed rebreathers.

d. Perform predive safety check.

e. Predive bag purge, GGG step, proper entry.

f. Weight adjustment and start descent.

3. Dive 1 — sequence as listed.

4. Postdive

a. Proper exit

b. Stow equipment as appropriate.

c. Debriefing.

d. Log dive. (Instructor signs log.)

e. Disassembly/maintenance of Ray (see VIII. Unit Disassembly and Maintenance)

VIII. Unit Disassembly and Maintenance

[Note to instructor: This section takes student divers through disassembly and maintenance according to the Instructions for Use manual. It's recommended that you demonstrate as you go, checking each student's work at each step.

The outline provides the steps as prompts for content and sequence. See and refer students to the Instructions for Use manual for detail and further specifics.

Drager can add or modify the suggested assembly and test procedures. Teach and use the current procedures Drager recommends.

You may, if necessary for logistics (such as having two Ray dives back-to-back) split this presentation into parts, but it should be entirely covered before Dive 3.]

Learning Objectives: By the end of this session, the student diver will be able to:

1. *Demonstrate the equipment-related steps to take immediately after ending the dive when using an Ray semiclosed rebreather.*
2. *Properly rinse the Ray semiclosed rebreather.*
3. *Properly disassemble, inspect and clean the Ray components.*
4. *Disinfect and dry the Ray components.*
5. *Explain how to store the unit.*
6. *State where to find the long-term service schedule requirements for the Ray.*

A. Immediately after exiting the water

   1. Close the mouthpiece (if not already closed). Close supply cylinder valve.
   2. Disconnect dry suit low pressure hose (if used). Remove unit (get buddy assistance) — don't bang valve/regulator as you set it down.
   3. Empty BCD of air.
   4. If necessary for safe transport, remove supply cylinder and transport appropriately.

B. Rinsing

   1. While still assembled, thoroughly rinse with fresh water keeping mouthpiece closed. Don't allow water into regulator (reattach cylinders if necessary).
   2. Rinse BCD just as you would open circuit equipment.

C. Disassembly and cleaning

1. Remove breathing hoses, mouthpiece, inhalation and exhalation bags and scrubber cartridge.
2. Empty cartridge and dispose of used DiveSorb® — do not allow DiveSorb® to come in contact with your skin or clothing — if it does, wash it off immediately with fresh water to avoid chemical burns.
3. Inspect bypass valve for DiveSorb® dust, rinse and shake out as necessary. Don't depress valve lever during rinsing, or water may enter the regulator.
4. Disassemble and rinse scrubber cartridge components thoroughly in fresh water away from other components. Set aside to dry in a ventilated shaded area.
5. Rinse hoses, bag and mouthpiece with fresh water, then disinfect with EW80des antiseptic at the strength recommended on the antiseptic packaging. Set aside to dry in a ventilated shaded area.
6. Drain rinse water from BCD and set aside to dry.

D. Storage

1. After all components are dry, reassemble loosely and store with mouthpiece open, hoses unkinked, and BCD partially inflated out of direct sunlight.
2. Make sure valves don't stick, that scrubber cartridge lid is loose and doesn't stick to its sealing surface. Ensure that the unit stays dry inside and out while stored.

E. Long Term Maintenance and Service

1. Lubricate o-rings and valves periodically with Molykote 111 as described in the Instructions for Use manual.
2. Have your unit serviced by an authorized Drager service center every year.
3. The required long-term service schedule appears in the rear of the Ray Instructions for Use manual.

IX. Ray Dive Two

Learning Objectives: By the end of this dive, with instructor guidance only as needed, the student diver will be able to:

1. *Prepare the Ray for use by correctly assembling it and performing all predive checks.*
2. *Plan an open water dive with the Ray including determining the NDL, and oxygen exposure limit.*
3. *Demonstrate the predive bag purge and GGG step before entering the water.*
4. *Adjust weight and breathing loop volume (over pressure valve setting) for diving in open water.*
5. *Descend in a controlled manner using the Ray.*
6. *Perform an underwater leak check with a buddy.*
7. *Monitor the SPG throughout the dive so the diver reaches the surface and ends the dive with at least 20 bar/300 psi remaining.*
8. *Monitor the oxygen sensor (if used) to be sure inhalation bags stay at or above the planned oxygen content.*
9. *Switch to and from the bailout system on signal without introducing water into the breathing loop.*
10. *Perform a bag purge on signal and before beginning an ascent to the surface.*
11. *Control buoyancy throughout the dive, remembering to exhale through the nose as necessary during ascent to control breathing loop volume.*
12. *Determine the residual nitrogen (pg) on the RDP and the oxygen exposure after the dive.*
13. *Demonstrate appropriate post dive maintenance/care of the Ray unit.*

1. Briefing.
    a. Evaluation of conditions.
    b. Facilities at dive site.
    c. Entry technique to be used — location.
    d. Exit technique to be used — location.
    e. Bottom composition and topography around training site.
    f. Depth range on bottom — maximum, 18 metres/60 feet.
    g. Ending tank pressure — when to terminate the dive.
    h. Interesting and helpful facts about the dive site.
    i. Sequence of training dive
        1. Suiting up

2. Predive bag purge
3. Gas/Gauge/Gag step
4. Enter water — adjust buoyancy. Remember to close mouthpiece before removing from mouth, put in mouth and clear before opening.
5. Descend, leak check.
6. Switch to bailout and back — randomly on signal throughout dive.
7. Bag purge — randomly on signal throughout dive.
8. Tour for fun and experience — divers monitor gauges and control buoyancy.
9. Preascent bag purge.
10. Ascent, maintain buoyancy control— safety stop at 5 metres/15 feet for three minutes.

j. Special communication underwater and topside.

k. Emergency procedures.

2. Predive procedures.

a. Prepare personal dive equipment and set up/check Ray (see VI. Unit Setup and Check)

b. Perform inhalation bag, oxygen exposure, maximum depth, no-decompression and cylinder duration calculations.

c. Don gear and semiclosed rebreathers.

d. Perform predive safety check.

e. Predive bag purge, GGG step, proper entry.

f. Weight adjustment and start descent.

3. Dive 2 — sequence as listed.

4. Postdive

a. Proper exit

b. Stow equipment as appropriate.

c. Debriefing.

d. Log dive. (Instructor signs log.)

e. Disassembly/maintenance of Ray (see VIII. Unit Disassembly and Maintenance)

X. Ray Dive Three

Learning Objectives: By the end of this dive, with little or no instructor guidance (but still under the instructor's supervision), the student diver will be able to:

1. *Prepare the Ray for use by correctly assembling it and performing all predive checks.*
2. *Plan an open water dive with the Ray including determining the NDL, and oxygen exposure limit.*
3. *Demonstrate the predive bag purge and GGG step before entering the water.*
4. *Adjust weight and breathing loop volume (over pressure valve setting) for diving in open water.*
5. *Descend in a controlled manner using the Ray.*
6. *Perform an underwater leak check with a buddy.*
7. *Monitor the SPG throughout the dive so the diver reaches the surface and ends the dive with at least 20 bar/300 psi remaining.*
8. *Monitor the oxygen sensor (if used) to be sure inhalation bags stay at or above the planned oxygen content.*
9. *Switch to and from the bailout system on signal without introducing water into the breathing loop.*
10. *Perform a bag purge on signal and before beginning an ascent to the surface.*
11. *Control buoyancy throughout the dive, remembering to exhale through the nose as necessary during ascent to control breathing loop volume.*
12. *Determine the residual nitrogen (pg) on the RDP and the oxygen exposure after the dive.*
13. *Demonstrate appropriate post dive maintenance/care of the Ray unit.*

1. Briefing.
   a. Evaluation of conditions.
   b. Facilities at dive site.
   c. Entry technique to be used — location.
   d. Exit technique to be used — location.
   e. Bottom composition and topography around training site.
   f. Depth range on bottom — maximum, 18 metres/60 feet.
   g. Ending tank pressure — when to terminate the dive.
   h. Interesting and helpful facts about the dive site.
   i. Sequence of training dive

1. Suiting up
2. Predive bag purge
3. Gas/Gauge/Gag step
4. Enter water — adjust buoyancy. Remember to close mouthpiece before removing from mouth, put in mouth and clear before opening.
5. Descend, leak check.
6. Switch to bailout and back — randomly on signal throughout dive.
7. Bag purge — randomly on signal throughout dive.
8. Tour for fun and experience — divers monitor gauges and control buoyancy.
9. Preascent bag purge.
10. Ascent, maintain buoyancy control— safety stop at 5 metres/15 feet for three minutes.

j. Special communication underwater and topside.

k. Emergency procedures.

2. Predive procedures.

a. Prepare personal dive equipment and set up/check Ray (see VI. Unit Setup and Check)

b. Perform inhalation bag, oxygen exposure, maximum depth, no-decompression and cylinder duration calculations.

c. Don gear and semiclosed rebreathers.

d. Perform predive safety check.

e. Predive bag purge, GGG step, proper entry.

f. Weight adjustment and start descent.

3. Dive 3 — sequence as listed.

4. Postdive

a. Proper exit

b. Stow equipment as appropriate.

c. Debriefing.

d. Log dive. (Instructor signs log.)

e. Disassembly/maintenance of Ray (see VIII. Unit Disassembly and Maintenance)

f. Graduation party and social