



UNIVERSITY OF  
**Rhode Island**

**Research Diving Manual**

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## SECTION 1.00

### GENERAL POLICY

#### 1.10 PURPOSE

#### 1.11 The Research Diving Standards

The purpose of these standards is to ensure that all research diving done under the auspices of the University of Rhode Island (URI) is conducted in a manner most likely to minimize accidental injury or occupational illnesses, comply with American Academy of Underwater Sciences (AAUS) standards and to promulgate criteria and standards necessary for an approved Research Diving Program.

Any person diving under URI auspices is required to observe the provisions of this guide. Diving by students, staff, marine scientists and faculty of the URI or with URI equipment as a necessary part of their occupation, and by other authorized divers under the supervision of the URI program as a necessary part of research, constitutes diving under URI auspices.

#### 1.12 The URI Research Diving Manual

The URI Research Diving Manual contains general regulations for all diving. All Authorized Divers will receive a copy. The manual is also on deposit in the Pell Library on the Narragansett Bay Campus. Addenda and changes are distributed similarly. URI's research diving standards include:

1. Diving regulation's procedures for conducting safe diving operations.
2. Requirements for obtaining and maintaining authorization.
3. Equipment use and maintenance procedures.
4. Medical Standards.

#### 1.13 Scientific Diving Exemption

OSHA has granted an exemption for scientific diving from commercial diving regulations under the following guidelines (Appendix B to 29CFR1910 Subpart T):

1. The Diving Control Board consists of a majority of active scientific divers and has autonomous and absolute authority over the scientific diving program's operation.
2. The purpose of the project using scientific diving is the advancement of science; therefore, information and data resulting from the project are non-proprietary.

3. The tasks of a scientific diver are those of an observer and data gatherer. Construction and trouble-shooting tasks traditionally associated with commercial divers are not included within scientific diving.
4. Scientific divers, based on the nature of their activities, must use scientific expertise in studying the underwater environment and therefore, are scientists or scientists-in-training.
5. In addition, the scientific diving program shall contain at least the following elements (29CFR1910.401):
  - a. Diving safety manual which includes at a minimum: Procedures covering all diving operations specific to the program; including procedures for emergency care, recompression and evacuation, and the criteria for divers training and certification.
  - b. Diving Control Board, with the majority of its members being active scientific divers, which shall at a minimum have the authority to: approve and monitor diving projects, review and revise the diving safety manual, assure compliance with the manual, certify the depths to which a diver has been trained, take disciplinary action for unsafe practices, and assure adherence to the buddy system (a diver is accompanied by and is in continuous contact with another diver in the water) for scuba diving.

#### 1.14 Review of Standards

As part of URI's annual report, any recommendations for modifications of these standards shall be submitted to the AAUS for consideration.

#### 1.20 CONTROL

#### 1.21 Research Diving Definition

Diving is human operations conducted at or below the surface of the water that includes the use of any compressed gas delivery system for life support. Throughout this guide the term diver indicates an individual who conducts diving operations.

#### 1.22 URI Auspices Defined

Diving under the auspices of the URI's DCB is limited to persons engaged in research; employees acting within the scope of their employment; students engaged in any research diving including those receiving or providing research diving instruction or involved in checkout dives, and diving conducted by individuals participating in coursework.

When recreational diving is conducted in conjunction with any URI program it is the recommendation of the URI DCB that guidelines set forth by the recreational diving industry are followed and normal safety procedures are adequate for task and conditions.

Transferred to another institution. Responsibility for and authority over a diver who would otherwise be under URI auspices is done with the concurrence of the diver, by agreement to do so between the URI Diving Control Board and its counterpart at the other institution.

### 1.23 Authorization Types

The Research Diving Program requires that no person shall engage in research diving unless that person holds a valid authorization issued by the URI Research Diving Program pursuant to the provisions of this manual (see Sec. 3.00 and 4.00). Examples of recognized authorizations are:

1. Scientific Diver Authorization. This is a permit to dive, usable only while it is current and for the purpose intended.
2. Temporary Diver Authorization. This authorization constitutes a waiver of the requirements of Sec. 4.00 and is issued only following a demonstration of the required proficiency in diving. It is valid only for a specified time and dive plan, as determined by the Diving Safety Officer.

### 1.24 Equipment

All diving equipment used by authorized Scientific Divers and applicants, regardless of ownership, shall conform to the standards set forth in this manual.

### 1.25 Sites

The regulations herein shall be observed at all locations where research diving is conducted under the auspices of the Research Diving Program.

### 1.26 Reciprocity

1. When two or more AAUS Organizational Members engage jointly in diving activities, or engage jointly in the use of diving resources, one of the participating Diving Control Boards (DCB) shall be designated as the lead DCB and govern the dive project.
2. A Scientific Diver from one Organizational Member shall apply for permission to dive under the auspices of another Organizational Member by submitting to the Diving Safety Officer of the host Organizational Member a document containing all the information described in Appendix 6. (Letter of Reciprocity) signed by the Diving Safety Officer or Chairperson of the home Diving Control Board.
3. A visiting Scientific Diver may be asked to demonstrate his/her knowledge and skills for the planned diving operation. An example of items to be demonstrated is presented in Appendix 8 (Checkout Dive).
4. If a host Organizational Member denies a visiting Scientific Diver permission to dive, the

host Diving Control Board shall notify the visiting Scientific Diver and his/her Diving Control Board with an explanation of all reasons for the denial.

5. The URI Research Diving Program shall recognize a Scientific Diver currently authorized by another organization, so long as that other organization is a member in good standing of the AAUS, and the diver agrees to operate under the standard operating procedures of the URI Research Diving Program. The visiting Scientific Diver may be asked to demonstrate his/her knowledge and skills as described in section 1.26.3.

#### 1.27 Waiver of Requirements

The Diving Control Board may grant a waiver for specific requirements of training, examinations, depth certification, and minimum activity to maintain certification.

#### 1.30 URI RESEARCH DIVING PROGRAM

##### 1.31 The Diving Safety Officer

1. Shall be appointed by the Vice Provost for Research or his/her designee, with the advice and counsel of the Diving Control Board.
2. Shall be a Scientific Diver and member of the AAUS.
3. Shall be responsible to the URI Vice Provost Research Office or their designee, for the conduct of the Research Diving Program. The operational authority for URI Research Diving Program, including the conduct of training and certification, approval of dive plans, maintenance of diving records, and ensuring compliance with this manual and all relevant regulations of the URI, rests with the Diving Safety Officer.
4. May permit portions of this program to be carried out by a qualified delegate, although the Diving Safety Officer may not delegate responsibility for the safe conduct of the Research Diving Program.
5. Shall be guided in the performance of the required duties by the advice of the Diving Control Board, but operational responsibility for the conduct of the local diving program will be retained by the Diving Safety Officer.
6. Shall suspend scientific diving operations that are considered unsafe.
7. Shall ensure that the Research Diving Program air station(s) meet air quality standards as described in Sec. 5.22 of this manual.
8. Shall be an active underwater instructor from a nationally recognized agency.

### 1.32 The Diving Control Board (DCB)

1. The Diving Control Board is an administrative committee, appointed by the Vice Provost for Research . It includes the Diving Safety Officer; the majority of the members must be Scientific Divers.
2. Shall be responsible to the Vice Provost for Research or his/her designee, and shall act as the official representative in matters concerning the Research Diving Program.
3. Shall act as a board of appeal to consider diver-related problems.
4. Shall issue, reissue, or revoke dive authorizations.
5. Shall recommend changes in policy and amendments to the AAUS and the research diving manual as the need arises. Any recommendations for modifications to the URI Research Diving Manual shall be submitted to the AAUS for consideration.
6. Shall establish and/or approve training programs through which the applicants for authorization can satisfy the requirements of the URI Research Diving Manual.
7. Shall suspend diving programs that it considers being unsafe.
8. Shall establish criteria for equipment selection and use.
9. Shall recommend new equipment or techniques.
10. Shall establish and/or approve facilities for the inspection and maintenance of diving and associated equipment.
11. Shall periodically review the Diving Safety Officer's performance and program.
12. Shall sit as a board of investigation to inquire into the nature and cause of diving accidents and/or incidents or violations of URI's Research Diving Manual.

### 1.40 PROGRAM RESPONSIBILITY

#### 1.41 Ultimate Authority

The Vice Provost for Research has the ultimate authority for the Research Diving Program and its related activities.

#### 1.42 Research Diving Program Policy

Policy recommendations relating to the Research Diving Program at URI shall be made to the Vice Provost for Research or his/her designee. The development of these recommendations is the joint responsibility of the Diving Safety Officer and the Diving Control Board.

#### 1.43 Policy Administration

The administration of the Research Diving Program policy will reside with the Diving Control Board.

#### 1.50 INSTRUCTIONAL PERSONNEL

All personnel involved in diving instruction under the auspices of the Research Diving Program shall be qualified as determined by the Diving Control Board for the type of instruction being given.

#### 1.60 MEDICAL EXAMINATION

All authorized divers shall pass a medical examination, and the expiration date of the examination will appear on the diving authorization. After each illness or injury requiring hospitalization of more than 24 hours, or after an episode of unconsciousness related to diving activity, or after treatment in a hyperbaric chamber following a diving accident or other serious illness, authorized divers shall submit to a medical interview or examination appropriate to the nature and extent of the injury or illness, as decided by the examining physician before resuming diving activities.

## SECTION 2.00

### DIVING REGULATIONS

#### 2.10 GENERAL POLICY

No person shall engage in research diving operations under the auspices of the Research Diving Program unless that person holds a current authorization issued pursuant to the provisions of this manual.

Research diving shall not be conducted unless procedures have been established for emergency evacuation of the diver(s) to a hyperbaric chamber or appropriate medical facility.

#### 2.20 DIVING PROCEDURES

##### 2.21 Solo Diving

All diving activities shall assure adherence to the buddy system (two comparably equipped scuba divers in the water in constant communication) for scuba diving. This buddy system is based upon mutual assistance, especially in the case of an emergency.

##### 2.22 Enclosed Spaces

Horizontal Entries under any obstruction that would preclude immediate, direct ascent to the surface may be made only with the prior approval of the Diving Safety Officer. Where an enclosed or confined space is not large enough for two divers, a diver shall be stationed at the underwater point of entry and an orientation line shall be used.

##### 2.23 Confined Waters

All diving activities shall be planned and executed in a way that ensures that every diver maintains constant, effective communication with at least one other person. If loss of effective communication occurs within a buddy team, all divers shall surface and reestablish contact.

##### 2.24 Diver's Flag

A diver's flag shall be prominently displayed at the dive site whenever diving is conducted.

##### 2.25 Flotation Devices

Buoyancy compensators (BC) are designed to allow the diver to adjust his/her buoyancy. All URI Scientific Divers are required to wear during all diving operations.

##### 2.26 Timing Devices and Depth and Pressure Gauges

Both members of the dive team must have an underwater timekeeping device, an approved depth indicator, and a submersible tank pressure gauge.

### 2.27 Dive Tables

A set of appropriate diving tables must be available at the dive location. These tables must be at least as conservative as the United States Navy Diving Tables.

### 2.28 Depth Limits

The research diving authorization will authorize the holder to dive to the depth entered on the authorization. The authorization must bear the signature of the Diving Safety Officer and chair of the Diving Control Board or his/her designee.

1. An authorized diver diving under the auspices of the Research Diving Program shall not exceed their depth authorization, unless accompanied by a diver authorized to a greater depth. Under these circumstances the diver may not exceed their depth limit by more than one step.
2. Dives between 0-190 feet in depth must be in conformance with Sec. 4.30.
3. Diving is not permitted beyond a depth of 190-feet.

### 2.29 Refusal to Dive

1. The decision to dive is that of the diver. A diver may refuse to dive, without fear of penalty, whenever they feel it is unsafe for them to make the dive.
2. The ultimate responsibility for safety rests with the individual diver. It is the diver's responsibility and duty to refuse to dive if, in their judgment, conditions are unsafe or unfavorable, or if they would be violating the precepts of their training or the regulations of this manual.

#### 2.29.1 Termination of the Dive

1. It is the responsibility of the diver to terminate the dive, without fear of penalty, whenever they feel it is unsafe to continue the dive, unless it compromises the safety of another diver already in the water.
2. All dives shall be terminated while there is still sufficient tank pressure to permit the diver to safely reach the surface, including decompression time, or to safely reach an additional air source at the decompression station.

## 2.29.2 Flying After Diving or Ascending to Altitude (Over 1000 feet)

Following a Single No-Decompression Dive: Divers should have a minimum preflight surface interval of 12 hours.

Following Multiple Dives per Day or Multiple Days of Diving: Divers should have a minimum preflight surface interval of 18 hours.

Following Dives Requiring Decompression Stops: Divers should have a minimum preflight surface interval of 24 hours.

Before ascending to Altitude above (1000 feet) by Land Transport: Divers should follow the appropriate guideline for preflight surface intervals unless the decompression procedure used has accounted for the increase in elevation.

## 2.30 OTHER DIVING TECHNOLOGY

Certain types of diving, some of which are listed below, require equipment or procedures that involve special training. Divers shall comply with all scuba diving procedures in this manual unless specified.

### 2.31 Staged Decompression Diving

No diver shall plan or conduct staged decompression dives without prior approval of the Diving Control Board.

### 2.32 Hookah

No diver shall plan or conduct Hookah dives without prior approval of the Diving Safety Officer.

1. Divers using the hookah mode shall be equipped with a diver-carried independent reserve breathing gas supply.
2. Each hookah diver shall be hose-tended by a separate dive team member while in the water.
3. The hookah breathing gas supply shall be sufficient to support all hookah divers in the water for the duration of the planned dive, including decompression.

### 2.33 Mixed Gas Diving

Saturation divers shall comply with the Research Diving Program saturation diving standards and only with the approval of the URI DCB – in a case-by-case basis.

Nitrox diving operations are covered in Appendix 10.

### 2.34 Surface Supplied Diving

Surface supplied divers shall comply with the Research Diving Program surface-supplied diving standards and only with the approval of the URI DCB – in a case-by-case basis.

Surface supplied divers shall comply with all SCUBA diving procedures in this manual. Surface supplied diving shall not be conducted at depths greater than 120 fsw (36.5 msw).

1. Divers using the surface supplied mode shall be equipped with a diver-carried independent reserve breathing gas supply.
2. Each surface-supplied diver shall be hose-tended by a separate dive team member while in the water.
3. Divers using the surface supplied mode shall maintain voice communication with the surface tender.
4. The surface supplied breathing gas supply shall be sufficient to support all surface supplied divers in the water for the duration of the planned dive, including decompression.
5. During surface supplied diving operations when only one diver is in the water, there must be a standby diver present at the dive location.

### 2.35 Blue Water Diving

Blue water diving is defined as diving in open water where the bottom is generally greater than 200-feet deep. It requires special training and the use of multiple-tethered diving techniques. Specific guidelines that should be followed are outlined in “Blue Water Diving Guidelines” (California Sea Grant Pub. No. T-CSGCP-014).

### 2.36 Ice and Polar Diving

No diver shall plan or conduct under the ice dives without prior approval of the Diving Control Board.

Divers planning to dive under ice or in polar conditions should use the following: “Guidelines for Conduct of Research Diving,” National Science Foundation, Division of Polar Programs, 1990.

## 2.40 DIVING OPERATIONS

### 2.41 Lead Diver

For each dive, one individual shall be designated as the lead diver. They shall be at the dive location during the diving operation. The lead diver shall be responsible for:

1. Coordination. Diving shall be coordinated with other known activities within the vicinity, which are likely to interfere with diving operations.
2. Briefing. The dive team members shall be briefed on:
  - a. Dive objectives.
  - b. Unusual hazards or environmental conditions that are likely to affect the safety of the divers and or diving operation.
  - c. Modifications to diving or emergency procedures (appendix 7 Diving Emergency Management) necessitated by the specific diving operation.
  - d. Reporting any physical problems or adverse physiological effects including symptoms of pressure-related injuries.
3. Dive Planning. Planning of a diving operation shall include considerations to the safety and health aspects of the following:
  - a. Diving mode.
  - b. Surface and underwater conditions and hazards.
  - c. Breathing gas supply.
  - d. Thermal protection.
  - e. Diving equipment.
  - f. Dive team assignments.
  - g. Residual inert gas status of dive team members.
  - h. No-decompression schedules and altitude corrections.
  - i. Emergency evacuation and medical treatment: For each dive location a plan shall be established to locate and transport a diver to an operational hyperbaric chamber or an appropriate medical facility as described in Appendix 7 of this manual.

## 2.42 Dive Plans

Before conducting any diving projects under the auspices of the Research Diving Program, the lead diver must formulate a dive plan, that dive plan should include the following:

1. Divers' qualifications and the type of authorization or permit held by each diver.
2. Emergency plan (refer to Appendix 7) with the following information:
  - a. Name, telephone number, and relationship of person(s) to be contacted for each diver in case of an emergency.
  - b. Nearest accessible hospital.
  - c. Local emergency telephone numbers: Divers Alert Network (DAN), local police, nearest U.S. Coast Guard Group, if appropriate, and a local Emergency Medical Service (EMS).
  - d. Available means of transportation.
3. Approximate number of proposed dives.
4. Location(s) of proposed dives.
5. Estimated depth(s) and bottom time(s) anticipated.
6. Determination of decompression status and repetitive dives: dive tables, dive computers. A set of diving tables, approved by the Diving Control Board, must be available at the dive location.
  - a. Dive computers may be utilized in place of diving tables, and must be approved by the Diving Control Board.
7. Proposed work, equipment, and boats to be employed.
8. Any hazardous conditions anticipated.

Submission of written dive plans for approval by the Diving Safety Officer is required for all diving projects and for dives considered outside the norm. Examples of these are, but are not limited to:

1. Accessory gear that is to be used such as tag lines, tethers, core tubes, photographic equipment, in which there is a potential for entanglement.
2. Environmental extreme: low visibility, strong current, diving in contaminated waters.
3. Exceeding standard diving norm: blue water diving, depths greater than 100-feet.

## 2.43 Pre-Dive Safety Checks

1. Diver's Responsibility:
  - a. Perform a functional inspection of their gear, their buddies gear and all other gear that is to be used in the dive. Each diver must fully understand what gear their buddy is using and how to remove it.
  - b. Satisfy themselves that both they and their buddy are physically and mentally prepared for the dive.
  - c. Assess all environmental risks: currents, surf, boat traffic, diving conditions and clearly state contingency plans.
  - d. State all limits to the dive such as depth, distance from entry, completion of dive concerning remaining tank pressure.
  - e. State all emergency procedures: out of air; call for assistance, buddy separation.

When all divers are satisfied that the above concerns are met to ensure their safety, then, and only then, may divers enter the water and commence the dive.

2. Equipment Evaluations:
  - a. Each diver shall insure that their equipment is in proper working order and that the equipment is suitable for the type of diving operation.
  - b. Each diver shall have the capability of achieving and maintaining positive buoyancy.

## 2.44 Post-Dive Safety Checks

1. After the completion of a dive, each diver shall report any physical problems, symptoms of decompression sickness, or equipment malfunctions.
  1. When diving outside the no-decompression limits, the divers should remain awake for at least one hour after diving, and in the company of a dive team member who is prepared to transport them to a hyperbaric chamber if necessary.
  2. The Diving Safety Officer will develop emergency procedures which follow the standards of care of the community and must include procedures for emergency care, recompression and evaluation for each dive location (See Appendix 7)

## 2.45 Deviations from Regulations

Any diver may deviate from the requirements of this manual only to the extent necessary to prevent or minimize a situation that is likely to cause death, serious physical harm, or major environmental damage. A written report of such actions must be submitted to the Diving Control Board explaining the circumstances and justifications.

#### 2.46 Consequence of Violation of Regulations by Scientific Divers

Failure to comply with the regulations of the Research Diving Program manual may be cause for the revocation or restriction of the diver's research diving authorization by action of the Diving Control Board.

### 2.50 RECORD KEEPING AND REQUIREMENTS

#### 2.51 Personal Diving Log

Each authorized Scientific Diver shall log every dive made under the auspices of the Research Diving Program, and is encouraged to log all other dives. The Diving Safety Officer will provide standard forms. Log sheets shall be submitted quarterly to the Diving Safety Officer to be placed in the diver's permanent file. The diving log shall include at least the following:

1. Name of diver, partner, and lead diver.
2. Date, time, and location.
3. Diving modes used.
4. General nature of diving activities.
5. Approximate surface and underwater conditions.
6. Maximum depths, bottom time, surface interval time and mixed gas profiles if used.
7. Diving tables or computer used.
8. Detailed report of any accidents or potentially dangerous incidents.

#### 2.52 Record Maintenance

The Diving Safety Officer or his/her designee shall maintain permanent records for each authorized Scientific Diver. The file shall include evidence of authorization, log sheets, results of current physical examination, waiver, reports of disciplinary actions by the Diving Control Board, and other pertinent information deemed necessary.

1. Availability of Records:

- a. Medical records shall be available to the attending physician of the diver or former diver when released in writing by the diver.
- b. The Research Diving Program shall retain records and documents required by this standard for the following period:
  1. Physician's written reports of medical examinations for dive team member(s) - five years.
  2. Manual for diving safety - current document only.
  3. Records of dive - one year, except five years where there has been an incident of pressure-related injury.
  4. Pressure-related injury assessment - five years.
  5. Equipment inspection and testing records - current entry, or until equipment is withdrawn from service.

#### 2.53 Required Accident Reporting

1. All diving accidents requiring recompression or resulting in moderate or serious injury must be reported to the Diving Safety Officer. The Diving Safety Officer will circulate this report to the Diving Control Board and AAUS.
2. All other accidents must be reported to the Director of Safety and Risk Management within 24 hours of the incident.
3. The Research Diving Program shall investigate and document any incident of pressure-related injury and prepare a report that is to be forwarded to the AAUS.

## SECTION 3.00

### ENTRY LEVEL REQUIREMENTS

#### 3.10 GENERAL POLICY

Individuals wanting to obtain authorization must first be certified by an internationally recognized SCUBA organization or scientific diving program. Documentation of this certification, a medical examination, and current certification in First aid, CPR and Emergency Oxygen Administration must be submitted on application. An open water evaluation, a written exam and proof of medical insurance are required before authorization can be granted.

#### 3.11 Scientific Diver-In-Training Permit

This permit signifies that a diver has completed and been certified as at least an open water diver through an national or international recognized certifying agency or scientific diving program. Applicants must successfully plan and execute 5 open water dives for a minimum 2 hour bottom time over the previous year.

#### 3.12 Medical Examination

The applicant for authorization shall be deemed by a licensed physician to be medically fit for diving before proceeding with the training as designated in Sec. 3.20 (see Sec. 6.00 and Appendices 2 through 6).

#### 3.20 EVALUATION

##### 3.21 Open Water Evaluation

Applicants must satisfy Diving Safety Officer or his/her designee of their ability to perform at least the following in open water (refer to appendix 8).

1. Surface dive to a depth of 10 feet in open water without scuba.
2. Demonstrate proficiency in air sharing as both donor and receiver.
3. Enter and leave open water or surf, or leave and board a vessel, while wearing scuba gear.

4. Kick on the surface 400 yards while wearing scuba gear, but not breathing from the scuba unit.
5. Demonstrate judgment adequate for safe diving.
6. Demonstrate, where appropriate, the ability to maneuver efficiently in the environment, at and below the surface.
7. Complete, or discuss a simulated emergency swimming ascent.
8. Demonstrate clearing of mask and regulator while submerged.
9. Demonstrate ability to achieve and maintain neutral buoyancy while submerged.
10. Demonstrate techniques of self-rescue and buddy rescue.
11. Navigate underwater.
12. Plan and execute a dive.

Upon completion of the open water exercise the applicant's evaluation will be submitted to the Diving Safety Officer to be placed in the diver's permanent file.

### 3.22 Written Examination

The applicant must pass a written examination that demonstrates knowledge of at least the following:

1. Function, care, use, and maintenance of diving equipment.
2. Physics and physiology of diving.
3. Diving regulations and precautions.
4. Near-shore currents and waves.
5. Dangerous marine animals.
6. Emergency procedures, including buoyant ascent and ascent by buddy breathing.
7. Currently accepted "no-decompression," repetitive "no-decompression," and decompression procedures.
8. Underwater communications.
9. Aspects of fresh water and altitude diving.

10. Hazards of breath-hold diving and ascents.
11. Planning and supervision of diving operations.
12. Diving hazards.
13. Cause, symptoms, treatment, and prevention of the following: near drowning, air embolism, carbon dioxide excess, squeezes, oxygen poisoning, nitrogen narcosis, exhaustion and panic, respiratory fatigue, motion sickness, decompression sickness, hypothermia, and hypoxia/anoxia.

### 3.23 CPR Certification, First-Aid and Emergency Oxygen Administration

The applicant must provide proof of current certification by a national recognized organization in cardiopulmonary resuscitation (CPR), First Aid and Emergency Oxygen Administration.

### 3.24 Acknowledgment of Manual

To complete the application process, applicants must read the URI Research Diving Manual and have discussed with the URI Diving Safety Officer all aspects of the material that may have confused them.

### 3.25 Application

Application for authorization shall be made to the Diving Safety Officer on the form available from the Diving Safety Officer.

### 3.26 Insurance

All divers in the URI Research Dive Program must have medical insurance that will cover the costs of a diving related accident or incident. Divers Alert Network (DAN) and/or URI workers' compensation provide the necessary coverage. It is the responsibility of the applicant to provide proof of medical insurance to the Diving Safety Officer.

## SECTION 4.00

### SCIENTIFIC DIVER AUTHORIZATION

#### 4.10 GENERAL POLICY

Scientific Divers are initially granted a 30-foot depth authorization regardless of skill or previous experience. This authorization may be changed as prescribed in this section. Additional authorization is required for surface supplied, dry suit, and saturation diving. To preserve authorization, divers must maintain proficiency and have a current medical evaluation on file with the Diving Safety Officer.

#### 4.20 TRAINING

The diver must complete additional theoretical aspects and practical training beyond the Entry Level Requirements (section 3.00) for a minimum cumulative time of 50 hours.

Required Topics (include, but not limited to):

1. Diving Emergency Care Training
  - Cardiopulmonary Resuscitation (CPR)
  - Standard or Basic First Aid
  - Recognition of DCS and AGE
  - Accident Management
  - Field Neurological Exam
  - Oxygen Administration
2. Dive Rescue
3. Dive Physics
4. Dive Physiology
5. Dive Environments
6. Decompression Theory and its Application
7. AAUS Scientific Diving Regulations and History
  - Scientific Dive Planning
  - Coordination with other Agencies
  - Appropriate Governmental Regulations
8. Scientific Method
9. Data Gathering Techniques (Only Items specific to area of study are required)
  - Quadrating
  - Transecting
  - Mapping
  - Coring
  - Photography
  - Tagging
  - Collecting
  - Animal Handling

- Archaeology
  - Common Biota
  - Organism Identification
  - Behavior
  - Ecology
  - Site Selection, Location, and Re-location
  - Specialized Equipment for data gathering
10. HazMat Training
- HP Cylinders
  - Chemical Hygiene, Laboratory Safety (Use Of Chemicals)

Suggested Topics (include, but not limited to):

1. Specific Dive Modes (methods of gas delivery)
    - Open Circuit
    - Hooka
    - Surface Supplied diving
  2. Small Boat Operation
  3. Specialized Breathing Gas
    - Nitrox
    - Mixed Gas
  4. Specialized Environments and Conditions
    - Blue Water Diving,
    - Ice and Polar Diving (Cold Water Diving)
    - Zero Visibility Diving
    - Polluted Water Diving,
    - Saturation Diving
    - Decompression Diving
    - Overhead Environments
    - Aquarium Diving
    - Night Diving
    - Kelp Diving
    - Strong Current Diving (Live-boating)
    - Potential Entanglement
  5. Specialized Diving Equipment
    - Full face mask
    - Dry Suit
    - Underwater Communications
2. Practical training shall include at least 7 supervised open water dives (beyond Entry Level Requirements, section 3.00) in a variety of dive sites and diving conditions, for a cumulative bottom time of 3-1/2 hours. Dives following the checkout dive must be supervised by an authorized scientific diver with experience in the type of diving planned, with the knowledge and

permission of the Diving Safety Officer. No more than three of these dives shall be made in one day.

#### 4.30 DEPTH AUTHORIZATION

##### Depth Certifications and Progression to Next Depth Level

A authorized diver may progress to the next depth level after successfully completing the required dives for the next level. Under these circumstances the diver may exceed their depth limit. Dives shall be planned and executed under close supervision of a diver certified to this depth, with the knowledge and permission of the DSO.

Certification to 30-Foot Depth - initial authorization, approved by the Diving Control Board upon successful completion of training as listed in Sec. 3.00.

Certification to 60- Foot Depth - A diver holding a 30-foot authorization may be authorized to a depth of 60-feet after successfully completing, with another URI/AAUS diver with a 60-foot rating or greater, 12 dives, logged to depths between 31 and 60-feet, for a minimum total time of four hours.

Certification to 100 Foot Depth - A diver holding a 60 foot certificate may be certified to a depth of 100 feet after successfully completing, 4 dives to depths between 61 and 100 feet. The diver shall also demonstrate proficiency in the use of the appropriate Dive Tables.

Certification to 130 Foot Depth - A diver holding a 100 foot certificate may be certified to a depth of 130 feet after successfully completing, 4 dives to depths between 100 and 130 feet. The diver shall also demonstrate proficiency in the use of the appropriate Dive Tables.

Certification to 150 Foot Depth - A diver holding a 130 foot certificate may be certified to a depth of 150 feet after successfully completing, 4 dives to depths between 130 and 150 feet. The diver must also demonstrate knowledge of the special problems of deep diving, and of special safety requirements.

Certification to 190 Foot Depth - A diver holding a 150 foot certificate may be certified to a depth of 190 feet after successfully completing, 4 dives to depths between 150 and 190 feet. The diver must also demonstrate knowledge of the special problems of deep diving, and of special safety requirements.

**Diving on air is not permitted beyond a depth of 190 feet.**

#### 4.40 CONTINUATION OF AUTHORIZATION

##### 4.41 Minimum Activity to Maintain Authorization

During the 12-month period, comprising the calendar year, each authorized Scientific Diver must log a minimum of 12 dives and submit the logs to the Diving Safety Officer quarterly. At least one dive must be logged near the maximum depth of the diver's authorization during each six-month period. Failure to meet these requirements may be cause for revocation or restriction of authorization.

#### 4.42 Re - Authorization of Inactive Divers

Once the initial authorization requirements of Section 3.10 through 3.26 are met, divers whose depth authorization has lapsed due to lack of activity may be re-authorized by submitting a request to the Diving Safety Officer, and complying with any subsequent conditions that may be imposed.

#### 4.43 Medical Examination

All authorized Scientific Divers shall pass a medical examination at the intervals specified in Section 6.12. After each major illness or injury, as described in Sec. 6.15, an authorized Scientific Diver shall receive clearance to return to diving from a physician before resuming diving activities.

#### 4.44 Emergency Care Training

All Scientific Diver must maintain current certification in the following:

- Adult CPR.
- Emergency oxygen administration.
- First aid for diving accidents.

#### 4.50 REVOCATION OF AUTHORIZATION

A diving authorization may be revoked or restricted by the Diving Safety Officer or the Diving Control Board. Violations of regulations set forth in this manual, or other governmental regulation not in conflict with this manual, may be considered cause. The Diving Safety Officer shall inform the diver in writing of the reason(s) for revocation. The diver will be given the opportunity to present his/her case in writing for reconsideration and re-authorization. All such written statements and requests, as identified in this section, are formal documents that will become part of the diver's file.

#### 4.60 RE-AUTHORIZATION

If a diver's authorization expires or is revoked, his/her may be re-authorized after complying with such conditions as the Diving Safety Officer or the Diving Control Board may impose. The diver shall be given an opportunity to present his/her case to the Diving Control Board before conditions for re-authorization are stipulated.

#### 4.70 TEMPORARY AUTHORIZATION

A temporary authorization will be granted to a diver if they can display the required skills necessary to conduct safe diving operations. Authorization is valid only for a specified dive plan and time, as decided by the Diving Safety Officer.

#### 4.80 SPECIAL AUTHORIZATION

Conditions requiring special authorization to be issued to a diver, include, but are not limited to:

1. Surface supplied diving;
2. Dry suit diving;
3. Staged Decompression diving;
4. Blue water diving;
5. Ice and polar diving;
6. Hookah;
7. Polluted water diving;

The Diving Control Board will issue all such authorizations.

## SECTION 5.00

### DIVING EQUIPMENT

#### 5.10 GENERAL POLICY

All equipment shall meet standards as determined by the Diving Safety Officer and the Diving Control Board. Equipment subjected to extreme usage under adverse conditions should require more frequent testing and maintenance.

All equipment shall be regularly examined by the person using them.

#### 5.11 Record keeping

Each equipment modification, repair, test, calibration, or maintenance service shall be logged by the owner, including the date and nature of work performed, serial number of the item, and the name of the person performing the work for the following equipment.

1. Regulators;
2. Submersible pressure gauges;
3. Depth gauges;
4. SCUBA cylinders;
5. Cylinder valves;
6. Diving helmets;
7. Submersible breathing masks;
8. Compressors;
9. Gas control panels;
10. Air storage cylinders;
11. Air filtration systems;
12. Analytical instruments;
13. Buoyancy Control Device;
14. Dry Suits.

## 5.12 Equipment Maintenance

Equipment maintenance is the responsibility of the owner. Each diver must keep personal records of all equipment inspections and maintenance and these records must be submitted to the Diving Safety Officer every twelve months to be placed in the diver's permanent file.

## 5.20 Equipment

### Regulators

1. Only those makes and models specifically approved by the Diving Safety Officer and the Diving Control Board shall be used.
2. Scuba regulators shall be inspected and tested prior to first use and every 12 months thereafter.
3. Regulators will consist of a primary second stage and an alternate air source (such as an octopus second stage or redundant air supply).

### Breathing Masks and Helmets

Breathing masks and helmets shall have:

1. A non-return valve at the attachment point between helmet or mask and hose, which shall close readily and positively.
2. An exhaust valve.
3. A minimum ventilation rate capable of maintaining the diver at the depth to which they are diving.

### Scuba Cylinders

Scuba cylinders shall be designed, constructed, and maintained in accordance with the applicable provisions of the Unfired Pressure Vessel Safety Orders.

1. Scuba cylinders must be hydrostatically tested in accordance with DOT standards.
2. Scuba cylinders must have an internal and external inspection at intervals not to exceed 12 months.
3. Scuba cylinder valves shall be functionally tested at intervals not to exceed 12 months.

## Backpacks

Backpacks without integrated flotation devices and weight systems shall have a quick release device designed to permit jettisoning with a single motion from either hand.

## Gauges

Gauges shall be inspected and tested before first use and every 12 months thereafter.

## Flotation Devices

1. Each diver shall have the capability of achieving and maintaining positive buoyancy.
2. Personal flotation systems, buoyancy compensators, dry suits, or other variable volume buoyancy compensation devices shall be equipped with an exhaust valve.
3. These devices shall be functionally inspected and tested at intervals not to exceed 12 months.

## Timing Devices, Depth, and Pressure Gauges

Both members of the buddy team must have an underwater timing device, an approved depth indicator, and a submersible pressure gauge.

## Determination of Decompression Status: Dive Tables, Dive Computers

1. A set of diving tables, approved by the Diving Control Board, must be available at the dive location.
2. Dive computers may be utilized in place of diving tables, and must be approved by the Diving Control Board. AAUS recommendations on dive computers are available at <http://www.aaus.org>

## 5.30 Auxiliary Equipment

Hand held underwater power tools. Electrical tools and equipment used underwater shall be specifically approved for this purpose. Electrical tools and equipment supplied with power from the surface shall be de-energized before being placed into or retrieved from the water. Hand held power tools shall not be supplied with power from the dive location until requested by the diver.

#### 5.40 Support Equipment

First aid supplies: A first aid kit and emergency oxygen shall be available.

Diver's Flag: A diver's flag shall be displayed prominently whenever diving is conducted under circumstances where required or where water traffic is probable.

#### 5.50 Breathing Air

#### 5.51 Compressor Systems

1. Designs and Location of Compressor:
  - a. Low-pressure compressors used to supply air to the diver shall be equipped with a volume tank with a check valve on the inlet side, a pressure gauge, a relief valve, and a drain valve.
  - b. Compressed air systems over 500 psig shall have slow-opening shut-off valves.
  - c. All air compressor intakes shall be located away from areas containing exhaust or other contaminants and suitably equipped with an air filter.
2. Compressor Operation and Air Test Records.
  - a. Gas analyses and air tests shall be performed on each Research Diving Program-controlled breathing air compressor at regular intervals of no more than 100 hours of operation or six months, whichever occurs first. The results of these tests shall be entered in a formal log and be maintained.
  - b. A log shall be maintained showing operation, repair, overhaul, filter maintenance, and temperature adjustment for each compressor.

#### 5.52 Air Quality Standards

Breathing air for scuba shall meet the following specifications as set forth by the Compressed Gas Association (CGA Pamphlet G-7.1).

<b>CGA Grade E</b>	
<b>Component</b>	<b>Maximum</b>
Oxygen	20 - 22%/v
Carbon Monoxide	10 PPM/v
Carbon Dioxide	1000 PPM/v
Condensed Hydrocarbons	5 mg/m <sup>3</sup>
Total Hydrocarbons as Methane	25 PPM/v
Water Vapor ppm	(2)
Objectionable Odors	None

For breathing air used in conjunction with self-contained breathing apparatus in extreme cold where moisture can condense and freeze, causing the breathing apparatus to malfunction, a dew point not to exceed -50°F (63 pm v/v) or 10 degrees lower than the coldest temperature expected in the area is required.

### 5.53 Oxygen Safety

1. Equipment used with oxygen or mixtures containing over 40% by volume oxygen shall be designed and maintained for oxygen service.
2. Components (except umbilical) exposed to oxygen or mixtures containing over 40% by volume oxygen shall be cleaned of flammable materials before being placed into service.
3. Oxygen systems over 125 psig shall have slow-opening shut-off valves.

## SECTION 6.00

### MEDICAL STANDARDS

#### 6.10 MEDICAL REQUIREMENTS OF DIVE TEAM

##### 6.11 General

1. The Research Diving Program shall determine that divers have passed a current diving physical examination and have been declared by the examining physician to be fit to engage in diving activities as may be limited or restricted in the medical evaluation report.
2. All medical evaluations required by this standard shall be performed by, or under the direction of, a licensed physician of the applicant (diver's choice), preferably one trained in diving/undersea medicine.
3. The diver should be free of any chronic disabling disease and be free of any conditions contained in the list of conditions for which restrictions from diving are generally recommended. (See Section 6.15)

##### 6.12 Frequency of Medical Evaluations

Medical evaluation shall be completed:

1. Before a diver may begin diving, unless an equivalent initial medical evaluation has been given within the preceding five years (three years if over the age of 40, two years if over the age of 60). The Research Diving Program must have obtained the results of that examination, and those results have been reviewed and found satisfactory by the Diving Control Board.
2. Thereafter, at five year intervals up to age 40, every three years after the age of 40, and every two years after the age of 60.
3. Clearance to return to diving must be obtained from a physician following any major injury or illness, or any condition requiring hospital care for more than 24 hours. If the injury or illness is pressure related, then the clearance to return to diving must come from a physician trained in diving medicine.

##### 6.13. Information Provided Examining Physician

The Research Diving Program shall provide a copy of the medical evaluation requirements of this standard to the examining physician. (Appendices 1, 2, and 3).

##### 6.14 Content of Medical Examinations

Medical examinations conducted initially and at the intervals specified in section 6.12 shall consist of the following:

1. Release agreement for medical information release to the Diving Safety Officer and the Diving Control Board;
2. General medical history;
3. Diving-related medical history;
4. Diving physical examination and completion of "MEDICAL EVALUATION OF FITNESS FOR SCUBA-DIVING REPORT" (appendix 3);
5. The tests indicated in Section 6.16;
6. Any additional tests the physician may consider necessary.

#### 6.15 Conditions for which Restriction from Diving is Recommended (Adapted from Bove, 1998)

1. Abnormalities of the tympanic membrane, such as perforation, presence of a monomeric membrane, or inability to auto inflate the middle ears.
2. Vertigo including Meniere's Disease.
3. Stapedectomy or middle ear reconstructive surgery.
4. Recent ocular surgery.
5. Psychiatric disorders including claustrophobia, suicidal ideation, psychosis, anxiety states, untreated depression.
6. Substance abuse, including alcohol.
7. Episodic loss of consciousness.
8. History of seizure.
9. History of stroke or a fixed neurological deficit.
10. Recurring neurologic disorders, including transient ischemic attacks.
11. History of intracranial aneurysm, other vascular malformation or intracranial hemorrhage.
12. History of neurological decompression illness with residual deficit.
13. Head injury with sequelae.
14. Hematologic disorders including coagulopathies.
15. Evidence of coronary artery disease or high risk for coronary artery disease.
16. Atrial septal defects.
17. Significant valvular heart disease - isolated mitral valve prolapse is not disqualifying.
18. Significant cardiac rhythm or conduction abnormalities.
19. Implanted cardiac pacemakers and cardiac defibrillators (ICD).
20. Inadequate exercise tolerance.
21. Severe hypertension.
22. History of spontaneous or traumatic pneumothorax.
23. Asthma.

24. Chronic pulmonary disease, including radiographic evidence of pulmonary blebs, bullae or cysts.

#### 6.16 Laboratory Requirements for Diving Medical Evaluation and Intervals.

Initial examination under age 40:

1. Medical History
2. Complete Physical Exam, emphasis on neurological and otological components
3. Chest X-ray
4. Spirometry
5. Hematocrit or Hemoglobin
6. Urinalysis
7. Any further tests deemed necessary by the physician.

Periodic re-examination under age 40 (every five years)

1. Medical History
2. Complete Physical Exam, emphasis on neurological and otological components
3. Hematocrit or Hemoglobin
4. Urinalysis
5. Any further tests deemed necessary by the physician

Initial exam over age 40:

1. Medical History
2. Complete Physical Exam, emphasis on neurological and otological components
3. Assessment of coronary artery disease using Multiple-Risk-Factor Assessment<sup>1</sup> (age, lipid profile, blood pressure, diabetic screening, smoker).
4. Resting EKG
5. Chest X-ray
6. Spirometry
7. Urinalysis
8. Hematocrit or Hemoglobin
9. Any further tests deemed necessary by the physician
10. Exercise stress testing may be indicated based on risk factor assessment.<sup>2</sup>

Periodic re-examination over age 40 (every three years); over age 60 (every two years):

1. Medical History
2. Complete Physical Exam, emphasis on neurological and otological components
3. Assessment of coronary artery disease using Multiple-Risk-Factor Assessment<sup>1</sup> (age, lipid profile, blood pressure, diabetic screening, smoker).
4. Resting EKG
5. Urinalysis
6. Hematocrit or Hemoglobin

7. Any further tests deemed necessary by the physician
8. Exercise stress testing may be indicated based on risk factor assessment.<sup>2</sup>

#### 6.17 Physician's Written Report.

1. After any medical examination required by this standard, the Research Diving Program shall obtain a written report prepared by the examining physician, which shall contain the examining physician's opinion of the individual's fitness to dive, including any recommended restrictions or limitations. This will be reviewed by the Diving Control Board, who shall recommend whether the individual should be authorized unconditionally, be authorized as a "Restricted Activity Diver," be required to undergo further testing, or be rejected.
2. The Diving Control Board shall provide the individual with a copy of the physician's written report.

<sup>1</sup> "Assessment of Cardiovascular Risk by Use of Multiple-Risk-Factor Assessment Equations." Grundy et. al. 1999. AHA/ACC Scientific Statement.  
<http://www.acc.org/clinical/consensus/risk/risk1999.pdf>

<sup>2</sup> Gibbons RJ, et al. ACC/AHA Guidelines for Exercise Testing. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). Journal of the American College of Cardiology. 30:260-311, 1997. <http://www.acc.org/clinical/guidelines/exercise/exercise.pdf>

## APPENDIX 1

### DEFINITION OF TERMS

Air sharing - The sharing of an air supply between divers.

Atmospheres Absolute (ATA) - Total pressure exerted on an object, by a gas or mixture of gases, at a specific depth or elevation, including normal atmospheric pressure.

Breath-hold Diving - A diving mode in which the diver uses no self-contained or surface-supplied air or oxygen supply.

Buddy Breathing - The sharing of a single air source between divers.

Buddy Diver - Second member of the dive team.

Buddy system - Two comparably equipped scuba divers in the water in constant communication.

Buoyant Ascent - An ascent made using some form of positive buoyancy.

Burst Pressure - The pressure at which a pressure containment device would fail structurally.

Certified Diver - A diver who holds a recognized valid certification from a nationally recognized SCUBA organization.

Controlled Ascent - Any one of several kinds of ascents including normal, swimming, and air sharing ascents where the diver(s) maintain control so a pause or stop can be made during the ascent.

Cylinder - A pressure vessel for the storage of gases.

Decompression Chamber - A pressure vessel for human occupancy. Also called a hyperbaric chamber or recompression chamber.

Decompression Sickness - A condition with a variety of symptoms which may result from gas and bubbles in the tissues of divers after pressure reduction.

Decompression Table - A profile or set of profiles of depth-time relationships for ascent rates and breathing mixtures to be followed after a specific depth-time exposure or exposures. (Also called dive tables.)

Dive - A descent into the water, an underwater diving activity utilizing compressed gas, an ascent, and return to the surface.

Dive Computer - A microprocessor based device which computes a diver's theoretical

decompression status, in real time, by using pressure (depth) and time as input to a decompression model, or set of decompression tables, programmed into the device.

Dive Location - A surface or vessel from which a diving operation is conducted.

Dive Site - The physical location of a diver during a dive.

Diver - An individual in the water who uses apparatus, including snorkel, which supplies breathing gas at ambient pressure.

Diver-Carried Reserve Breathing Gas - A diver-carried independent supply of air or mixed gas (as appropriate) sufficient under standard operating conditions to allow the diver to reach the surface, or another source of breathing gas, or to be reached by another diver.

Diver-In-Training - An individual gaining experience and training in additional diving activities under the supervision of a dive team member experienced in those activities.

Diving Control Board (DCB). The group of individuals who act as the official representative of the URI Research Diving Program in matters concerning the scientific diving.

Diving Mode - A type of diving required specific equipment, procedures, and techniques, for example, snorkel, scuba, surface-supplied air, or mixed gas.

Diving Safety Officer (DSO) - The individual responsible for the safe conduct of the URI Research Diving Program.

Emergency Ascent - An ascent made under emergency conditions where the diver exceeds the normal ascent rate.

Enriched Air (EAN<sub>x</sub>): a name for a breathing mixture of air and oxygen when the percent of oxygen exceeds 21%. This term is considered synonymous with the term “nitrox”.

Equivalent Air Depth (EAD): The depth at which air will have the same nitrogen partial pressure as the nitrox mixture being used. This number, expressed in units of feet seawater, will always be less than the actual depth for any enriched air mixture.

FN<sub>2</sub>: fraction of nitrogen in a gas mixture, expressed as either a decimal or percentage, by volume.

FO<sub>2</sub>: fraction of oxygen in a gas mixture, expressed as either a decimal or percentage, by volume.

FSW - Feet of seawater, or equivalent static head.

Hookah Diving - A type of shallow water surface-supplied diving where there is no voice communication with the surface.

Hyperbaric Chamber - See decompression chamber.

Hyperbaric Conditions - Pressure conditions in excess of normal atmospheric pressure at the dive location.

Lead Diver - The certified Scientific Diver with experience and training to conduct the diving operation.

Maximum Working Pressure - The maximum pressure to which a pressure vessel may be exposed under standard operating conditions.

Mixed-Gas Diving - A diving mode in which the diver is supplied in the water with a breathing gas other than air.

MOD: Maximum Operating Depth, usually determined as the depth at which the PO<sub>2</sub> for a given gas mixture reaches a predetermined maximum.

MSW - Meters of seawater or equivalent static head.

Nitrox: Any gas mixture comprised predominately of nitrogen and oxygen, most frequently containing between 21% and 40% oxygen. Also be referred to as Enriched Air Nitrox, abbreviated EAN.

NOAA Diving Manual: refers to the NOAA Diving Manual, Diving for Science and Technology, 2001 edition. National Oceanic and Atmospheric Administration, Office of Undersea Research, US Department of Commerce.

No-Decompression limits - The depth-time limits of the "no-decompression limits and repetitive dive group designations table for no-decompression air dives" of the U.S. Navy Diving Manual or equivalent limits.

Normal Ascent - An ascent made with an adequate air supply at a rate of 30 feet per minute or less.

Organizational Member (OM) - An organization which is a current member of the AAUS, and which has a program that adheres to the standards of the AAUS as set forth in the AAUS Standards for Scientific Diving Certification and Operation of Scientific Diving Programs.

Oxygen Clean: All combustible contaminants have been removed.

Oxygen Compatible: A gas delivery system that has components (o-rings, valve seats, diaphragms, etc. ...) that are compatible with oxygen at a stated pressure and temperature.

Oxygen Service: A gas delivery system that is both oxygen clean and oxygen compatible.

Oxygen Toxicity: Any adverse reaction of the central nervous system (“acute” or “CNS” oxygen toxicity) or lungs (“chronic”, “whole-body”, or “pulmonary” oxygen toxicity) brought on by exposure to an increased (above atmospheric level) partial pressure of oxygen (PO<sub>2</sub>).

Pressure-Related Injury - An injury resulting from pressure disequilibrium within the body as the result of hyperbaric exposure. Examples include: decompression sickness, pneumothorax, mediastinal emphysema, air embolism, subcutaneous emphysema, or ruptured eardrum.

Pressure Vessel - See cylinder.

PN<sub>2</sub>: Inspired partial pressure of nitrogen, usually expressed in units of atmospheres absolute.

PO<sub>2</sub>: Inspired partial pressure of oxygen, usually expressed in units of atmospheres absolute.

PSI: Abbreviation for the unit of pressure, “pounds per square inch”.

PSIG: Abbreviation for the unit of pressure, "pounds per square inch gauge".

Recompression Chamber - see decompression chamber.

Scuba Diving - A diving mode independent of surface supply in which the diver uses open circuit self-contained underwater breathing apparatus.

Standby Diver - A diver at the dive location capable of rendering assistance to a diver in the water.

Surface Supplied Diving - A diving mode in which the diver in the water is supplied from the dive location with compressed gas for breathing.

Swimming Ascent - An ascent which can be done under normal or emergency conditions accomplished by simply swimming to the surface.

Umbilical - The composite hose bundle between a dive location and a diver or bell, or between a diver and a bell, which supplies a diver or bell with breathing gas, communications, power, or heat, as appropriate to the diving mode or conditions, and includes a safety line between the diver and the dive location.

Working Pressure - The normal pressure at which the system is designed to operate.

## APPENDIX 2

### URI DIVING MEDICAL EXAM OVERVIEW FOR THE EXAMINING PHYSICIAN

#### TO THE EXAMINING PHYSICIAN:

This person, \_\_\_\_\_, requires a medical examination to assess his/her fitness for certification as a Scientific Diver for the University of Rhode Island. His /her answers on the Diving Medical History Form (attached), may indicate potential health or safety risks as noted. Your evaluation is requested on the attached scuba Diving Fitness Medical Evaluation Report. If you have questions about diving medicine, you may wish to consult one of the references on the attached list or contact one of the physicians with expertise in diving medicine whose names and phone numbers appear on an attached list. Please contact the undersigned Diving Safety Officer if you have any questions or concerns about diving medicine or the University of Rhode Island Research diving Standards. Thank you for your assistance.

Mark Gustafson  
Diving Safety Officer  
University of Rhode Island  
Tel: 401.874.6205

Scuba and other modes of compressed-gas diving can be strenuous and hazardous. A special risk is present if the middle ear, sinuses or lung segments do not readily equalize air pressure changes. The most common cause of distress is eustachian insufficiency. Most fatalities involve deficiencies in prudence, judgment, emotional stability or physical fitness. Please consult the following list of conditions, which usually restrict candidates from diving.

(Adapted from Bove, 1998: 61 -63, bracketed numbers are pages in Bove)

#### CONDITIONS THAT MAY DISQUALIFY CANDIDATES FROM DIVING

1. Abnormalities of the tympanic membrane, such as perforation, presence of a monomeric membrane, or inability to autoinflate the middle ears. [5,7,8,9]
2. Vertigo including Meniere's Disease. [13]
3. Stapedectomy or middle ear reconstructive surgery. [11]
4. Recent ocular surgery. [15,18,19]
5. Psychiatric disorders including claustrophobia, suicidal ideation, psychosis, anxiety states, untreated depression. [20-23]
6. Substance abuse, including alcohol. [24-25]
7. Episodic loss of consciousness. [1,26,27]
8. History of seizure. [27,28]
9. History of stroke or a fixed neurological deficit. [29,30]
10. Recurring neurologic disorders, including transient ischemic attacks. [29,30]

11. History of intracranial aneurysm, other vascular malformation or intracranial hemorrhage. [31]
12. History of neurological decompression illness with residual deficit. [29,30]
13. Head injury with sequelae. [26,27]
14. Hematologic disorders including coagulopathies. [41,42]
15. Evidence of coronary artery disease or high risk for coronary artery disease<sup>1</sup>. [33-35]
16. Atrial septal defects. [39]
17. Significant valvular heart disease - isolated mitral valve prolapse is not disqualifying. [38]
18. Significant cardiac rhythm or conduction abnormalities. [36-37]
19. Implanted cardiac pacemakers or cardiac defibrillators (ICD). [39,40]
20. Inadequate exercise tolerance. [34]
21. Severe hypertension. [35]
22. History of spontaneous or traumatic pneumothorax. [45]
23. Asthma<sup>2</sup>. [42-44]
24. Chronic pulmonary disease, including radiographic evidence of pulmonary blebs, bullae or cysts. [45,46]
25. Diabetes mellitus. [46-47]
26. Pregnancy. [56]

1. "Assessment of Cardiovascular Risk by Use of Multiple-Risk-Factor Assessment Equations." Grundy et. al. 1999. AHA/ACC Scientific Statement.  
<http://www.acc.org/clinical/consensus/risk/risk1999.pdf>
2. "Are Asthmatics Fit to Dive?" Elliott DH, ed. 1996 Undersea and Hyperbaric Medical Society, Kensington, MD.

#### SELECTED REFERENCES IN DIVING MEDICINE

Most of these are available from Best Publishing Company, P.O. Box 30100, Flagstaff, AZ 86003-0100, the Divers Alert Network (DAN) or the Undersea and Hyperbaric Medical Association (UHMS), Bethesda, MD.

ACC/AHA Guidelines for Exercise Testing. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). Gibbons RJ, et al. 1997. Journal of the American College of Cardiology. 30:260-311.  
<http://circ.ahajournals.org/cgi/content/full/96/1/345>

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<http://www.diversalertnetwork.org/medical/articles/index.asp>

"Are Asthmatics Fit to Dive?" Elliott DH, ed. 1996 Undersea and Hyperbaric Medical Society, Kensington, MD.

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MEDICAL EXAMINATION OF SPORT SCUBA DIVERS, 1998. Alfred Bove, M.D.,Ph.D. (ed.). Medical Seminars, Inc. San Antonio, TX

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U.S. NAVY DIVING MANUAL. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

APPENDIX 3  
MEDICAL EVALUATION OF FITNESS FOR SCUBA DIVING REPORT

\_\_\_\_\_  
Name of Applicant (Print or Type)

\_\_\_\_\_  
Date (Mo/Day/Year)

To The PHYSICIAN:

This person is an applicant for training or is presently certified to engage in diving with self-contained underwater breathing apparatus (scuba). This is an activity that puts unusual stress on the individual in several ways. Your opinion on the applicant's medical fitness is requested. Scuba diving requires heavy exertion. The diver must be free of cardiovascular and respiratory disease. An absolute requirement is the ability of the lungs, middle ear and sinuses to equalize pressure. Any condition that risks the loss of consciousness should disqualify the applicant.

**TESTS:** Please initial that the following tests were completed.

**[ ] Initial Examination**

- \_\_\_\_\_ Medical History
- \_\_\_\_\_ Complete Physical Exam with emphasis on neurological and otological components
- \_\_\_\_\_ Chest X-Ray
- \_\_\_\_\_ Spirometry
- \_\_\_\_\_ Hematocrit or Hemoglobin
  
- \_\_\_\_\_ Urinalysis
- \_\_\_\_\_ Any further tests deemed necessary by the physician

**Additional testing for first over age 40**

- \_\_\_\_\_ Resting EKG
- \_\_\_\_\_ Assessment of coronary artery disease using Multiple-Risk-Factor Assessment<sup>1</sup>  
(age, lipid profile, blood pressure, diabetic screening, smoker) Note: Exercise stress testing may be indicated based on risk factor assessment<sup>2</sup>

**[ ] Re-examination**

**(Every 5 years under age 40,  
first exam over age 40,  
every 3 years over age 40,  
every 2 years over age 60)**

- \_\_\_\_\_ Medical History
- \_\_\_\_\_ Complete Physical Exam, with emphasis on neurological and otological components
- \_\_\_\_\_ Hematocrit or Hemoglobin
- \_\_\_\_\_ Urinalysis
- \_\_\_\_\_ Any further tests deemed necessary by the physician

**Additional testing for over age 40**

- \_\_\_\_\_ Resting EKG
- \_\_\_\_\_ Assessment of coronary artery disease using Multiple-Risk-Factor Assessment<sup>5</sup>  
(age, lipid profile, blood pressure, diabetic screening, smoker) Note: Exercise stress testing may be indicated based on risk factor assessment<sup>6</sup>

Recommendation:  
  
\_\_\_\_\_

<sup>1</sup> "Assessment of Cardiovascular Risk by Use of Multiple-Risk-Factor Assessment Equations." Grundy et. al. 1999. AHA/ACC Scientific Statement. <http://www.acc.org/clinical/consensus/risk/risk1999.pdf>

<sup>6</sup> Gibbons RJ, et al. ACC/AHA Guidelines for Exercise Testing. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). Journal of the American College of Cardiology. 30:260-311, 1997. <http://www.acc.org/clinical/guidelines/exercise/exercise.pdf>

- [ ] APPROVAL. I find no medical condition(s), which I consider incompatible with diving.
- [ ] RESTRICTEDACTIVITY APPROVAL. The applicant may dive in circumstances as described in REMARKS.
- [ ] FURTHER TESTING REQUIRED. I have encountered a potential contraindication to diving. Additional medical tests must be performed before a final assessment can be made. See REMARKS.
- [ ] REJECT. This applicant has medical condition(s), which, in my opinion, clearly would constitute unacceptable hazards to health and safety in diving.

**REMARKS:**

---

**PHYSICIAN'S STATEMENT:**

I have evaluated the above-mentioned individual according to the American Academy of Underwater Sciences medical standards for scientific diving (Section 6.00), and find no conditions that may be disqualifying. I have discussed with the patient any medical condition(s) that would not disqualify him/her from diving but which may seriously compromise subsequent health. The patient understands the nature of the hazards and the risks involved in diving with these conditions.

\_\_\_\_\_ M.D. or DO  
 Date    Signature

---

Name (Print or Type)

---

Address

---

Telephone Number  
 My familiarity with applicant is:  
     \_\_\_\_ With this exam only  
     \_\_\_\_ Regular Physician for \_\_\_\_\_ years  
     \_\_\_\_ Other  
     (describe)\_\_\_\_\_

---

My familiarity with diving medicine is: \_\_\_\_\_

**APPLICANT'S RELEASE OF MEDICAL INFORMATION FORM**

I authorize the release of this information and all medical information subsequently acquired in association with my diving to URI's Diving Safety Officer and Diving Control Board or their designee at (place) \_\_\_\_\_ on (date)\_\_\_\_\_.  
 Signature of Applicant \_\_\_\_\_

APPENDIX 4  
DIVING MEDICAL HISTORY FORM  
(To Be Completed by Applicant-Diver)

Name \_\_\_\_\_ Sex \_\_\_\_ Age \_\_\_\_\_ Wt.\_\_\_\_ Ht.\_\_\_\_\_

Sponsor \_\_\_\_\_ Date \_\_\_\_/\_\_\_\_/\_\_\_\_  
(Dept./Project/Program/School, etc.) (Mo/Day/Yr)

TO THE APPLICANT:

Scuba diving makes considerable demands on you, both physically and mentally. Diving with certain medical conditions may be asking for trouble not only for yourself, but also to anyone coming to your aid if you get into difficulty in the water. Therefore, it is prudent to meet certain medical and physical requirements before beginning a diving or training program.

Your answers to the questions are as important, in determining your fitness as your physical examination. Obviously, you should give accurate information or the medical screening procedure becomes useless.

This form shall be kept confidential. If you believe any question amounts to invasion of your privacy, you may elect to omit an answer, provided that you shall subsequently discuss that matter with your own physician and he/she must then indicate, in writing, that you have done so and that no health hazard exists.

Should your answers indicate a condition, which might make diving hazardous, you will be asked to review the matter with your physician. In such instances, his/her written authorization will be required in order for further consideration to be given to your application. If your physician concludes that diving would involve undue risk for you, remember that he/she is concerned only with your well-being and safety. Please respect the advice and the intent of this medical history form.

Have you ever had or do you presently have any of the following? Please answer Yes or No. If yes please provide comments.

1. Trouble with your ears, including ruptured eardrum, difficulty clearing your ears, or surgery.
2. Trouble with dizziness.
3. Eye surgery.
4. Depression, anxiety, claustrophobia, etc.
5. Substance abuse, including alcohol.
6. Loss of consciousness.
7. Epilepsy or other seizures, convulsions or fits.
8. Stroke or a fixed neurological deficit.
9. Recurring neurologic disorders, including transient ischemic attacks.

10. Aneurysms or bleeding in the brain.
  11. Decompression sickness or embolism.
  12. Head injury.
  13. Disorders of the blood, or easy bleeding.
  14. Heart disease, diabetes, high cholesterol
  15. Anatomical heart abnormalities including patent foramen ovale, valve problems, etc.
  16. Heart rhythm problems.
  17. Need for a pacemaker or defibrillator?
  18. Difficulty with exercise.
  19. High blood pressure.
  20. Collapsed lung.
  21. Asthma.
  22. Other lung disease.
  23. Diabetes mellitus.
  24. Pregnancy.
  - 25 Surgery If yes explain below.
  26. Hospitalizations. If yes explain below.
  27. Do you take any medications? If yes list below.
  28. Do you have any allergies to medications, foods, environmental? If yes explain below.
  29. Do you smoke?
  30. Do you drink alcoholic beverages?
  31. Is there a family history of high cholesterol?
  32. Is there a family history of heart disease or stroke?
  33. Is there a family history of diabetes?
  34. Is there a family history of asthma?
- Please explain any "yes" answers to the above questions.

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---

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I certify that the above answers and information represent an accurate and complete description of my medical history.

Signature:

Date:

## APPENDIX 5

### SELECTED REFERENCES IN DIVING MEDICINE

1. DIVING AND SUBAQUATIC MEDICINE. C. Edmonds, C. Lowery and J. Pennefather. Diving Medical Center, Mosman, N.S.W. Australia. (Available from Best Publishing Company, P.O. Box 1978, San Pedro, CA 90733)
2. MEDICAL EXAMINATION OF SPORT SCUBA DIVERS. Jefferson Davis, M.D. (ed.). Best Publishing Company, P.O. Box 1978, San Pedro, CA 90733
3. NEW SCIENCE OF SKIN AND SCUBA DIVING. Associations Press, NY
4. NOAA DIVING MANUAL, NOAA. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.
5. SCUBA DIVING IN SAFETY AND HEALTH. C.W. Deuker. Madison Publishing Associates, Diving Safety Digest, P.O. Box 2735, Menlo Park, CA 94026
6. THE PHYSICIAN'S GUIDE TO DIVING MEDICINE. C.W. Shilling, C.B. Carlston and R.A. Mathias. Plenum Press, New York, NY (Available through the Undersea and Hyperbaric Medical Association, Bethesda, MD)
7. U.S. NAVY DIVING MANUAL. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.



University of Rhode Island  
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South Ferry Road  
Narragansett, RI 02882  
401-874-6205  
401-874-6574 (fax)  
gustaf@gso.uri.edu

To Whom It May Concern:

RE: URI AAUS Letter of Reciprocity

This letter serves to verify that NAME has met the training and prerequisites to be authorized as a scientific diver as established by the **University of Rhode Island's** Diving Safety Manual, and has demonstrated competency in the indicated areas. The **University of Rhode Island** is a current organizational member of the AAUS and meets or exceeds all AAUS training requirements.

Date of last medical exam:  
Date of last CPR course  
Date of last first aid course  
Date of last oxygen provider course  
Date of last regulator service  
Written exam completed  
Number of dives in last 12 months  
Date of last dive  
Depth certification  
Date of last dive to certification depth

Expiration:  
Expiration:  
Expiration:  
Expiration

Any diving restrictions? Yes ( ) No ( ) Explain:

Are there any waivers in effect related to dive certification or training? Yes ( ) No ( )  
Explain:

Additional training or certification:

Emergency Contact Information:

## APPENDIX 7

### DIVING EMERGENCY MANAGEMENT PROCEDURES

#### Introduction

A diving accident victim could be any person who has been breathing air underwater regardless of depth. It is essential that emergency procedures are pre-planned and that medical treatment is initiated as soon as possible. It is the responsibility of each AAUS organizational member to develop procedures for diving emergencies including evacuation and medical treatment for each dive location.

#### General Procedures

Depending on and according to the nature of the diving accident:

1. Make appropriate contact with victim or rescue as required.
2. Establish (A)irway, (B)reathing, (C)irculation as required.
3. Stabilize the victim
4. Administer 100% oxygen, if appropriate (in cases of Decompression Illness, or Near Drowning).
5. Call local Emergency Medical System (EMS) for transport to nearest medical treatment facility. Explain the circumstances of the dive incident to the evacuation teams, medics and physicians. Do not assume that they understand why 100% oxygen may be required for the diving accident victim or that recompression treatment may be necessary.
5. Call appropriate Diving Accident Coordinator for contact with diving physician and decompression chamber. etc.
6. Notify DSO or designee according to the Emergency Action Plan of the organizational member.
7. Complete and submit Incident Report Form ([www.aaus.org](http://www.aaus.org)) to the DCB of the organization

#### List of Emergency Contact Numbers Appropriate For Dive Location:

1. U.S. Navy Submarine Base, Groton, CT. (860) 694-3674 (24 hr number)
2. DAN (919) 684-8111 (24 hr number)
3. Our Lady of Fatima Hospital, North Providence, RI. (401) 456-3957  
(No Weekends or after hours Hyperbaric Service.)
4. Kent Hospital, Hyperbaric Service (401) 736-4646, after hrs (401) 737-7000

#### Emergency Plan Content

- Name, telephone number, and relationship of person to be contacted for each diver in the event of an emergency.
- Nearest operational decompression chamber.
- Nearest accessible hospital.
- Available means of transport.

## APPENDIX 8 URI CHECKOUT DIVE EVALUATION

Authorized Scientific Divers from URI should be able to demonstrate proficiency in the following skills during checkout dives or training evaluation dives with the Dive Safety Officer or designee:

### General skills:

1. Knowledge of URI diving standards and regulations;
2. Pre-dive planning, briefing, site orientation, and buddy check;
3. Use dive tables and/or dive computer;
4. Equipment familiarity;
5. Underwater signs and signals;
6. Proper buddy contact;
7. Monitor cylinder pressure, depth, and bottom time.

### Swimming skills:

1. Surface dive to 10 ft. without scuba gear;
2. Demonstrate watermanship and snorkel skills;
3. Surface swim without swim aids (400 yd. in approximately 12-min.);
4. Underwater swim without swim aids (25 yd. without surfacing);
5. Tread water without swim aids (10 min.), or without use of hands (2 min.);
6. Transport another swimmer without swim aids (25-yd);
7. Entry and exit (pool, boat, shore);
8. Mask removal and clearing;
9. Regulator removal and clearing;
10. Surface swim with scuba; alternate between snorkel and regulator (400 yd.);
11. Neutral buoyancy (hover motionless in mid water);
12. Proper descent and ascent with BC;
13. Remove and replace weight belt while submerged;
14. Remove and replace scuba cylinder while submerged;
15. Alternate air source breathing with and without mask (donor/receiver);
16. Buddy breathing with and without mask (donor/receiver);
17. Simulated emergency swimming ascent;
18. Compass and underwater navigation;
19. Simulated decompression and safety stop.

### Rescue:

1. Self rescue techniques;
2. Tows of conscious and unconscious victim 100-yards. ;
3. Simulated in-water rescue breathing;
4. Rescue of submerged non-breathing diver (including equipment removal, simulated rescue breathing, towing, and recovery to boat or shore);
5. Use of emergency oxygen on breathing and non-breathing victim;
6. Accident management and evacuation procedures.

### Additional Training (optional)

1. Compressor/ Fill station orientation and usage;
2. Small boat handling.

## APPENDIX 9

### DIVING FROM THE R/V ENDEAVOR

#### POLICY

Scientific diving is a normal operation from the research vessel Endeavor. All diving from the Endeavor is under the auspices of the University National Oceanographic Laboratory Systems (UNOLS) Research Vessel Safety Standards and the guidelines of the University of Rhode Island (URI) Research Diving Manual. All scientific diving conducted from the Endeavor must be approved by the vessel's Master and URI's Diving Safety Officer (DSO). All diving must meet the minimum standards of the American Academy of Underwater Sciences (AAUS).

#### ADMINISTRATIVE PROCEDURES

In a multi-institutional diving cruise, a lead Diving Control Board (DCB) will be designated by agreement of all DCB's involved. The procedures, rules and regulations that govern diving operations for that particular cruise will be those of the designated lead DCB.

#### Cruise Planning

An onboard Diving Supervisor will be proposed by the Principal Investigator (PI) and approved by the lead institution's DCB. It is the responsible of the Diving Supervisor to assure that all scientific diving is conducted in accordance with all applicable regulations. The Principal Investigator (PI) or their designee will supply a detailed dive plan to their DCB, who will forward the dive plan, once approved, to the lead institution's DCB 90 days before cruise departure. The dive plan will include:

1. Diving credentials for all diving members of the scientific party, including Scientific Diver certification, current diving physicals, dive logs. Reciprocity exists for Scientific Divers in good standing between URI and other AAUS organizations (Appendix 6 URI Research Diving Manual).
2. An emergency plan including:
  - a. accident management and emergency evacuation protocols;
  - b. a list of medical supplies required;
  - c. a specified quantity of medical grade oxygen with a positive pressure demand delivery system;
  - e. request for diving support equipment (e.g., small boats).
3. Forward the approved dive plan to the Chief Scientist and Marine Superintendent.

#### Cruise Personnel

1. The Master has responsibility for the safety of all activities aboard Endeavor, including diving (Section 14.4 UNOLS Research Vessel Safety Standards).

2. The PI of the diving project is responsible for the planning and coordination of the research diving operations.
3. The Diving Supervisor will be the main point of contact for scientists, technicians and crewmembers participating in research diving. The diving supervisor is responsible for the execution of the research diving operations in accord with the dive plan. He or she has the authority to restrict or suspend diving operations and alter the cruise plan in consultation with the Master and the PI. The diving supervisor's responsibilities include:
  - a. Meeting with the Master and Chief Scientist to review the dive plan and emergency procedures prior to any diving activities.
  - b. Assure that a copy of the URI Research Diving Manual or the lead institution's Diving Manual is on board, and available to the scientists and crew. The Research Diving Manual and emergency plan should be filed on the bridge.
  - c. Act, at all times, as supervisor of diving operations. Before diving, divers should submit, in writing, or verbally, a detailed dive plan to the diving supervisor for approval. The dive supervisor will then communicate the plan to the bridge for final go ahead. No diving is to be undertaken without the knowledge of both the Diving Supervisor and the Master or Watch Officer. Failure to follow this procedure can result in revocation of diving privileges for the duration of the cruise.
  - d. Inspecting high-pressure SCUBA cylinders and breathing air compressors to assure that they meet URI's standards (Section 5.5 URI Research Diving Manual).
4. Scientific Divers must recognize their individual responsibility for their safety.

#### Small Boats

Diving from Endeavor will be supported from one of the vessel's small boats. Crewmembers or a member of the scientific party can operate small boats. The Master, or their designee, will decide the competency of all boat operators and approve the use of the scientific party members as small boat operators. Whenever divers are in the water, a small boat will be deployed to assist. All small boat operators will be versed in emergency procedures. Small boats will be equipped with a hand-held VHF marine radio and medical grade oxygen with a positive pressure demand delivery system.

#### DIVING EQUIPMENT

Diving from the Endeavor often reflects the regional and personal preferences of participants from multiple institutions and this is reflected in their equipment choices. Most of the variability in diving equipment does not present a problem, but sometimes this variation can be potentially hazardous. To avoid such incidents, it is the responsibility of the PI to advise URI's DSO of any significant equipment variations 60 days before cruise departure (Section 5.0 URI Research Diving Manual).

### SCUBA Cylinders

Sixty days before cruise departure, certification of a current visual internal inspection (VIP) and hydrostatic testing, performed according to accepted methods, must be supplied by the SCUBA cylinder's owner, to the Diving Safety Officer. The diving supervisor, in consultation with the appropriate ship's personnel will secure all SCUBA cylinders aboard Endeavor in an appropriate manner.

### Compressed Air

Diving-quality compressed air is available on board the Endeavor in the form of a diving support van. Certification of air quality for all compressors will be supplied to the lead DCB upon request. All compressors are operated in accordance with manufacturers' specifications and meet AAUS minimum standards.

## APPENDIX 10

### **NITROX DIVING GUIDELINES**

The following guidelines address the use of nitrox by scientific divers under the auspices of the University of Rhode Island Research Diving Program. Nitrox is defined for these guidelines as breathing mixtures composed predominately of nitrogen and oxygen, most commonly produced by the addition of oxygen or the removal of nitrogen from air. These guidelines are directly from the *AAUS 2003 Standards for Scientific Diving*, section 7.

#### **PREREQUISITES**

##### Eligibility

Only a certified Scientific Diver or Scientific Diver In Training (see AAUS Standards Sec. 4.00 and 5.00) diving under the auspices of a member organization is eligible for authorization to use nitrox. After completion, review and acceptance of application materials, training and qualification as per Sec. 7.12 of these guidelines, an applicant will be authorized to use nitrox within his/her depth authorization, as specified in AAUS Standards Sec 5.40.

##### Application and documentation

Application and documentation for authorization to use nitrox should be made on forms specified by the Diving Control Board.

#### **REQUIREMENTS FOR AUTHORIZATION TO USE NITROX**

Submission of documents and participation in aptitude examinations does not automatically result in authorization to use nitrox. The applicant must convince the DSO and members of the DCB that he/she is sufficiently skilled and proficient. The signature of the DSO on the authorization form will acknowledge authorization. After completion of training and evaluation, authorization to use nitrox may be denied to any diver who does not demonstrate to the satisfaction of the DSO or DCB the appropriate judgment or proficiency to ensure the safety of the diver and dive buddy. Prior to authorization to use nitrox, the following minimum requirements should be met:

##### Training

The diver must complete additional theoretical and practical training beyond the Scientific Diver In Training air certification level, to the satisfaction of the member organizations DSO and DCB (see Section 7.20).

##### Examinations

Each diver should demonstrate proficiency in skills and theory in written, oral, and practical examinations covering:

1. Written examinations covering the information presented in the classroom training session(s) (i.e., gas theory, oxygen toxicity, partial pressure determination, etc.).
2. Practical examinations covering the information presented in the practical training session(s) (i.e., gas analysis, documentation procedures, etc).
3. Open water checkout dives, to appropriate depths, to demonstrate the application of theoretical and practical skills learned.
4. Minimum Activity to Maintain Authorization  
The diver should log at least one (1) nitrox dive per year. Failure to meet the minimum activity level may be cause for restriction or revocation of nitrox authorization.

## **NITROX TRAINING GUIDELINES**

Training in these guidelines should be in addition to training for Diver-In-Training authorization (AAUS Standards Sec. 4.00). It may be included as part of training to satisfy the Scientific Diver training requirements (AAUS Standards Sec. 5.32).

### Classroom Instruction

1. Topics should include, but are not limited to: review of previous training; physical gas laws pertaining to nitrox; partial pressure calculations and limits; equivalent air depth (EAD) concept and calculations; oxygen physiology and oxygen toxicity; calculation of oxygen exposure and maximum safe operating depth (MOD); determination of decompression schedules (both by EAD method using approved air dive tables, and using approved nitrox dive tables); dive planning and emergency procedures; mixing procedures and calculations; gas analysis; personnel requirements; equipment marking and maintenance requirements; dive station requirements.
2. The DCB may choose to limit standard nitrox diver training to procedures applicable to diving, and subsequently reserve training such as nitrox production methods, oxygen cleaning, and dive station topics to divers requiring specialized authorization in these areas.

### Practical Training

The practical training portion will consist of a review of skills as stated for scuba (AAUS Standards Sec. 4.00), with additional training as follows:

1. Oxygen analysis of nitrox mixtures;
2. Determination of MOD, oxygen partial pressure exposure, and oxygen toxicity time limits, for various nitrox mixtures at various depths;
3. Determination of nitrogen-based dive limits status by EAD method using air dive tables, and/or using nitrox dive tables, as approved by the DCB.

4. Nitrox dive computer use may be included, as approved by the DCB.
5. Written Examination (based on classroom instruction and practical training)

Before authorization, the trainee should successfully pass a written examination demonstrating knowledge of at least the following:

1. Function, care, use, and maintenance of equipment cleaned for nitrox use;
2. Physical and physiological considerations of nitrox diving (ex. O<sub>2</sub> and CO<sub>2</sub> toxicity);
3. Diving regulations and procedures as related to nitrox diving, either scuba or surface-supplied (depending on intended mode);
4. Given the proper information, calculation of:
  - 1 Equivalent air depth (EAD) for a given fO<sub>2</sub> and actual depth;
  - 2 pO<sub>2</sub> exposure for a given fO<sub>2</sub> and depth;
  - 3 Optimal nitrox mixture for a given pO<sub>2</sub> exposure limit and planned depth;
  - 4 Maximum operational depth (MOD) for a given mix and pO<sub>2</sub> exposure limit;
  - 5 For nitrox production purposes, percentages/psi of oxygen present in a given mixture, and psi of each gas required to produce a fO<sub>2</sub> by partial pressure mixing.
5. Decompression table and dive computer selection and usage;
6. Nitrox production methods and considerations;
7. Oxygen analysis;
8. Nitrox operational guidelines (Section 7.40), dive planning, and dive station components.

### Open water Dives

A minimum of two supervised open water dives using nitrox is required for authorization. The mode used in the dives should correspond to the intended application (i.e., scuba or surface-supplied). If the MOD for the mix being used can be exceeded at the training location, direct, in-water supervision is required.

### Surface-Supplied Training

All training as applied to surface-supplied diving (practical, classroom, and open water) will follow the member organization's surface-supplied diving standards, including additions listed in Sec. 7.21 and 7.22.

## **SCIENTIFIC NITROX DIVING REGULATIONS**

### Dive Personnel Requirements

Nitrox Diver In Training - A Diver In Training, who has completed the requirements of AAUS Standards Section 4.00 and the training and authorization sections of these guidelines, may be authorized by the DSO to use nitrox under the direct supervision a Scientific Diver who also holds nitrox authorization. Dive depths should be restricted to those specified in the diver's authorization.

Scientific Diver - A Scientific Diver who has completed the requirements of AAUS Standards Section 5.00 and the training and authorization sections of these guidelines, may be authorized by the DSO to use nitrox. Depth authorization to use nitrox should be the same as those specified in the diver's authorization, as described in AAUS Sec. 5.40.

Lead Diver - On any dive during which nitrox will be used by any team member, the Lead Diver should be authorized to use nitrox, and hold appropriate authorizations required for the dive, as specified in AAUS Standards. Lead Diver authorization for nitrox dives by the DSO and/or DCB should occur as part of the dive plan approval process.

In addition to responsibilities listed in AAUS Section 1.26, the Lead diver should:

1. As part of the dive planning process, verify that all divers using nitrox on a dive are properly qualified and authorized.
2. As part of the pre-dive procedures, confirm with each diver the nitrox mixture the diver is using, and establish dive team maximum depth and time limits, according to the shortest time limit or shallowest depth limit among the team members.
3. The Lead Diver should also reduce the maximum allowable pO<sub>2</sub> exposure limit for the dive team if on-site conditions so indicate (see Sec. 7.42.1.2)

#### Dive Parameters

##### Oxygen Exposure Limits

1. The inspired oxygen partial pressure experienced at depth should not exceed 1.6 ATA. All dives performed using nitrox-breathing mixtures should comply with the current *NOAA Diving Manual* "Oxygen Partial Pressure Limits for 'Normal' Exposures"
2. The maximum allowable exposure limit should be reduced in cases where cold or strenuous dive conditions, or extended exposure times are expected. The DCB should consider this in the review of any dive plan application, which proposes to use nitrox. The Lead Diver should also review on-site conditions and reduce the allowable pO<sub>2</sub> exposure limits if conditions indicate.
3. If using the equivalent air depth (EAD) method the maximum depth of a dive should be based on the oxygen partial pressure for the specific nitrox breathing mix to be used.

##### Bottom Time Limits

1. Maximum bottom time should be based on the depth of the dive and the nitrox mixture being used.
2. Bottom time for a single dive should not exceed the NOAA maximum allowable "Single Exposure Limit" for a given oxygen partial pressure, as listed in the current NOAA Diving Manual.

##### Decompression Tables and Gases

1. A set of DCB approved nitrox decompression tables should be available at the dive site.
2. When using the equivalent air depth (EAD) method, dives should be conducted using air decompression tables approved by the DCB.
3. If nitrox is used to increase the safety margin of air-based dive tables, the MOD and oxygen exposure and time limits for the nitrox mixture being dived should not be exceeded.
4. Breathing mixtures used while performing in-water decompression, or for bailout purposes, should contain the same or greater oxygen content as that being used during the dive, within the confines of depth limitations and the oxygen partial pressure limits.

#### Nitrox Dive Computers

1. Dive Computers may be used to compute decompression status during nitrox dives. Manufacturers' guidelines and operations instructions should be followed.
2. Use of Nitrox dive computers should comply with dive computer guidelines included in the AAUS Standards (Appendix 10).
3. Nitrox Dive computer users should demonstrate a clear understanding of the display, operations, and manipulation of the unit being used for nitrox diving prior to using the computer, to the satisfaction of the DSO or his/her designee.
4. If nitrox is used to increase the safety margin of an air-based dive computer, the MOD and oxygen exposure and time limits for the nitrox mixture being dived should not be exceeded.
5. Dive computers capable of pO<sub>2</sub> limit and fO<sub>2</sub> adjustment should be checked by the diver prior to the start each dive to assure compatibility with the mix being used.

#### Repetitive Diving

1. Repetitive dives using nitrox mixtures should be performed in compliance with procedures required of the specific dive tables used.
2. Residual nitrogen time should be based on the EAD for the specific nitrox mixture to be used on the repetitive dive, and not that of the previous dive.
3. The total cumulative exposure (bottom time) to a partial pressure of oxygen in a given 24 hour period should not exceed the current *NOAA Diving Manual* 24-hour Oxygen Partial Pressure Limits for "Normal" Exposures.
4. When repetitive dives expose divers to different oxygen partial pressures from dive to dive, divers should account for accumulated oxygen exposure from previous dives when determining acceptable exposures for repetitive dives. Both acute (CNS) and chronic (pulmonary) oxygen toxicity concerns should be addressed.

#### Oxygen Parameters

1. Authorized Mixtures - Mixtures meeting the criteria outlined may be used for nitrox diving operations, upon approval of the DCB.

## Purity

1. Oxygen used for mixing nitrox-breathing gas should meet the purity levels for “Medical Grade” (U.S.P.) or “Aviator Grade” standards.
2. In addition to the AAUS Air Purity Guidelines (AAUS Sec. 3.60), the following standard should be met for breathing air that is either:
  - a. Placed in contact with oxygen concentrations greater than 40%, or
  - b. Used in nitrox production by the partial pressure mixing method with gas mixtures containing greater than 40% oxygen as the enriching agent:

Air Purity: CGA Grade E (AAUS Sec. 3.60)

Condensed Hydrocarbons: 5mg/M<sup>3</sup>

Hydrocarbon Contaminants: No greater than 0.1 mg/m<sup>3</sup>

## Gas Mixing and Analysis

### Personnel Requirements

1. Individuals responsible for producing and/or analyzing nitrox mixtures should be knowledgeable and experienced in all aspects of the technique.
2. Only those individuals approved by the DSO and/or DCB should be responsible for mixing and/or analyzing nitrox mixtures.

Production Methods - It is the responsibility of the DCB to approve the specific nitrox production method used.

### Analysis Verification by User

1. It is the responsibility of each diver to analyze prior to the dive the oxygen content of his/her scuba cylinder and acknowledge in writing the following information for each cylinder: fO<sub>2</sub>, MOD, cylinder pressure, date of analysis, and user’s name.
2. Individual dive log-reporting forms should report fO<sub>2</sub> of nitrox used, if different than 21%.

## **NITROX DIVING EQUIPMENT**

All of the designated equipment and stated requirements regarding scuba equipment required in the AAUS Standards should apply to nitrox scuba operations. Additional minimal equipment necessary for nitrox diving operations includes:

- a. Labeled SCUBA Cylinders
- b. Oxygen Analyzers

### Oxygen Cleaning and Maintenance Requirements

#### Requirement for Oxygen Service

1. All equipment which during the dive or cylinder filling process is exposed to concentrations greater than 40% oxygen at pressures above 150 psi should be cleaned and maintained for oxygen service.
2. Equipment used with oxygen or mixtures containing over forty percent (40%) by volume oxygen shall be designed and maintained for oxygen service. Oxygen systems over 125 psig shall have slow-opening shut-off valves.

This should include the following equipment: scuba cylinders, cylinder valves, scuba and other regulators, cylinder pressure gauges, hoses, diver support equipment, compressors, and fill station components and plumbing.

### Scuba Cylinder Identification Marking

Scuba cylinders to be used with nitrox mixtures should have the following identification documentation affixed to the cylinder.

1. Cylinders should be marked “NITROX”, or “EANx”, or “Enriched Air”
2. Nitrox identification color-coding should include a 4-inch wide green band around the cylinder, starting immediately below the shoulder curvature. If the cylinder is not yellow in, the green band should be bordered above and below by a 1-inch yellow band.
3. The alternate marking of a yellow cylinder by painting the cylinder crown green and printing the word “NITROX” parallel to the length of the cylinder in green print is acceptable.
4. Other markings which identify the cylinder as containing gas mixes other than air may be used as the approval of the DCB.
5. A contents label should be affixed, to include the current fO<sub>2</sub>, date of analysis, and MOD.
6. The cylinder should be labeled to indicate whether the cylinder is prepared for oxygen or nitrox mixtures containing greater than 40% oxygen.

### Regulators

Regulators to be used with nitrox mixtures containing greater than 40% oxygen should be cleaned and maintained for oxygen service, and marked in an identifying manner.

### Other Support Equipment

1. An oxygen analyzer is required which is capable of determining the oxygen content in the scuba cylinder. Two analyzers are recommended to reduce the likelihood of errors due to a faulty analyzer. The analyzer should be capable of reading a scale of 0 to 100% oxygen, within (one) 1% accuracy.
2. All diver and support equipment should be suitable for the fO<sub>2</sub> being used.

### Compressor and Fill Station

Compressor system

1. The compressor/filtration system **MUST** produce oil-free air.
2. An oil-lubricated compressor placed in service for a nitrox system should be checked for oil and hydrocarbon contamination at least quarterly.

Fill Station Components - All components of a nitrox fill station that will contact nitrox mixtures containing greater than 40% oxygen should be cleaned and maintained for oxygen service. This includes cylinders, whips, gauges, valves, and connecting lines.

## APPENDIX 11

### AQUARIUM DIVING OPERATIONS

#### GENERAL POLICY

This section applies to scientific aquarium divers only.

Definition - A scientific aquarium diver is a Scientific Diver who is diving solely within an aquarium. An aquarium is a shallow, confined body of water, which is operated by or under the control of an institution and is used for the purposes of specimen exhibit, education, husbandry, or research, examples of such facilities are the MERL tanks and mesocosm located at URI's Narragansett Bay Campus.

#### THE BUDDY SYSTEM IN SCIENTIFIC AQUARIUM DIVING

All scuba diving activities in the confined environment of an aquarium shall be conducted in accordance with the buddy system, whereby both divers, or a diver and a tender are always in visual contact with one another, can always communicate with one another, and can always render prompt and effective assistance either in response to an emergency or to prevent an emergency. A diver and tender comprise a buddy team in the confined environment of an aquarium only when the maximum depth does not exceed 30 feet, and there are no overhead obstructions or entanglement hazards for the diver, and the tender is equipped, ready and able to conduct or direct a prompt and effective in-water retrieval of the diver at all times during the dive.

#### DIVING EQUIPMENT

In an aquarium of a known maximum obtainable depth:

1. A depth indicator is not required, except that a repetitive diver shall use the same computer used on any prior dive.
2. Only one buddy must be equipped with a timing device."
3. The maximum obtainable depth of the aquarium shall be used as the diving depth.

#### SCIENTIFIC AQUARIUM DIVER CERTIFICATION

A Scientific Aquarium Diver is a certification enabling the qualified diver to participate in scientific diving in accordance with the standards of this section as provided below.

All of the standards set forth in of this manual shall apply, except this section of this manual is modified to read as follows:

Practical training shall include at least 12 supervised aquarium dives for a cumulative bottom time of 6 hours. No more than 3 of these dives shall be made in one day.

## SCIENTIFIC AQUARIUM DIVING USING OTHER DIVING TECHNOLOGY

### Surface Supplied Scientific Aquarium Diving.

Definition: For purposes of scientific aquarium diving, surface supplied diving is described as a mode of diving using open circuit, surface supplied compressed gas which is provided to the diver at the dive location and may or may not include voice communication with the surface tender.

Divers using the surface supplied mode shall be equipped with a diver-carried independent reserve breathing gas supply.

Scientific aquarium divers using conventional scuba masks, full-face masks or non-lockdown type helmets are exempt from this standard provided:

- a) There are no overhead obstructions or entanglements, and
- b) the diver is proficient in performing a Controlled Emergency Swimming Ascent from at least as deep as the maximum depth of the aquarium, and
- c) the diver is proficient in performing out of air emergency drills, including ascent and mask/helmet removal.

Each surface supplied diver shall be hose-tended by a separate dive team member while in the water. Scientific aquarium divers are exempt from this standard, provided the tender is monitoring only one air source, there is mutual assistance between divers and there are no overhead obstructions or entanglements.

Divers using the surface supplied mode shall maintain communication with the surface tender. The surface supplied breathing gas supply (volume and intermediate pressure) shall be sufficient to support all surface supplied divers in the water for the duration of the planned dive.

During surface supplied diving operations when only one diver is in the water, there must be a standby diver in attendance at the dive location. Scientific aquarium divers are exempt from this standard, provided the tender is equipped, ready and able to conduct a prompt and effective in-water retrieval of the diver at all times during the dive.

Surface supplied equipment must be configured to allow retrieval of the diver by the surface tender without risk of interrupting air supply to the diver.

All surface supplied applications used for scientific aquarium diving shall have a non-return valve at the attachment point between helmet or mask hose, which shall close readily and positively.

## APPENDIX 12

### STAGED DECOMPRESSION DIVING

Decompression diving shall be defined as any diving during which the diver cannot perform a direct return to the surface without performing a mandatory decompression stop to allow the release of inert gas from the diver's body.

The following procedures shall be observed when conducting dives requiring planned decompression stops

#### Minimum Experience and Training Requirements

Prerequisites:

Scientific Diver qualification according to URI Research Dive Manual.

Minimum of 100 logged dives.

Demonstration of the ability to safely plan and conduct dives deeper than 100 feet.

Nitrox certification/authorization according to URI Research Dive Manual.

Training shall be appropriate for the conditions in which dive operations are to be conducted.

Minimum Training shall include the following:

A minimum of 6 hours of classroom training to ensure theoretical knowledge to include: physics and physiology of decompression; decompression planning and procedures; gas management; equipment configurations; decompression method, emergency procedures.

It is recommended that at least one training session be conducted in a pool or sheltered water setting, to cover equipment handling and familiarization, swimming and buoyancy control, to estimate gas consumption rates, and to practice emergency procedures.

At least 6 open-water training dives simulating/requiring decompression shall be conducted, emphasizing planning and execution of required decompression dives, and including practice of emergency procedures.

Progression to greater depths shall be by 4-dive increments at depth intervals as specified in URI's Research Dive Manual.

No training dives requiring decompression shall be conducted until the diver has demonstrated acceptable skills under simulated conditions.

The following are the minimum skills the diver must demonstrate proficiently during dives simulating and requiring decompression:

- Buoyancy control
- Proper ascent rate
- Proper depth control
- Equipment manipulation
- Stage/decompression bottle use as pertinent to planned diving operation
- Buddy skills
- Gas management
- Time management
- Task loading
- Emergency skills

Divers shall demonstrate to the satisfaction of the DSO or the DSO's designee proficiency in planning and executing required decompression dives appropriate to the conditions in which diving operations are to be conducted.

Upon completion of training, the diver shall be authorized to conduct required decompression dives with DSO approval.

#### Minimum Equipment Requirements

Valve and regulator systems for primary (bottom) gas supplies shall be configured in a redundant manner that allows continuous breathing gas delivery in the event of failure of any one component of the regulator/valve system.

Cylinders with volume and configuration adequate for planned diving operations.

One of the second stages on the primary gas supply shall be configured with a hose of adequate length to facilitate effective emergency gas sharing in the intended environment.

Minimum dive equipment shall include:

Snorkel is optional at the DCB's discretion, as determined by the conditions and environment.

Diver location devices adequate for the planned diving operations and environment.

Compass

Redundancy in the following components is desirable or required at the discretion of the DCB or DSO:

Decompression Schedules

Dive Timing Devices

Depth gauges

Buoyancy Control Devices

Cutting devices

Lift bags and line reels

30 Minimum Operational Requirements

Approval of dive plan applications to conduct required decompression dives shall be on a case-by-case basis.

The maximum  $pO_2$  to be used for planning required decompression dives is 1.6. It is recommended that a  $pO_2$  of less than 1.6 be used during bottom exposure.

Divers gas supplies shall be adequate to meet planned operational requirements and foreseeable emergency situations.

Decompression dives may be planned using dive tables, dive computers, and/or PC software approved by the DSO/DCB.

Breathing gases used while performing in-water decompression shall contain the same or greater oxygen content as that used during the bottom phase of the dive.

The dive team prior to each dive shall review emergency procedures appropriate for the planned dive.

If breathing gas mixtures other than air are used for required decompression, their use shall be in accordance with those regulations set forth in the appropriate sections of this standard.

The maximum depth for required decompression using air as the bottom gas shall be 190 feet.

Use of additional nitrox and/or high-oxygen fraction decompression mixtures as travel and decompression gases to decrease decompression obligations is encouraged.

Use of alternate inert gas mixtures to limit narcosis is encouraged for depths greater than 150 feet.

If a period of more than 6 months has elapsed since the last mixed gas dive, a series of progressive workup dives to return the diver(s) to proficiency status prior to the start of project diving operations are recommended.

Mission specific workup dives are recommended.

## APPENDIX 13

### REBREATHERS

This section defines specific considerations regarding the following issues for the use of rebreathers:

- Training and/or experience verification requirements for authorization
- Equipment requirements
- Operational requirements and additional safety protocols to be used

Application of this standard is in addition to pertinent requirements of all other sections of the AAUS Standards for Scientific Diving, Volumes 1 and 2.

For rebreather dives that also involve staged decompression and/or mixed gas diving, all requirements for each of the relevant diving modes shall be met. Diving Control Board reserves the authority to review each application of all specialized diving modes, and include any further requirements deemed necessary beyond those listed here on a case-by-case basis.

No diver shall conduct planned operations using rebreathers without prior review and approval of the DCB.

In all cases, trainers shall be qualified for the type of instruction to be provided. Training shall be conducted by agencies or instructors approved by DSO and DCB.

#### Definitions and General Information

Rebreathers are defined as any device that recycles some or all of the exhaled gas in the breathing loop and returns it to the diver. Rebreathers maintain levels of oxygen and carbon dioxide that support life by metered injection of oxygen and chemical removal of carbon dioxide. These characteristics fundamentally distinguish rebreathers from open-circuit life support systems, in that the breathing gas composition is dynamic rather than fixed.

Advantages of rebreathers may include increased gas utilization efficiencies that are often independent of depth, extended no-decompression bottom times and greater decompression efficiency, and reduction or elimination of exhaust bubbles that may disturb aquatic life or sensitive environments.

Disadvantages of rebreathers include high cost and, in some cases, a high degree of system complexity and reliance on instrumentation for gas composition control and monitoring, which may fail. The diver is more likely to experience hazardous levels of hypoxia, hyperoxia, or hypercapnia, due to user error or equipment malfunction, conditions which may lead to underwater blackout and drowning. Inadvertent flooding of the breathing

loop and wetting of the carbon dioxide absorbent may expose the diver to ingestion of an alkaline slurry ("caustic cocktail").

An increased level of discipline and attention to rebreather system status by the diver is required for safe operation, with a greater need for self-reliance. Rebreather system design and operation varies significantly between make and model. For these reasons when evaluating any dive plan incorporating rebreathers, risk-management emphasis should be placed on the individual qualifications of the diver on the specific rebreather make and model to be used, in addition to specific equipment requirements and associated operational protocols.

**Oxygen Rebreathers.** Oxygen rebreathers recycle breathing gas, consisting of pure oxygen, replenishing the oxygen metabolized by the diver. Oxygen rebreathers are generally the least complicated design, but are normally limited to a maximum operation depth of 20 fsw due to the risk of unsafe hyperoxic exposure.

**Semi-Closed Circuit Rebreathers.** Semi-closed circuit rebreathers (SCR) recycle the majority of exhaled breathing gas, venting a portion into the water and replenishing it with a constant or variable amount of a single oxygen-enriched gas mixture. Gas addition and venting is balanced against diver metabolism to maintain safe oxygen levels by means which differ between SCR models, but the mechanism usually provides a semi-constant fraction of oxygen ( $FO_2$ ) in the breathing loop at all depths, similar to open-circuit SCUBA.

**Closed-Circuit Mixed Gas Rebreathers.** Closed-circuit mixed gas rebreathers (CCR) recycle all of the exhaled gas and replace metabolized oxygen via an electronically controlled valve, governed by electronic oxygen sensors. Manual oxygen addition is available as a diver override, in case of electronic system failure. A separate inert gas source (diluent), usually containing primarily air, heliox, or trimix, is used to maintain oxygen levels at safe levels when diving below 20fsw. CCR systems operate to maintain a constant oxygen partial pressure ( $PPO_2$ ) during the dive, regardless of depth.

#### Prerequisites

Specific training requirements for use of each rebreather model shall be defined by DCB on a case-by-case basis. Training shall include factory-recommended requirements, but may exceed this to prepare for the type of mission intended (e.g., staged decompression or heliox/trimix CCR diving).

#### Training Prerequisites

Active scientific diver status, with depth qualification sufficient for the type, make, and model of rebreather, and planned application.

Completion of a minimum of 50 open-water dives on SCUBA.

For SCR or CCR, a minimum 100-fsw-depth qualification is generally recommended, to ensure the diver is sufficiently conversant with the complications of deeper diving. If the sole expected application for use of rebreathers is shallower than this, a lesser depth qualification may be allowed with the approval of the DCB.

Nitrox training. Training in use of nitrox mixtures containing 25% to 40% oxygen is required. Training in use of mixtures containing 40% to 100% oxygen may be required, as needed for the planned application and rebreather system. Training may be provided as part of rebreather training.

### Training

Successful completion of the following training program qualifies the diver for rebreather diving using the system on which the diver was trained, in depths of 130fsw and shallower, for dives that do not require decompression stops, using nitrogen/oxygen breathing media.

Satisfactory completion of a rebreather training program authorized or recommended by the manufacturer of the rebreather to be used, or other training approved by the DCB. Successful completion of training does not in itself authorize the diver to use rebreathers. The diver must demonstrate to the DCB or its designee that the diver possesses the proper attitude, judgment, and discipline to safely conduct rebreather diving in the context of planned operations.

Classroom training shall include:

A review of those topics of diving physics and physiology, decompression management, and dive planning included in prior scientific diver, nitrox, staged decompression and/or mixed gas training, as they pertain to the safe operation of the selected rebreather system and planned diving application.

In particular, causes, signs and symptoms, first aid, treatment and prevention of the following must be covered:

- Hyperoxia (CNS and Pulmonary Oxygen Toxicity)
- Middle Ear Oxygen Absorption Syndrome (oxygen ear)
- Hyperoxia-induced myopia
- Hypoxia
- Hypercapnia
- Inert gas narcosis
- Decompression sickness
- Rebreather-specific information required for the safe and effective operation of the system to be used, including:
  - System design and operation, including:
  - Counterlung(s)
  - CO<sub>2</sub> scrubber

- CO<sub>2</sub> absorbent material types, activity characteristics, storage, handling and disposal
- Oxygen control system design, automatic and manual
- Diluent control system, automatic and manual (if any)
- Pre-dive set-up and testing
- Post-dive break-down and maintenance
- Oxygen exposure management
- Decompression management and applicable decompression tracking methods
- Dive operations planning
- Problem recognition and management, including system failures leading to hypoxia, hyperoxia, hypercapnia, flooded loop, and caustic cocktail
- Emergency protocols and bailout procedures
- Practical Training (with model of rebreather to be used)

A minimum number of hours of underwater time.

Type	Pool/Confined Water	O/W Training	O/W Supervised
Oxygen Rebreather	1 dive, 90 min	4 dives, 120 min.*	2 dives, 60 min
Semi-Closed Circuit	1 dive, 90-120 min	4 dives, 120 min.**	4 dives, 120 min
Closed-Circuit	1 dive, 90-120 min	8 dives, 380 min.***	4 dives, 240 min

\* Dives should not exceed 20 fsw.  
 \*\* First two dives should not exceed 60 fsw. Subsequent dives should be at progressively greater depths, with at least one dive in the 80 to 100 fsw range.  
 \*\*\* Total underwater time (pool and open water) of approximately 500 minutes. First two open water dives should not exceed 60 fsw. Subsequent dives should be at progressively greater depths, with at least 2 dives in the 100 to 130 fsw range.

Amount of required in-water time should increase proportionally to the complexity of rebreather system used.

Training shall be in accordance with the manufacturer's recommendations.

### Practical Evaluations

Upon completion of practical training, the diver must demonstrate to the DCB or its designee proficiency in pre-dive, dive, and post-dive operational procedures for the particular model of rebreather to be used. Skills shall include, at a minimum:

- Oxygen control system calibration and operation checks
- Carbon dioxide absorbent canister packing
- Supply gas cylinder analysis and pressure check
- Test of one-way valves
- System assembly and breathing loop leak testing
- Pre-dive breathing to test system operation
- In-water leak checks
- Buoyancy control during descent, bottom operations, and ascent

- System monitoring and control during descent, bottom operations, and ascent
- Proper interpretation and operation of system instrumentation (PO2 displays, dive computers, gas supply pressure gauges, alarms, etc. as applicable)
- Unit removal and replacement on the surface.
- Bailout and emergency procedures for self and buddy, including:
- System malfunction recognition and solution
- Manual system control
- Flooded breathing loop recovery (if possible)
- Absorbent canister failure
- Alternate bailout options
- Symptom recognition and emergency procedures for hyperoxia, hypoxia, and hypercapnia
- Proper system maintenance, including:
- Full breathing loop disassembly and cleaning (mouthpiece, check-valves, hoses, counterlung, absorbent canister, etc.)
- Oxygen sensor replacement (for SCR and CCR)
- Other tasks required by specific rebreather models

#### Written Evaluation

A written evaluation approved by the DCB with a pre-determined passing score, covering concepts of both classroom and practical training, is required.

#### Supervised Rebreather Dives

Upon successful completion of open water training dives, the diver is authorized to conduct a series of supervised rebreather dives, during which the diver gains additional experience and proficiency.

Supervisor for these dives should be the DSO or designee, and should be an active scientific diver experienced in diving with the make/model of rebreather being used.

Dives at this level may be targeted to activities associated with the planned science diving application. See the following table for number and cumulative water time for different rebreather types.

Type	Pool/Confined Water	O/W Training	O/W Supervised
Oxygen Rebreather	1 dive, 90 min	4 dives, 120 min.*	2 dives, 60 min
Semi-Closed Circuit	1 dive, 90-120 min	4 dives, 120 min.**	4 dives, 120 min
Closed-Circuit	1 dive, 90-120 min	8 dives, 380 min.***	4 dives, 240 min

\* Dives should not exceed 20 fsw.

\*\* First two dives should not exceed 60 fsw. Subsequent dives should be at progressively greater depths, with at least one dive in the 80 to 100 fsw range.

\*\*\* Total underwater time (pool and open water) of approximately 500 minutes. First two open water dives should not exceed 60 fsw. Subsequent dives should be at progressively

greater depths, with at least 2 dives in the 100 to 130 fsw range.

Maximum ratio of divers per designated dive supervisor is 4:1. The supervisor may dive as part of the planned operations.

#### Extended Range, Required Decompression and Helium-Based Inert Gas

Rebreather dives involving operational depths in excess of 130 fsw, requiring staged decompression, or using diluents containing inert gases other than nitrogen are subject to additional training requirements, as determined by DCB on a case-by-case basis. Prior experience with required decompression and mixed gas diving using open-circuit SCUBA is desirable, but is not sufficient for transfer to dives using rebreathers without additional training.

As a prerequisite for training in staged decompression using rebreathers, the diver shall have logged a minimum of 25 hours of underwater time on the rebreather system to be used, with at least 10 rebreather dives in the 100 fsw to 130 fsw range.

As a prerequisite for training for use of rebreathers with gas mixtures containing inert gas other than nitrogen, the diver shall have logged a minimum of 50 hours of underwater time on the rebreather system to be used and shall have completed training in stage decompression methods using rebreathers. The diver shall have completed at least 12 dives requiring staged decompression on the rebreather model to be used, with at least 4 dives near 130 fsw.

Training shall be in accordance with standards for required-decompression and mixed gas diving, as applicable to rebreather systems, starting at the 130 fsw level.

#### Maintenance of Proficiency

To maintain authorization to dive with rebreathers, an authorized diver shall make at least one dive using a rebreather every 8 weeks. For divers authorized for the conduct of extended range, stage decompression or mixed-gas diving, at least one dive per month should be made to a depth near 130 fsw, practicing decompression protocols.

For a diver in arrears, the DCB shall approve a program of remedial knowledge and skill tune-up training and a course of dives required to return the diver to full authorization. The extent of this program should be directly related to the complexity of the planned rebreather diving operations.

#### Equipment Requirements

##### General Requirements

Only those models of rebreathers specifically approved by DCB shall be used.

Rebreathers should be manufactured according to acceptable Quality Control/Quality Assurance protocols, as evidenced by compliance with the essential elements of ISO

9004. Manufacturers should be able to provide to the DCB supporting documentation to this effect.

Unit performance specifications should be within acceptable levels as defined by standards of a recognized authority (CE, US Navy, Royal Navy, NOAA, etc...).

Prior to approval, the manufacturer should supply the DCB with supporting documentation detailing the methods of specification determination by a recognized third-party testing agency, including unmanned and manned testing. Test data should be from a recognized, independent test facility.

The following documentation for each rebreather model to be used should be available as a set of manufacturer's specifications. These should include:

- Operational depth range
- Operational temperature range
- Breathing gas mixtures that may be used
- Maximum exercise level which can be supported as a function of breathing gas and depth
- Breathing gas supply durations as a function of exercise level and depth
- CO<sub>2</sub> absorbent durations, as a function of depth, exercise level, breathing gas, and water temperature
- Method, range and precision of inspired PPO<sub>2</sub> control, as a function of depth, exercise level, breathing gas, and temperature
- Likely failure modes and backup or redundant systems designed to protect the diver if such failures occur
- Accuracy and precision of all readouts and sensors
- Battery duration as a function of depth and temperature
- Mean time between failures of each subsystem and method of determination

A complete instruction manual is required, fully describing the operation of all rebreather components and subsystems as well as maintenance procedures.

A maintenance log is required. The unit maintenance shall be up-to-date based upon manufacturer's recommendations.

#### Minimum Equipment

A surface/dive valve in the mouthpiece assembly, allowing sealing of the breathing loop from the external environment when not in use.

An automatic gas addition valve, so that manual volumetric compensation during descent is unnecessary.

Manual gas addition valves, so that manual volumetric compensation during descent and

manual oxygen addition at all times during the dive are possible.

The diver shall carry alternate life support capability (open-circuit bail-out or redundant rebreather) sufficient to allow the solution of minor problems and allow reliable access to a pre-planned alternate life support system.

#### Oxygen Rebreathers

Oxygen rebreathers shall be equipped with manual and automatic gas addition valves.

#### Semi-Closed Circuit Rebreathers.

SCR's shall be equipped with at least one manufacturer-approved oxygen sensor sufficient to warn the diver of impending hypoxia. Sensor redundancy is desirable, but not required.

#### Closed Circuit Mixed-gas Rebreathers.

CCR shall incorporate a minimum of three independent oxygen sensors.

A minimum of two independent displays of oxygen sensor readings shall be available to the diver.

Two independent power supplies in the rebreather design are desirable. If only one is present, a secondary system to monitor oxygen levels without power from the primary battery must be incorporated.

CCR shall be equipped with manual diluent and oxygen addition valves, to enable the diver to maintain safe oxygen levels in the event of failure of the primary power supply or automatic gas addition systems.

Redundancies in onboard electronics, power supplies, and life support systems are highly desirable.

#### Operational Requirements

##### General Requirements

All dives involving rebreathers must comply with applicable operational requirements for open-circuit SCUBA dives to equivalent depths.

No rebreather system should be used in situations beyond the manufacturer's stated design limits (dive depth, duration, water temperature, etc).

Modifications to rebreather systems shall be in compliance with manufacturer's recommendations.

Rebreather maintenance is to be in compliance with manufacturer's recommendations including sanitizing, replacement of consumables (sensors, CO<sub>2</sub> absorbent, gas, batteries, etc) and periodic maintenance.

Dive Plan. In addition to standard dive plan components stipulated in AAUS Section 2.0, all dive plans that include the use of rebreathers must include, at minimum, the following details:

- Information about the specific rebreather model to be used
- Make, model, and type of rebreather system
- Type of CO<sub>2</sub> absorbent material
- Composition and volume(s) of supply gases
- Complete description of alternate bailout procedures to be employed, including manual rebreather operation and open-circuit procedures
- Other specific details as requested by DCB

#### Buddy Qualifications.

A diver whose buddy is diving with a rebreather shall be trained in basic rebreather operation, hazard identification, and assist/rescue procedures for a rebreather diver.

If the buddy of a rebreather diver is using open-circuit scuba, the rebreather diver must be equipped with a means to provide the open-circuit scuba diver with a sufficient supply of open-circuit breathing gas to allow both divers to return safely to the surface.

#### Oxygen Exposures

Planned oxygen partial pressure in the breathing gas shall not exceed 1.4 atmospheres at depths greater than 30 feet.

Planned oxygen partial pressure set point for CCR shall not exceed 1.4 atm. Set point at depth should be reduced to manage oxygen toxicity according to the NOAA Oxygen Exposure Limits.

Oxygen exposures should not exceed the NOAA oxygen single and daily exposure limits. Both CNS and pulmonary (whole-body) oxygen exposure indices should be tracked for each diver.

#### Decompression Management

DCB shall review and approve the method of decompression management selected for a given diving application and project.

Decompression management can be safely achieved by a variety of methods, depending on the type and model of rebreather to be used. Following is a general list of methods for different rebreather types:

Oxygen rebreathers: Not applicable.

SCR (presumed constant  $FO_2$ ):

- Use of any method approved for open-circuit scuba diving breathing air, above the maximum operational depth of the supply gas.
- Use of open-circuit nitrox dive tables based upon expected inspired  $FO_2$ . In this case, contingency air dive tables may be necessary for active-addition SCR's in the event that exertion level is higher than expected.
- Equivalent air depth correction to open-circuit air dive tables, based upon expected inspired  $FO_2$  for planned exertion level, gas supply rate, and gas composition. In this case, contingency air dive tables may be necessary for active-addition SCR's in the event that exertion level is higher than expected.

CCR (constant  $PPO_2$ ):

- Integrated constant  $PPO_2$  dive computer.
- Non-integrated constant  $PPO_2$  dive computer.
- Constant  $PPO_2$  dive tables.
- Open-circuit (constant  $FO_2$ ) nitrox dive computer, set to inspired  $FO_2$  predicted using  $PPO_2$  set point at the maximum planned dive depth.
- Equivalent air depth (EAD) correction to standard open-circuit air dive tables, based on the inspired  $FO_2$  predicted using the  $PPO_2$  set point at the maximum planned dive depth.
- Air dive computer, or air dive tables used above the maximum operating depth (MOD) of air for the  $PPO_2$  setpoint selected.
  
- Maintenance Logs, CO2 Scrubber Logs, Battery Logs, and Pre-And Post-Dive Checklists

Logs and checklists will be developed for the rebreather used, and will be used before and after every dive. Diver shall indicate by initialing that checklists have been completed before and after each dive. Such documents shall be filed and maintained as permanent project records. No rebreather shall be dived which has failed any portion of the pre-dive check, or is found to not be operating in accordance with manufacturer's specifications. Pre-dive checks shall include:

- Gas supply cylinders full
- Composition of all supply and bail-out gases analyzed and documented
- Oxygen sensors calibrated
- Carbon dioxide canister properly packed
- Remaining duration of canister life verified
- Breathing loop assembled
- Positive and negative pressure leak checks
- Automatic volume addition system working
- Automatic oxygen addition systems working

- Pre-breathe system for 3 minutes (5 minutes in cold water) to ensure proper oxygen addition and carbon dioxide removal (be alert for signs of hypoxia or hypercapnia)
- Other procedures specific to the model of rebreather used
- Documentation of ALL components assembled
- Complete pre-dive system check performed
- Final operational verification immediately before to entering the water:
- PO<sub>2</sub> in the rebreather is not hypoxic
- Oxygen addition system is functioning;
- Volumetric addition is functioning
- Bail-out life support is functioning

### Alternate Life Support System

The diver shall have reliable access to an alternate life support system designed to safely return the diver to the surface at normal ascent rates, including any required decompression in the event of primary rebreather failure. The complexity and extent of such systems are directly related to the depth/time profiles of the mission. Examples of such systems include, but are not limited to:

Open-circuit bailout cylinders or sets of cylinders, either carried or pre-positioned

Redundant rebreather

Pre-positioned life support equipment with topside support

### CO<sub>2</sub> Absorbent Material

CO<sub>2</sub> absorption canister shall be filled in accordance with the manufacturer's specifications.

CO<sub>2</sub> absorbent material shall be used in accordance with the manufacturer's specifications for expected duration.

If CO<sub>2</sub> absorbent canister is not exhausted and storage between dives is planned, the canister should be removed from the unit and stored sealed and protected from ambient air, to ensure the absorbent retains its activity for subsequent dives.

Long-term storage of carbon dioxide absorbents shall be in a cool, dry location in a sealed container. Field storage must be adequate to maintain viability of material until use.

### Consumables (e.g., batteries, oxygen sensors, etc.)

Other consumables (e.g., batteries, oxygen sensors, etc.) shall be maintained, tested, and replaced in accordance with the manufacturer's specifications.

## Unit Disinfections

The entire breathing loop, including mouthpiece, hoses, counterlungs, and CO<sub>2</sub> canister, should be disinfected periodically according to manufacturer's specifications. The loop must be disinfected between each use of the same rebreather by different divers.

### Oxygen Rebreathers

Oxygen rebreathers shall not be used at depths greater than 20 feet.

Breathing loop and diver's lungs must be adequately flushed with pure oxygen prior to entering the water on each dive. Once done, the diver must breathe continuously and solely from the intact loop, or re-flushing is required.

Breathing loop shall be flushed with fresh oxygen prior to ascending to avoid hypoxia due to inert gas in the loop.

### Semi-Closed Circuit Rebreathers

The composition of the injection gas supply of a semi-closed rebreather shall be chosen such that the partial pressure of oxygen in the breathing loop will not drop below 0.2 atm, even at maximum exertion at the surface.

The gas addition rate of active addition SCR (e.g., Draeger Dolphin and similar units) shall be checked before every dive, to ensure it is balanced against expected workload and supply gas FO<sub>2</sub>.

The intermediate pressure of supply gas delivery in active-addition SCR shall be checked periodically, in compliance with manufacturer's recommendations.

Maximum operating depth shall be based upon the FO<sub>2</sub> in the active supply cylinder.

Prior to ascent to the surface the diver shall flush the breathing loop with fresh gas or switch to an open-circuit system to avoid hypoxia. The flush should be at a depth of approximately 30 fsw during ascent on dives deeper than 30 fsw, and at bottom depth on dives 30 fsw and shallower.

### Closed-Circuit Rebreathers

The FO<sub>2</sub> of each diluent gas supply used shall be chosen so that, if breathed directly while in the depth range for which its use is intended, it will produce an inspired PPO<sub>2</sub> greater than 0.20 atm but no greater than 1.4 atm.

Maximum operating depth shall be based on the FO<sub>2</sub> of the diluent in use during each phase of the dive, so as not to exceed a PO<sub>2</sub> limit of 1.4 atm.

Divers shall monitor both primary and secondary oxygen display systems at regular

intervals throughout the dive, to verify that readings are within limits, that redundant displays are providing similar values, and whether readings are dynamic or static (as an indicator of sensor failure).

The PPO<sub>2</sub> set point shall not be lower than 0.4 atm or higher than 1.4 atm.