

# **The University of Michigan**



## **Standards for Scientific Diving Operations**

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## PREFACE

This standard for University of Michigan Diving Operations has been prepared as a legal requirement under Act 154 of the Public Acts of 1974, as amended (Parts 3, 31, and 79), Departments of Public Health and Labor, State of Michigan.

The State of Michigan Diving Operations Standard specifically states applicability "to diving and related support operations" conducted in connection with all types of work and employments. It specifically does not exclude scientific diving. The state standard was effective as of June 15, 1979.

Although, the U.S. Department of Labor officially released the scientific diving community from Part 1910 of Title 29 of the Code of Federal Regulations (Subpart T), the State of Michigan has, never, to my knowledge, officially taken such action. Consequently, the University of Michigan shall make every effort to comply with the State requirements.

The University of Michigan Standard also meets or exceeds the "Standards for Scientific Diving Certification and Operation of Scientific Diving Programs" of the American Academy of Underwater Sciences (AAUS) that was promulgated in May of 1984 and revised in August of 2006. Training requirements have been updated to more realistically address the population of divers and researchers served by the University of Michigan. Unlike the AAUS standard, a recreational diver scuba diver certification is listed as a prerequisite for entry into scientific diver training. Medical standards comply with the current, and more stringent University of Michigan Risk Management requirement (annual exam by a university medical practitioner) rather than the AAUS guidelines.

This document is subject to periodic revision and specific items may be modified at the discretion of the Diving Safety Control Board. Employees, supervisors, and others are encouraged to notify the Diving Safety Coordinator of typographical and wording errors, unclear statements, and other items of concern. In addition, the Board welcomes suggestions for improvements to this standard.

Nonotnaulcuba divers are reminded that the standard addresses "working" diving operations rather than recreational activities and that the State, rather than the University, of Michigan, designates some requirements in this manual.

The policy of the University is to comply to applicable federal and state occupational safety and environmental health standards. This standard shall be considered effective upon approval of the Diving Safety Control Board and until specific and official variance or exclusion from state standards, in part or total, are obtained and the preparation of a revised University standard.

This manual updates the 1990 version authored by Lee H. Somers, Ph.D.

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## **GENERAL SCIENTIFIC DIVING POLICIES**

## SECTION 1

### GENERAL POLICIES

#### 1.10 AAUS General Guidelines for Scientific Diving Standards

##### Purpose

The purpose of these Scientific Diving Standards is to ensure that all scientific diving is conducted in a manner that will maximize protection of scientific divers from accidental injury and/or illness, and to set forth standards for training and certification that will allow a working reciprocity between AAUS organizational members. Fulfillment of the purposes shall be consistent with the furtherance of research and safety.

This policy manual sets minimal standards for the establishment of an American Academy of Underwater Sciences (AAUS) recognized scientific diving program at the University of Michigan, the organizational structure for conducting diving operations, and the basic regulations and procedures for safety while conducting scientific diving operations. It also establishes a framework for reciprocity between AAUS organizational members that adhere to these minimum standards.

This standard was developed and written by the AAUS by compiling the policies set forth in the diving manuals of several university, private, and governmental scientific diving programs. These programs share a common heritage with the scientific diving program at the Scripps Institution of Oceanography (SIO). Adherence to the SIO standards has proven both feasible and effective in protecting the health and safety of scientific divers since 1954.

In 1982, OSHA (29CFR1910, Subpart T) exempted scientific diving from commercial diving regulations under certain conditions that are outlined below. The final guidelines for the exemption became effective in 1985 (Federal Register, Vol. 50, No.6, p.1046). The AAUS is recognized by OSHA as the scientific diving standard setting organization.

##### Scientific Diving Definition

Scientific diving is defined (*29CFR1910A02*) as diving performed solely as a necessary part of a scientific, research, or educational activity by employees whose sole purpose for diving is to perform scientific research tasks.

##### Scientific Diving Exemption

OSHA has granted an exemption for scientific diving from commercial diving regulations under the following institutional guidelines:

- a) The University of Michigan (U of MI) has created a Diving Control Board consisting of a majority of active scientific divers and has autonomous and absolute authority over the scientific diving program's operation. This includes, but is not limited to, authority to: approve and monitor diving projects, review and revise the diving safety manual, assure procedural compliance, certify diver diving depths, take disciplinary action for unsafe practices, and assure adherence to the buddy system (a diver is in continuous contact with another diver in the water) for scuba diving.
- b) The purpose of any project using scientific diving is the advancement of science; therefore, information and data resulting from the project are non-proprietary.
- c) The tasks of a scientific diver are those of an observer and data gatherer. Construction and trouble-shooting tasks traditionally associated with commercial diving are not included within scientific diving.



- d) 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.
- e) The scientific diving program has promulgated a Diving Safety Manual which includes procedures covering all diving operations; including procedures for emergency care, recompression and evacuation, and the criteria for diver training and certification

#### Review of Standards.

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

### **1.20 Operational Control**

#### Organizational Member Auspices Defined

For the purposes of these standards the auspices of the organizational member includes any scientific diving operation associated with the U of MI connected because of ownership of any equipment used, locations selected, or relationship with the individual(s) concerned. This includes all cases involving the operations of employees of the U of MI or employees of auxiliary organizations, where such employees are acting within the scope of their employment, and the operations of other persons, including students, who are engaged in scientific diving of the U of MI or are diving as members of an authority to: approve and monitor diving projects, review and revise the diving safety manual, assure procedural compliance, certify diver diving depths, take disciplinary action for unsafe practices, and assure adherence to the buddy system (a diver is in continuous contact with another diver in the water) for scuba diving.

It is the U of MI's responsibility to adhere to the AAUS Standards for Scientific Diving Certification and Operation of Scientific Diving Programs. The administration of the U of MI program will reside with the U of MI's Diving Control Board (DCB).

The regulations herein shall be observed at all locations where scientific diving is conducted.

#### Organizational Member's Scientific Diving Standards and Safety Manual

The U of MI maintain a scientific diving safety manual that provides for the development and implementation of policies and procedures that will enable each organizational member to meet requirements of local environments and conditions as well as to comply with the AAUS scientific diving standards. The U of MI scientific diving manual shall include, but not be limited to:

- a) Emergency evacuation and medical treatment procedures.
- b) Criteria for diver training and certification.
- c) Standards written or adopted by reference for each diving mode utilized which include the following:
  1. Safety procedures for the diving operation.
  2. Responsibilities of the dive team members.
  3. Equipment use and maintenance procedures.
  4. Emergency procedures.

## Diving Safety Officer

The Diving Safety Officer (DSO) serves as a member of the Diving Control Board (DCB). This person should have broad technical and scientific expertise in research related diving. The DSO shall be::

- a) Appointed by the responsible OSEH administrative officer or designee, with the advice and counsel of the Diving Control Board.
- b) Trained as a scientific diver.
- c) A full member of the AAUS.
- d) A graduate of an AAUS-sponsored DSO Orientation Program
- e) Be an active underwater instructor from an internationally recognized diving certifying agency.

The DSO shall:

- a) Be responsible to the OSEH administrative officer or designee, for the conduct of the scientific diving program of the U of MI. The routine operational authority for this program, including the conduct of training and certification, approval of dive plans, maintenance of diving records, and ensuring compliance with this standard and all relevant regulations of the U of MI, rests with the Diving Safety Officer.
- b) 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 local diving program.
- c) Be guided in the performance of the required duties by the advice of the DCB, but operational responsibility for the conduct of the local diving program will be retained by the Diving Safety Officer.
- d) Suspend diving operations considered to be unsafe or unwise.

## Diving Control Board

The Diving Control Board (DCB) shall consist of a majority of active scientific divers. Voting members shall include the Diving Safety Officer, the responsible OSEH administrative officer, or designee, and should include other representatives of university diving. A chairperson and a secretary may be chosen from the membership of the board. No single research group or single project may constitute a majority of the DCB membership. The DCB shall:

- a) Have autonomous and absolute authority over the scientific diving operations.
- b) Approve and monitor all diving projects.
- c) Review and revise the diving safety manual.
- d) Assure compliance with the diving safety manual.
- e) Certify the depths to which a diver has been trained.
- f) Take disciplinary action for unsafe practices.
- g) Assure adherence to the buddy system for scuba diving.
- h) Act as the official representative of the membership organization
- i) Act as a board of appeals to consider diver-related problems.

- j) Recommend the issue, reissue, or the revocation of diving certifications.
- k) Recommend changes in policy and amendments to AAUS and the membership organization's diving safety manual as the need arises.
- l) Establish and/or approve training programs through which the applicants for certification can satisfy the requirements of the U of MI's diving safety manual.
- m) Suspend diving programs that are considered to be unsafe or unwise.
- n) Establish criteria for equipment selection and use.
- o) Recommend new equipment or techniques.
- p) Establish and/or approve facilities for the inspection and maintenance of diving and associated equipment.
- q) Ensure that the any U of MI operated air station(s) meet air quality standards as described in Section 3.60.
- r) Periodically review the Diving Safety Officer's performance and program.
- s) Sit as a board of investigation to inquire into the nature and cause of diving accidents or violations of the U of MI's diving safety manual.

Instructional Personnel shall be:

- a) Qualified for the type of instruction being given.
- b) Selected by the responsible administrative officer, or designee, with the advice of the DCB in conducting preliminary screening of applicants for instructional positions.

#### Lead Diver

For each dive, one individual shall be designated as the Lead Diver who shall be at the dive location during the diving operation. The Lead Diver shall be responsible for:

- a) Coordination with other known activities in the vicinity that are likely to interfere with diving operations.
- b) Ensuring all dive team members possess current certification and are qualified for the type of diving operation.
- c) Planning dives in accordance with Section 2.20
- d) Ensuring safety and emergency equipment is in working order and at the dive site.
- e) Briefing dive team members on
  - 1. Dive objectives.
  - 2. Hazards or environmental conditions likely to affect the safety of the diving operation.
  - 3. Any modifications to diving or emergency procedures.
  - 4. Suspending diving operations if in their opinion conditions are not safe.
  - 5. Reporting to the DSO and DCB any physical problems or adverse physiological effects including symptoms of pressure-related injuries.

## Reciprocity and Visiting Scientific Diver

- a) Two or more AAUS Organizational Members engaged jointly in diving activities, or resources shall designate one of the participating Diving Control Boards to govern the joint dive project.
- b) A Scientific Diver from one Organizational Member shall apply for permission to dive under the auspices of another Organizational Member by submitting to the host Diving Safety Officer the reciprocity document described in Appendix 6, signed by the Diving Safety Officer or Chairperson of the home DCB.
- c) A visiting Scientific Diver may be asked to demonstrate knowledge and skills by written examination and/or in-water evaluation by the DSO for the planned dive.
- d) 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 their Diving Control Board with an explanation of all reasons for the denial.

## Waiver of Requirements

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

### **1.30 Consequence of Violation of Regulations by Scientific Divers**

Failure to comply with the regulations of the U of MI's diving safety manual may be cause for the revocation or restriction of the diver's scientific diving certificate by action of the U of MI's Diving Control Board.

### **1.40 Consequences of Violation of Regulations by Organizational Members**

Failure to comply with the regulations of this standard may be cause for the revocation or restriction of the U of MI's recognition by the AAUS.

### **1.50 Record Maintenance**

The Diving Safety Officer or designee shall maintain permanent records for each Scientific Diver certified. The file shall include evidence of certification level, log sheets, results of current physical examination, reports of disciplinary actions by the U of MI Diving Control Board, and other pertinent information deemed necessary. In addition:

- a) Medical records shall be available to an attending physician of a diver or former diver when released in writing by the diver.
- b) Records and documents required by this standard shall be retained by the U of MI for the following periods:
  - 1. Diving safety manual - current document only.
  - 2. Dive logs - 1 year, except 5 years where there has been an incident of pressure-related injury.
  - 3. Pressure-related injury assessment - 5 years.
  - 4. Equipment inspection and testing records - current entry or tag, or until equipment is withdrawn from service.
  - 5. Physician's written reports for dive team members - 5 years.

## **SECTION 2**

### **DIVING REGULATIONS FOR SCUBA (OPEN CIRCUIT, COMPRESSED AIR)**

#### **2.10 Introduction**

No person shall engage in scientific diving operations under the auspices of the U of MI scientific diving program unless they hold a current University of Michigan diving authorization

#### **1.20 Dive Plans**

Dives should be planned around the competency of the least experienced diver. Before conducting any diving operations under the auspices of the U of MI, the lead diver for a proposed operation must formulate a dive plan that should include the following:

- a) Divers qualifications and the type of certificate or certification held by each diver.
- b) Emergency Action Plan (EAP, Appendix 7) with the following information:
  - 1. Name, telephone number, and relationship of person to be contacted for each diver in the event of an emergency.
  - 2. Nearest accessible emergency medical facility.
  - 3. Available means of emergency transport.
- c) Approximate number of proposed dives.
- d) Location(s) of proposed dives.
- e) Estimated depth(s) and bottom time(s) anticipated.
- f) Decompression status and repetitive dive plans, if required.
- g) Proposed work, equipment, and boats to be employed.
- h) Any hazardous conditions anticipated.

#### **Pre-dive Safety Checks**

The scientific diver prior to the dive shall:

- a) Conduct a functional check of their diving equipment in the presence of the diving buddy or tender.
- b) Refuse to dive if, in their judgment, conditions are unfavorable, or if they would be violating the precepts of their training, of this standard, or the U of MI's diving safety manual.
- c) Not be required to be exposed to hyperbaric conditions against their will, except when necessary to prevent or treat a pressure-related injury.
- d) Not be permitted to dive for the duration of any known medical condition, which is likely to adversely affect the safety and health of the diver or other dive members.
- e) Ensure that their equipment is in proper working order and that the equipment is suitable for the type of diving operation.
- f) Have the capability of achieving and maintaining surface floatation.
- g) Evaluate environmental conditions at the dive site.

## **2.30 Diving Procedures**

### **Solo Diving Prohibition**

All diving activities shall assure adherence to the buddy system for scuba diving. This buddy system is based upon mutual assistance, especially in the case of an emergency.

### **Refusal to Dive**

The decision not to dive is the right 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. 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 in this standard.

### **Termination of the Dive**

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.

The dive shall be terminated while there is still sufficient cylinder 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.

### **Emergencies and Deviations from Regulations**

Any diver may deviate from the requirements of this standard 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.

## **2.40 Post-Dive Procedures**

### **Post-Dive Safety Checks**

After the completion of a dive, each diver shall report any physical problems, symptoms of decompression sickness, or equipment malfunctions.

When diving outside the no-decompression limits, the divers should remain awake for at least 1 hour after diving, and in the company of a dive team member who is prepared to transport them to a recompression chamber if necessary.

## **2.50 Emergency Procedures**

The U of MI will develop emergency procedures (Emergency Action Plan (EAP)) which follow the standards of care of the community and must include procedures for emergency care, recompression and evacuation for each dive location (Appendix 7). The EAP for the local diving site must be present on all U of MI sanctioned dives.

## **2.60 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.

## **2.70 Record Keeping Requirements**

### **Personal Diving Log**

Each certified scientific diver shall log every dive made under the auspices of the U of MI's program, and is encouraged to log all other dives. Standard forms will be provided by the U of MI DSO. Completed log sheets shall be submitted to the Diving Safety Officer to be placed in the diver's permanent file. Details of the submission procedures are left to the discretion of the Diving Safety Officer. The diving log shall include at least the following:

- a) Name of diver, buddy, and Lead Diver.
- b) Date, time, and location.
- c) Diving modes used.
- d) General nature of diving activities.
- e) Approximate surface and underwater conditions.
- f) Maximum depths, bottom time, and surface interval time.
- g) Diving tables or computers used.
- h) Detailed report of any near or actual incidents.

### **Required Incident Reporting**

All diving incidents requiring recompression treatment, or resulting in moderate or serious injury, or death shall be reported to the U of MI's Diving Control Board and the AAUS. The U of MI's regular procedures for incident reporting, including those required by the AAUS, shall be followed. The report will specify the circumstances of the incident and the extent of any injuries or illnesses.

Additional information must meet the following reporting requirements:

- a) The U of MI shall record and report occupational injuries and illnesses in accordance with requirements of the appropriate Labor Code section.
- b) If pressure-related injuries are suspected, or if symptoms are evident, the following additional information shall be recorded and retained by the U of MI, with the record of the dive, for a period of 5 years:
  - 1. Name, address, phone numbers of the principal parties involved.
  - 2. Summary of experience of divers involved.
  - 3. Location and description of dive site environmental conditions
  - 4. Description of symptoms, including dive depth and time of onset.
  - 5. Description and results of treatment.
  - 6. Disposition of case.
- c) Complete an AAUS Incident Report at <http://www.aaus.org>.
- d) Prepare a written descriptive report to include:

7. Recommendations to avoid repetition of incident.

- e) The U of MI shall investigate and document any incident of pressure- related injury and prepare a report that is to be forwarded to AAUS during the annual reporting cycle. This report must first be reviewed and released by the U of MI's Diving Control Board.



## **SECTION 3**

### **DIVING EQUIPMENT**

#### **3.10 General Policy**

All equipment shall meet standards as determined by the Diving Safety Officer and the Diving Control Board. Equipment that is 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.

#### **3.20 Equipment**

##### **Regulators**

- a) Only those makes and models specifically approved by the Diving Safety Officer and the Diving Control Board shall be used.
- b) Scuba regulators shall be inspected and tested prior to first use and every 12 months thereafter.
- c) 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:

- a) A non-return valve at the attachment point between helmet or mask and hose.
- b) An exhaust valve.
- c) A minimum ventilation rate capable of maintaining the diver at the depth to which they are diving.

##### **Scuba Cylinders**

- a) Cylinders shall be designed, constructed, and maintained in accordance with the applicable provisions of the Unfired Pressure Vessel Safety Orders.
- b) Cylinders must be hydrostatically tested in accordance with DOT standards.
- c) Cylinders must have a visual inspection at intervals not to exceed 12 months.
- d) 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**

- a) Each diver shall have the capability of achieving and maintaining surface flotation.
- b) Personal flotation systems, buoyancy compensators, dry suits, or other variable volume buoyancy compensation devices shall be equipped with an exhaust valve.
- c) These devices shall be 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

- a) A set of diving tables, approved by the Diving Control Board, must be available at the dive location.
- b) In multiple-level diving scenarios, dive computers may be utilized in place of diving tables, but use of computers must be approved by the Diving Control Board. AAUS recommendations on dive computers are located in appendix 8
- c) Divers using computers must demonstrate to the U of MI DSO an awareness of risks associated with computer use for planning decompression status.

## 3.30 Auxiliary Equipment

Hand held underwater power tools or 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.

## 1.40 Support Equipment

### First aid supplies

A first aid kit and emergency oxygen by demand-inhalator 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.

## Compressor Systems – U of MI Controlled

The following will be considered in design and location of compressor systems:

- a) Low-pressure compressors used to supply air to the diver if equipped with a volume tank shall have a check valve on the inlet side, 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.

## 3.50 Equipment Maintenance

### Record Keeping

Each equipment modification, repair, test, calibration, or maintenance service shall be logged, 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:

- a) Regulators
- b) Submersible pressure gauges
- c) Depth gauges
- d) Scuba cylinders

- e) Cylinder valves
- f) Diving helmets/Full-face masks
- g) Buoyancy control devices
- h) Compressors
- i) Gas control panels
- j) Air storage cylinders
- k) Air filtration systems
- l) Analytical instruments
- m) Dry suits

#### Compressor Operation and Air Test Records

Gas analyses and air tests shall be performed on each U of MI-controlled breathing air compressor at regular intervals of no more than 100 hours of operation or 6 months, whichever occurs first. The results of these tests shall be entered in a formal log and be maintained.

A log shall be maintained showing operation, repair, overhaul, filter maintenance, and temperature adjustment for each compressor.

#### 3.60 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 (by volume)</b>
Oxygen	20-22 %
Carbon Monoxide	10 ppm
Carbon Dioxide	1000 ppm
Condensed Hydrocarbons	5 mg/m <sup>3</sup>
Total Hydrocarbons as Methane	25 ppm
Objectionable Odors	None

For breathing air in extreme cold (increased risk of condensation of water vapor in the cylinder), the dew point of the breathing mix should not exceed -50°F (63 ppm v/v) or 10 degrees Fahrenheit lower than the coldest temperature expected in the area

## **SECTION 4**

### **ENTRY-LEVEL TRAINING REQUIREMENTS**

This section describes training for the non-diver applicant, previously not certified for diving, and equivalency for the certified diver.

#### **4.10 Evaluation**

##### **Medical Examination**

The applicant for training shall be certified by the University of Michigan medical practitioner (designated by University of Michigan Risk Management) to be medically qualified for diving before proceeding with the training as designated in Section 4.20 (Section 6.00 and Appendices 1 through 4).

##### **Swimming Evaluation**

Applicant shall successfully perform the following tests, or equivalent, in the presence of the Diving Safety Officer, or an examiner approved by the Diving Safety Officer.

- a) Swim underwater without swim aids for a distance of 25 yards without surfacing.
- b) Swim 400 yards in less than 12 minutes without swim aids.
- c) Tread water for 10 minutes, or 2 minutes without the use of hands, without swim aids.
- d) Without the use of swim aids, transport another person of equal size a distance of 25 yards in the water.

#### **4.20 Scuba Training**

##### **Practical Training**

At the completion of training, the trainee must satisfy the Diving Safety Officer or the instructor of their ability to perform the following, as a minimum, in a pool or in sheltered water:

- a) Enter water with full equipment.
- b) Clear face mask.
- c) Demonstrate air sharing, including both buddy breathing and the use of alternate air source, as both donor and recipient, with and without a face mask.
- d) Demonstrate ability to alternate between snorkel and scuba while kicking.
- e) Demonstrate understanding of underwater signs and signals.
- f) Demonstrate simulated in-water mouth-to-mouth resuscitation.
- g) Rescue and transport, as a diver, a passive simulated victim of an accident.
- h) Demonstrate ability to remove and replace equipment while submerged.
- i) Demonstrate watermanship ability, which is acceptable to the instructor.

##### **Written Examination**

Before completing training, the trainee must pass a written examination that demonstrates knowledge of at least the following:

- a) Function, care, use, and maintenance of diving equipment.

- b) Physics and physiology of diving.
- c) Diving regulations and precautions.
- d) Near-shore currents and waves.
- e) Dangerous marine animals.
- f) Emergency procedures, including buoyant ascent and ascent by air sharing.
- g) Currently accepted decompression procedures.
- h) Demonstrate the proper use of dive tables.
- i) Underwater communications.
- j) Aspects of freshwater and altitude diving.
- k) Hazards of breath-hold diving and ascents.
- l) Planning and supervision of diving operations.
- m) Diving hazards.
- n) 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.

#### Open Water Evaluation

The trainee must satisfy an instructor, approved by the Diving Safety Officer, of their ability to perform at least the following in open water:

- a) Surface dive to a depth of 10 feet in open water without scuba.
- b) Demonstrate proficiency in air sharing as both donor and receiver.
- c) Enter and leave open water or surf, or leave and board a diving vessel, while wearing scuba gear.
- d) Kick on the surface 400 yards while wearing scuba gear, but not breathing from the scuba unit.
- e) Demonstrate judgment adequate for safe diving.
- f) Demonstrate, where appropriate, the ability to maneuver efficiently in the environment, at and below the surface.
- g) Complete a simulated emergency swimming ascent.
- h) Demonstrate clearing of mask and regulator while submerged.
- i) Demonstrate ability to hover at depth while submerged.
- j) Demonstrate techniques of self-rescue and buddy rescue.
- k) Navigate underwater.
- l) Plan and execute a dive.
- m) Successfully complete 5 open water dives for a minimum total time of 3 hours, of which 2 hours cumulative bottom time must be on scuba. No more than 3 training dives shall be made in any 1 day.

## **SECTION 5**

### **SCIENTIFIC DIVER CERTIFICATION**

#### **5.10 Certification Types**

##### **Scientific Diver Certification**

This is a permit to dive, usable only while authorization is current and for the purpose intended.

##### **Temporary Diver Permit**

This permit constitutes a waiver of the requirements of Section 5.00 and is issued only following a demonstration of the required proficiency in diving. It is valid only for a limited time, as determined by the Diving Safety Officer. This permit is not to be construed as a mechanism to circumvent existing standards set forth in this standard.

Requirements of this section may be waived by the Diving Safety Officer if the person in question has demonstrated proficiency in diving and can contribute measurably to a planned dive. A statement of the temporary diver's qualifications shall be submitted to the Diving Safety Officer as a part of the dive plan. Temporary permits shall be restricted to the planned diving operation and shall comply with all other policies, regulations, and standards of this standard, including medical requirements.

#### **5.20 General Policy**

AAUS requires that no person shall engage in scientific diving unless that person is authorized by the U of MI pursuant to the provisions of this standard. Only a person diving under the auspices of the U of MI that subscribes to the practices of AAUS is eligible for a scientific diver certification.

#### **5.30 Requirements For Scientific Diver Certification**

Submission of documents and participation in aptitude examinations does not automatically result in certification. The applicant must convince the Diving Safety Officer and members of the DCB that they are sufficiently skilled and proficient to be certified. This skill will be acknowledged by the signature of the Diving Safety Officer. Any applicant not possessing the necessary judgment, under diving conditions, for the safety of the diver and their partner, may be denied U of MI scientific diving privileges. Minimum documentation and examinations required are as follows:

##### **Prerequisites**

- a) Application – The Application for U of MI Diving Authorization, Diving Liability Waiver, and Acknowledgement of Risk shall be made to the Diving Safety Officer.
- b) Medical approval. Each applicant for diver certification shall submit a statement from the designated University of Michigan medical practitioner based on an approved medical examination, attesting to the applicant's fitness for diving (Section 6.00 and Appendices 1 through 4).
- c) Scientific Diver- In- Training Permit - This permit signifies that a diver has been certified as at least an open water diver through an internationally recognized certifying agency or scientific diving program, and has the knowledge skills and experience **equivalent** to that gained by successful completion of training as specified in Section 4.00.

## Theoretical and Practical Training

The diver must complete theoretical aspects and practical training for a minimum cumulative time of 100 hours. Theoretical aspects shall include principles and activities appropriate to the intended area of scientific study.

- a) Required Topics (including, but not limited to):
  1. Diving Emergency Care Training
    - a) Cardiopulmonary Resuscitation (CPR)
    - b) Standard or Basic First Aid
    - c) Recognition of DCS and AGE
    - d) Accident Management
    - e) Field Neurological Exam
    - f) 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
    - a) Scientific Dive Planning
    - b) Coordination with other Agencies
    - c) Appropriate Governmental Regulations
  8. Scientific Method
  9. Data Gathering Techniques (Only Items specific to area of study are required)
    - a) Transect Sampling
    - b) Transecting
    - c) Mapping
    - d) Coring
    - e) Photography
    - f) Tagging
      1. Collecting
      2. Animal Handling
      3. Archaeology
  10. Common Biota
    - a) Organism Identification
    - b) Behavior

11. Ecology
  12. Site Selection, Location, and Re-location
  13. Specialized Equipment for data gathering
  14. HazMat Training
  15. HP Cylinders
- b) Suggested Topics (including, but not limited to):
  - c) Practical training must include a checkout dive, with evaluation of the skills listed in Section 4.20 (Open Water Evaluation), with the DSO or qualified delegate followed by at least 11 ocean or open water dives in a variety of dive sites and diving conditions, for a cumulative minimum bottom time of 6 hours. Dives following the checkout dive must be supervised by a certified Scientific Diver with experience in the type of diving planned, with the knowledge and permission of the DSO.
  - d) Examinations
    1. Written examination
      - a) General exam required for scientific diver certification.
      - b) Examination covering the suggested topics at the DSO's discretion.
    2. Examination of equipment.
      - a) Personal diving equipment
      - b) Task specific equipment

## **5.40 Depth Certifications**

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

A U of MI authorized scientific 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.

- a) Certification to 30 Foot Depth - Initial permit level, approved upon the successful completion of training listed in Section 4.00 and 5.30.
- b) Certification to 60 Foot Depth - A diver holding a 30 foot certificate may be certified to a depth of 60 feet after successfully completing, under supervision, 12 logged training dives to depths between 31 and 60 feet, for a minimum total time of 4 hours.
- c) 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.
- d) 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.
- e) 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.

- f) 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.

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

## **5.50 Continuation of Diving Authorization Certificate**

### **Minimum Activity to Maintain Certification**

During any 12-month period, each certified scientific diver must log a minimum of 12 dives. At least one dive must be logged near the maximum depth of the diver's certification during each 6-month period. Divers certified to 150 feet or deeper may satisfy these requirements with dives to 130 feet or over. Failure to meet these requirements may be cause for revocation or restriction of certification.

### **Re-qualification of Depth Certificate**

Once the initial certification requirements of Section 5.30 are met, divers whose depth certification has lapsed due to lack of activity may be re-qualified by diving to the desired depth of certification with the DSO or DSO-designate.

### **Medical Examination**

All certified scientific divers at the University of Michigan shall pass an annual medical examination. After each major illness or injury, as described in Section 6.10, a certified scientific diver shall receive clearance to return to diving from a university designated medical practitioner before resuming diving activities.

### **Emergency Care Training.**

The scientific diver must provide and maintain proof of current training in the following:

- a) Adult CPR (American Red Cross or American Heart)
- a) Emergency oxygen administration (DAN O<sub>2</sub> Provider)
- b) Standard First Aid (American Red Cross)

## **5.60 Revocation of Certification**

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

## **5.70 Recertification**

If a diver's certificate expires or is revoked, they may be re-certified after complying with such conditions as the Diving Safety Officer or the DCB may impose. The diver shall be given an opportunity to present their case to the DCB before conditions for re-certification are stipulated.

## **SECTION 6**

### **MEDICAL STANDARDS**

#### **6.10 Medical Requirements**

##### **General**

Divers must be declared medically fit for diving by a University of Michigan medical practitioner.

The University of Michigan Risk Management Group maintains that the only acceptable medical examination is one conducted by a University of Michigan medical practitioner.

The diver should be free of any chronic disabling disease and be free of any conditions contained in the list of conditions found in Appendix 1.

##### **Frequency of Medical Evaluations**

Medical evaluation shall be completed:

- a) Before a diver may begin diving or in-water evaluations.
- b) Annually. (This is a U of Michigan Risk Management Mandate)
- c) Clearance to return to diving must be obtained from a University of Michigan medical practitioner following any major injury or illness, or any condition requiring hospital care. If the injury or illness is pressure related, then the clearance to return to diving must come from a physician trained in diving medicine.

##### **Information Provided Examining Physician**

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

##### **Content of Medical Evaluations**

Medical examinations conducted initially and at the intervals specified in Section 6.10 shall consist of the following:

- a) Applicant agreement for release of medical information to the Diving Safety Officer and the DCB (Appendix 2).
- b) Medical history (Appendix 3).
- c) Diving physical examination (Required tests listed below and in Appendix 2).

##### **Conditions Which May Disqualify Candidates From Diving (Adapted from Bove, 1998)**

- a) Abnormalities of the tympanic membrane, such as perforation, presence of a monomeric membrane, or inability to auto inflate the middle ears.
- b) Vertigo including Meniere's Disease.
- c) Stapedectomy or middle ear reconstructive surgery.
- d) Recent ocular surgery.
- e) Psychiatric disorders including claustrophobia, suicidal ideation, psychosis, anxiety states, untreated depression.
- f) Substance abuse, including alcohol.
- g) Episodic loss of consciousness.

- h) History of seizure.
- i) History of stroke or a fixed neurological deficit.
- j) Recurring neurologic disorders, including transient ischemic attacks.
- k) History of intracranial aneurysm, other vascular malformation or intracranial hemorrhage.
- l) History of neurological decompression illness with residual deficit.
- m) Head injury with sequelae.
- n) Hematologic disorders including coagulopathies.
- o) Evidence of coronary artery disease or high risk for coronary artery disease.
- p) Atrial septal defects.
- q) Significant valvular heart disease - isolated mitral valve prolapse is not disqualifying.
- r) Significant cardiac rhythm or conduction abnormalities.
- s) Implanted cardiac pacemakers and cardiac defibrillators (ICD).
- t) Inadequate exercise tolerance.
- u) Severe hypertension.
- v) History of spontaneous or traumatic pneumothorax.
- w) Asthma.
- x) Chronic pulmonary disease, including radiographic evidence of pulmonary blebs, bullae or cysts.
- y) Diabetes mellitus.
- z) Pregnancy.

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

- a) 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.
- b) Periodic re-examination under age 40 (every 5 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
- c) Initial exam over age 40:
  1. Medical History
  2. Complete Physical Exam, emphasis on neurological and otological components  
Assessment of coronary artery disease using Multiple-Risk-Factor Assessment
  3. (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. 2

- d) Periodic re-examination over age 40 (every 3 years); over age 60 (every 2 years):

Medical History

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

- e) Physician's Written Report

1. After any medical examination relating to the individual's fitness to dive, the U of MI shall obtain a written report prepared by the examining physician that 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 DCB.
2. The U of MI shall make a copy of the physician's written report available to the individual.

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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/clinicalconsensus/risk/risk1999.pdf>

2 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/clinicalguidelines/exercise/exercise.pdf>

## **Specialty Diving Standards**

## **SECTION 7**

### **OXYGEN-ENRICHED AIR (“NITROX”) DIVING GUIDELINES**

The following guidelines address the use of oxygen enriched air (commonly called Nitrox in the recreational diving community) by scientific divers under the auspices of the University of Michigan. 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.

#### **7.10 Prerequisites**

##### **Eligibility**

Only a certified Scientific Diver or Scientific Diver In Training (Sections 4.00 and 5.00) diving under the auspices of the U of MI is eligible for authorization to use nitrox. After completion, review and acceptance of application materials, training and qualification, an applicant will be authorized to use nitrox within their depth authorization, as specified in Section 5.40.

##### **Application and Documentation**

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

#### **7.20 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 they are 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

##### **Examinations**

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

- a) Written examinations covering the information presented in the classroom training session(s) (i.e., gas theory, oxygen toxicity, partial pressure determination, etc.)
- b) Practical examinations covering the information presented in the practical training session(s) (i.e., gas analysis, documentation procedures, etc.)
- c) Open water checkout dives, to appropriate depths, to demonstrate the application of theoretical and practical skills learned.

##### **Minimum Activity to Maintain Authorization**

The diver should log at least one nitrox dive per year. Failure to meet the minimum activity level may be cause for restriction or revocation of nitrox authorization.

### 7.30 Nitrox Training Guidelines

Training in these guidelines should be in addition to training for Diver-In-Training authorization (Section 4.00). It may be included as part of training to satisfy the Scientific Diver training requirements (Section 5.30).

#### Classroom Instruction

- a) Topics should include, but are not limited to:
  - 1. review of previous training
  - 2. physical gas laws pertaining to nitrox
  - 3. partial pressure calculations and limits
  - 4. equivalent air depth (EAD) concept and calculations
  - 5. oxygen physiology and oxygen toxicity
  - 6. calculation of oxygen exposure and maximum safe operating depth (MOD)
  - 7. determination of decompression schedules (both by EAD method using approved air dive tables, and using approved nitrox dive tables)
  - 8. dive planning and emergency procedures
  - 9. mixing procedures and calculations
  - 10. gas analysis
  - 11. personnel requirements
  - 12. equipment marking and maintenance requirements
  - 13. dive station requirements.
- b) 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 (Section 4.00), with additional training as follows:

- a) Oxygen analysis of nitrox mixtures.
- b) Determination of MOD, oxygen partial pressure exposure, and oxygen toxicity time limits, for various nitrox mixtures at various depths.
- c) 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.
- d) Nitrox dive computer use may be included, as approved by the DCB.

#### 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:

- a) Function, care, use, and maintenance of equipment cleaned for nitrox use.

- b) Physiological considerations of nitrox diving (especially O<sub>2</sub> and CO<sub>2</sub> toxicity).
- c) Diving regulations and procedures as related to nitrox diving, either scuba or surface supplied (depending on intended mode).
- d) 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.
- e) Dive table and dive computer selection and usage;
- f) Nitrox production methods and considerations.
- g) Oxygen analysis.
- h) 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 U of MI's surface-supplied diving standards.

### **7.40 Scientific Nitrox Diving Regulations**

#### Dive Personnel Requirements

- a) Nitrox Diver In Training
  - 1. A Diver In Training, who has completed the requirements of 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.
  - 2. Dive depths should be restricted to those specified in the diver's authorization.
- b) Scientific Diver
  - 1. A Scientific Diver, who has completed the requirements of Section 5.00 and the training and authorization sections of these guidelines, may be authorized by the DSO to use nitrox.
  - 2. Dive depths should be restricted to those specified in the diver's authorization.



c) Lead Diver

1. 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.
2. Lead Diver authorization for nitrox dives by the DSO and/or DCB should occur as part of the dive plan approval process.
3. As part of the dive planning process, the Lead Diver should:
  - a) verify that all divers using nitrox on a dive are properly qualified and authorized;
  - b) confirm with each diver the nitrox mixture the diver is using
  - c) establish dive team maximum depth and time limits, according to the shortest time limit or shallowest depth limit among the team members.
  - d) reduce the maximum allowable  $pO_2$  exposure limit for the dive team if on-site conditions so indicate

Dive Parameters

a) 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  $pO_2$  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.

b) 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*

c) Dive Tables and Gases

1. A set of DCB approved nitrox dive tables should be available at the dive site. When using the equivalent air depth (EAD) method, dives should be conducted using air dive tables approved by the DCB.
2. 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
3. Breathing mixtures used while performing in-water decompression, or for bail-out

purposes, should contain the same or greater oxygen content as that being used during the dive, within the confines of set depth and oxygen partial pressure limits.

d) 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.
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 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.

e) 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.

f) Oxygen Parameters

1. Mixtures meeting the criteria outlined in Section 7.40 may be used for nitrox diving operations, upon approval of the DCB.
2. Oxygen used for mixing nitrox-breathing gas should meet the purity levels for "Medical Grade" (U.S.P.) or "Aviator Grade" standards.

For any contact with oxygen concentrations greater than 40%.

Air Purity: CGA Grade E (Section 3.60)	
Condensed Hydrocarbons	5 mg/m <sup>3</sup>
Hydrocarbon Contaminants	No greater than 0.1 mg/m'

Gas Mixing and Analysis

a) 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.
- b) Production Methods must be approved by the DCB.
- c) Analysis Verification by User
  1. It is the responsibility of each diver to analyze prior to the dive the oxygen content of their scuba cylinder and acknowledge in writing the following information for each cylinder:  $fO_2$ , MOD, cylinder pressure, date of analysis, and user's name,
  2. Individual dive log reporting forms should report non-21%  $O_2$  EANx mixtures

## 7.50 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

- a) 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.
- b) Equipment used with oxygen or mixtures containing over 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.

- a) Cylinders should be marked "NITROX", or "EANx", or "Enriched Air".
- b) 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, the green band should be bordered above and below by a 1-inch yellow band.
- c) 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.
- d) Other markings, which identify the cylinder as containing gas mixes other than Air, may be used as the approval of the DCB.
- e) A contents label should be affixed showing the current  $fO_2$ , analysis date, and MOD.
- f) 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

- a) 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 1 % accuracy.
- b) All diver and support equipment should be suitable for the  $fO_2$  being used.

## Compressor system

- a) Compressor/filtration system must produce oil- free air.
- b) 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.

## SECTION 8

### 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.

#### **8.10 Minimum Experience and Training Requirements**

- a) Prerequisites:
  - 1. Scientific Diver qualification according to Section 5.00.
  - 2. Minimum of 100 logged dives.
  - 3. Demonstration of the ability to safely plan and conduct dives deeper than 100 feet.
  - 4. Nitrox certification/authorization according to AAUS Section 7.00 recommended.
- b) Training shall approximate the conditions of potential dive operations.
- c) Minimum Training shall include the following:
  - 1. 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.
  - 2. 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.
  - 3. 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.
  - 4. Progression to greater depths shall be by 4-dive increments at depth intervals as specified in Section 5.40.
  - 5. No training dives requiring decompression shall be conducted until the diver has demonstrated acceptable skills under simulated conditions.
  - 6. The following are the minimum skills the diver must demonstrate proficiently during dives simulating and requiring decompression:
    - a. Buoyancy control
    - b. Proper ascent rate
    - c. Proper depth control
    - d. Equipment manipulation
    - e. Stage/decompression bottle use as pertinent to planned diving operation
    - f. Buddy skills
    - g. Gas management

- h. Time management
  - i. Task loading
  - j. Emergency skills
7. 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.
  8. Upon completion of training, the diver shall be authorized to conduct required decompression dives with DSO approval.

## **8.20 Minimum Equipment Requirements**

- a) 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 anyone component of the regulator/valve system.
- b) Cylinders with volume and configuration adequate for planned diving operations.
- c) 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.
- d) Minimum dive equipment shall include:
  1. Snorkel is optional at the DCB's discretion.
  2. Diver location devices adequate for the planned diving operations and environment.
  3. Compass
- e) Redundancy in the following components is desirable or required at the discretion of the DCB or DSO:
  1. Decompression Schedules
  2. Dive Timing Devices
  3. Depth gauges
  4. Buoyancy Control Devices
  5. Cutting devices
  6. Lift bags and line reels

## **8.30 Minimum Operational Requirements**

- a) Approval of dive plan applications to conduct required decompression dives shall be on a case-by-case basis.
- b) The maximum pO<sub>2</sub> to be used for planning required decompression dives is 1.6. It is recommended that a pO<sub>2</sub> of less than 1.6 be used during bottom exposure.
- c) Divers gas supplies shall be adequate to meet planned operational requirements and foreseeable emergency situations.
- d) Decompression dives may be planned using dive tables, dive computers, and/or PC software approved by the DSO/DCB.
- e) 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.

- f) The dive team prior to each dive shall review emergency procedures appropriate for the planned dive.
- g) If breathing gas mixtures other than air are used for required decompression, their use shall be in accordance with those regulations set forth in Section 7.
- h) The maximum depth for required decompression using air as the bottom gas shall be 190 feet.
- i) Use of additional nitrox and/or high-oxygen fraction decompression mixtures as travel and decompression gases to decrease decompression obligations is encouraged.
- j) Use of alternate inert gas mixtures to limit narcosis is encouraged for depths greater than 150 feet.
- k) 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.
- l) Mission specific workup dives are recommended.

## **SECTION 9**

### **MIXED GAS DIVING**

Mixed gas diving is defined as dives done while breathing gas mixes containing proportions greater than 1 % by volume of an inert gas other than nitrogen.

#### **9.10 Minimum Experience and Training Requirements**

- a) Prerequisites:
  - 1. Nitrox certification and authorization (Section 7.00)
  - 2. If the intended use entails required decompression stops, divers will be previously certified and authorized in decompression diving (Section 8.00).
  - 3. Divers shall demonstrate to the DCB's satisfaction skills, knowledge, and attitude appropriate for training in the safe use of mixed gases.
- b) Classroom training including:
  - 1. Review of topics and issues previously outlined in nitrox and required decompression diving training as pertinent to the planned operations.
  - 2. The use of helium or other inert gases, and the use of multiple decompression gases.
  - 3. Equipment configurations
  - 4. Mixed gas decompression planning Gas management planning Thermal considerations
  - 5. END determination
  - 6. Mission planning and logistics Emergency procedures
  - 7. Mixed gas production methods
  - 8. Methods of gas handling and cylinder filling Oxygen exposure management
  - 9. Gas analysis
  - 10. Mixed gas physics and physiology
- c) Practical Training:
  - 1. Confined water session(s) in which divers demonstrate proficiency in required skills and techniques for proposed diving operations.
  - 2. Minimum of 6 open water training dives.
  - 3. At least one initial dive shall be in 130 feet or less to practice equipment handling and emergency procedures.
  - 4. Subsequent dives will gradually increase in depth, with a majority of the training dives being conducted between 130 feet and the planned operational depth.
  - 5. Planned operational depth for initial training dives shall not exceed 260 feet.
  - 6. Diving operations beyond 260 feet requires additional training dives.

#### **9.20 Equipment and Gas Quality Requirements**

- a) Equipment requirements shall be developed and approved by the DCB, and met by divers, prior to engaging in mixed-gas diving. Equipment shall meet other pertinent requirements set forth elsewhere in this standard.



- b) The quality of inert gases used to produce breathing mixtures shall be of an acceptable grade (USP) for human consumption.

### **9.30 Minimum Operational Requirements**

- a) Approval of dive plan applications to conduct mixed gas dives shall be on a case-by-case basis.
- b) All applicable operational requirements for nitrox and decompression diving shall be met.
- c) The maximum pO<sub>2</sub> to be used for planning required decompression dives is 1.6. It is recommended that a pO<sub>2</sub> of less than 1.6 be used during bottom exposure.
- d) Maximum planned Oxygen Toxicity Units (OTU) will be considered based on mission duration.
- e) Divers decompressing on high-oxygen concentration mixtures shall closely monitor one another for signs of acute oxygen toxicity.

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.

## **SECTION 10**

### **OTHER DIVING TECHNOLOGY**

Certain types of diving, some of which are listed below, require equipment or procedures that require training. Supplementary guidelines for these technologies are in development by the AAUS. Organizational member's using these, must have guidelines established by their Diving Control Board. Divers shall comply with all scuba diving procedures in this standard unless specified.

#### **10.10 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 Publ. No. T-CSGCP-014).

#### **10.20 Ice And Polar Diving**

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.

#### **10.30 Overhead Environments**

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.

#### **10.40 Saturation Diving**

If using open circuit compressed air scuba in saturation diving operations, divers shall comply with the saturation diving guidelines of the organizational member.

#### **10.50 Hookah**

While similar to Surface Supplied in that the breathing gas is supplied from the surface by means of a pressurized hose, the supply hose does not require a strength member, pneumofathometer hose, or communication line. Hookah equipment may be as simple as a long hose attached to a standard scuba cylinder supplying a standard scuba second stage. The diver is responsible for the monitoring their own depth, time, and diving profile.

#### **10.60 Surface Supplied Diving**

Surface Supplied: Dives where the breathing gas is supplied from the surface by means of a pressurized umbilical hose. The umbilical generally consists of a gas supply hose, strength member, pneumofathometer hose, and communication line. The umbilical supplies a helmet or full-face mask. The diver may rely on the tender at the surface to keep up with the divers' depth, time and diving profile.

## **SECTION 11**

### **REBREATHERS**

This section considers the following issues for the use of rebreathers:

- a) Training and/or experience verification requirements for authorization
- b) Equipment requirements
- c) 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 University of Michigan Standards for Scientific Diving,

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 diving 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.

#### **11.10 Definitions and General Information**

- a) 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.
  - 1. 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.
  - 2. 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").
  - 3. 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.
- b) 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.

- c) **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.
- d) **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.

### 11.20 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

- a. **Training Prerequisites**
  - 1. Active scientific diver status, with depth qualification sufficient for the type, makes, and model of rebreather, and planned application.
  - 2. Completion of a minimum of 50 open-water dives on SCUBA.
  - 3. 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.
  - 4. 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.

### 11.30 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.

- a) 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.

b) Classroom training shall include:

1. 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.
2. In particular, causes, signs and symptoms, first aid, treatment and prevention of the following must be covered:
  - a. Hyperoxia (CNS and Pulmonary Oxygen Toxicity)
  - b. Middle Ear Oxygen Absorption Syndrome (oxygen ear)
  - c. Hyperoxia-induced myopia
  - d. Hypoxia
  - e. Hypercapnia
  - f. Inert gas narcosis
  - g. Decompression sickness
3. Rebreather-specific information required for the safe and effective operation of the system to be used, including:
  - a. System design and operation, including:
  - b. Counterlung(s)
  - c. CO<sub>2</sub> scrubber
  - d. CO<sub>2</sub> absorbent material types, activity characteristics, storage, handling and disposal
  - e. Oxygen control system design, automatic and manual
  - f. Diluent control system, automatic and manual (if any)
  - g. Pre-dive set-up and testing
  - h. Post-dive break-down and maintenance
  - i. Oxygen exposure management
  - j. Decompression management and applicable decompression tracking methods
  - k. Dive operations planning
  - l. Problem recognition and management, including system failures leading to hypoxia, hyperoxia, hypercapnia, flooded loop, and caustic cocktail
  - m. Emergency protocols and bailout procedures

c) Practical Training (with model of rebreather to be used)

1. The 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 1 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.

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

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

d) 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:

1. Oxygen control system calibration and operation checks
2. Carbon dioxide absorbent canister packing
3. Supply gas cylinder analysis and pressure check
4. Test of one-way valves
5. System assembly and breathing loop leak testing
6. Pre-dive breathing to test system operation
7. In- water leak checks
8. Buoyancy control during descent, bottom operations, and ascent
9. System monitoring and control during descent, bottom operations, and ascent
10. Proper interpretation and operation of system instrumentation (P02 displays, dive computers, gas supply pressure gauges, alarms, etc, as applicable)
11. Unit removal and replacement on the surface.
12. Bailout and emergency procedures for self and buddy, including:
13. System malfunction recognition and solution
14. Manual system control
15. Flooded breathing loop recovery (if possible)
16. Absorbent canister failure
17. Alternate bailout options

18. Symptom recognition and emergency procedures for hyperoxia, hypoxia, and hypercapnia
19. Proper system maintenance, including:
20. Full breathing loop disassembly and cleaning (mouthpiece, check-valves, hoses, counterlung, absorbent canister, etc.)
21. Oxygen sensor replacement (for SCR and CCR)
22. Other tasks required by specific rebreather models

e) 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.

f) 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.

1. 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.
2. Dives at this level may be targeted to activities associated with the planned science diving. The 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 60 fsw.

\*\* First two dives should not exceed 60 fsw. Subsequent dives should be at progressively greater depths, with at least 1 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.

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

g) 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.

1. 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.

2. 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.
  3. 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.
- h) Maintenance of Proficiency
1. 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.
  2. 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.

#### **11.40 Equipment Requirements**

- a) General Requirements
1. Only those models of rebreathers specifically approved by DCB shall be used.
  2. 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.
  3. Unit performance specifications should be within acceptable levels as defined by standards of a recognized authority (CE, US Navy, Royal Navy, NOAA, etc.).
  4. 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.
  5. The following documentation for each rebreather model to be used should be available as a set of manufacturer's specifications. These should include:
    - a) Operational depth range
    - b) Operational temperature range
    - c) Breathing gas mixtures that may be used
    - d) Maximum exercise level which can be supported as a function of breathing gas and depth
    - e) Breathing gas supply durations as a function of exercise level and depth
    - f) CO<sub>2</sub> absorbent durations, as a function of depth, exercise level, breathing gas, and water temperature



- g) Method, range and precision of inspired PPO<sub>2</sub> control, as a function of depth, exercise level, breathing gas, and temperature
- h) Likely failure modes and backup or redundant systems designed to protect the diver if such failures occur
- i) Accuracy and precision of all readouts and sensors
- j) Battery duration as a function of depth and temperature
- k) Mean time between failures of each subsystem and method of determination
- l) A complete instruction manual is required, fully describing the operation of all rebreather components and subsystems as well as maintenance procedures.
- m) A maintenance log is required. The unit maintenance shall be up-to-date based upon manufacturer's recommendations.

b) Minimum Equipment

- 1. A surface/dive valve in the mouthpiece assembly, allowing sealing of the breathing loop from the external environment when not in use.
- 2. An automatic gas addition valve, so that manual volumetric compensation during descent is unnecessary.
- 3. Manual gas addition valves, so that manual volumetric compensation during descent and manual oxygen addition at all times during the dive are possible.
- 4. 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.

c) Oxygen Rebreathers

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

d) 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.

e) Closed Circuit Mixed-gas Rebreathers.

- 1. CCR shall incorporate a minimum of three independent oxygen sensors.
- 2. A minimum of two independent displays of oxygen sensor readings shall be available to the diver.
- 3. 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.
- 4. 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.
- 5. Redundancies in onboard electronics, power supplies, and life support systems are highly desirable.

## 11.50 Operational Requirements

### a) General Requirements

1. All dives involving rebreathers must comply with applicable operational requirements for open-circuit SCUBA dives to equivalent depths.
2. No rebreather system should be used in situations beyond the manufacturer's stated design limits (dive depth, duration, water temperature, etc).
3. Modifications to rebreather systems shall be in compliance with manufacturer's recommendations.
4. 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.
5. 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:
  - a. Information about the specific rebreather model to be used
  - b. Make, model, and type of rebreather system
  - c. Type of CO<sub>2</sub> absorbent material
  - d. Composition and volume(s) of supply gases
  - e. Complete description of alternate bailout procedures to be employed, including manual rebreather operation and open-circuit procedures
  - f. Other specific details as requested by DCB

### b) Buddy Qualifications.

1. 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.
2. 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.

### c) Oxygen Exposures

1. Planned oxygen partial pressure in the breathing gas shall not exceed 1.4 atmospheres at depths greater than 30 feet.
2. 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.
3. 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.

### d) Decompression Management

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

2. 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:
  - a. Oxygen rebreathers: Not applicable.
  - b. SCR (presumed constant  $fO_2$ ):
    1. Use of any method approved for open-circuit scuba diving breathing air, above the maximum operational depth of the supply gas.
    2. 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.
    3. Equivalent air depth correction to open-circuit air dive tables, based upon expected inspired  $F_{O_2}$  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.
  - c. CCR (constant  $PPO_2$ ):
    1. Integrated constant  $PPO_2$  dive computer.
    2. Non-integrated constant  $PPO_2$  dive computer.
    3. Constant  $PPO_2$  dive tables.
    4. Open-circuit (constant  $FO_2$ ) nitrox dive computer, set to inspired  $F_{O_2}$  predicted using  $PPO_2$  set point at the maximum planned dive depth.
    5. 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.
    6. Air dive computer, or air dive tables used above the maximum operating depth (MOD) of air for the  $PPO_2$  set point selected
  - d. Maintenance Logs and 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:

1. Gas supply cylinders full
2. Composition of all supply and bail-out gases analyzed and documented
3. Oxygen sensors calibrated
4. Carbon dioxide canister properly packed
5. Remaining duration of canister life verified
6. Breathing loop assembled
7. Positive and negative pressure leak checks

8. Automatic volume addition system working
9. Automatic oxygen addition systems working
10. Pre-breathe system for 3 minutes (5 minutes in cold water)
11. Check carbon dioxide removal (be alert for signs of hypoxia or hypercapnia)
12. Other procedures specific to the model of rebreather used
13. Documentation of ALL components assembled
14. Complete pre-dive system check performed
15. Final operational verification immediately before to entering the water:
16. PO<sub>2</sub> in the rebreather is not hypoxic
17. Oxygen addition system is functioning;
18. Volumetric addition is functioning
19. Bail-out life support is functioning
20. 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:

1. Open-circuit bailout cylinders or sets of cylinders, either carried or pre-positioned
  2. Redundant rebreather
- e. Pre-positioned life support equipment with topside support CO<sub>2</sub> Absorbent Material
1. CO<sub>2</sub> absorption canister shall be filled in accordance with the manufacturer's specifications.
  2. CO<sub>2</sub> absorbent material shall be used in accordance with the manufacturer's specifications for expected duration.
  3. 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.
  4. 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.
- f. 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.

- g. 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.

#### **11.60 Oxygen Rebreathers**

- a) Oxygen rebreathers shall not be used at depths greater than 20 feet.
- b) 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.
- c) Breathing loop shall be flushed with fresh oxygen prior to ascending to avoid hypoxia due to inert gas in the loop.

#### **11.70 Semi-Closed Circuit Rebreathers**

- a) 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.
- b) 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  $FO_2$ .
- c) The intermediate pressure of supply gas delivery in active-addition SCR shall be checked periodically, in compliance with manufacturer's recommendations.
- d) Maximum operating depth shall be based upon the  $FO_2$  in the active supply cylinder.
- e) 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.

#### **11.80 Closed-Circuit Rebreathers**

- a) The  $FO_2$  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  $PPO_2$  greater than 0.20 atm, but no greater than 1.4 atm.
- b) Maximum operating depth shall be based on the  $FO_2$  of the diluent in use during each phase of the dive, so as not to exceed a  $PO_2$  limit of 1.4 atm.
- c) 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).
- d) The  $PPO_2$  set point shall not be lower than 0.4 atm or higher than 1.4 atm.

## SECTION 12

### SCIENTIFIC CAVE AND CAVERN DIVING STANDARD

This standard helps to ensure all scientific diving in overhead environments is conducted in a manner which will maximize the protection of scientific divers from accidental injury and/or illness and provide the basis allowing the working reciprocity between AAUS organizational members.

If a conflict exists between this standard and other standards in this manual, the information set forth in this standard only takes precedence when the scientific diving being conducted takes place wholly or partly within an underwater cave or cavern environment.

A dive team shall be considered to be cave or cavern diving if at any time during the dive they find themselves in a position where they cannot complete a direct, unobstructed ascent to the surface because of rock formations.

The member organization requires that no person shall engage in scientific cave or cavern diving unless that person holds a recognized certificate/authorization issued pursuant to the provisions of this manual.

The diver must demonstrate to the DCB or its designee that the diver possesses the proper attitude, judgment, and discipline to safely conduct cave and cavern diving in the context of planned operations.

Operational requirements for cave and cavern diving have been established through accident analysis of previous cave diving accidents.

#### 12.1 Definitions

**Alternate Gas Supply** - Fully redundant system capable of providing a gas source to the diver should their primary gas supply fail.

**Bubble Check** - Visual examination by the dive team of their diving systems, looking for o-ring leaks or other air leaks conducted in the water prior to entering a cave. Usually included in the "S" Drill.

**Cave** - A dive shall be considered a cave dive if anyone or more of the environmental limits specified in the definition of cavern are exceeded or otherwise not -allowed. Linear penetrations limits shall not exceed the limits of each diver's training.

**Cave Dive** - A dive, which takes place partially or wholly underground, in which one or more of the environmental parameters defining a cavern dive are exceeded.

**Cavern** - An entrance and first chamber to a cave where:

- a) Sunlight at the entrance is visible to all divers at all times during the dive.
- b) Members of the dive team do not pass through any restrictions that don't allow the divers to swim side by side during the dive, nor are there any restrictions between the divers and the most expeditious exit to the surface.
- c) Maximum depth achieved shall not exceed the depth ratings of any diver.

**Cavern Dive** - A dive which takes place partially or wholly underground, in which the following environmental parameters are met:

- a) Natural sunlight is continuously visible from the entrance.

b) The DSO or designee will set appropriate limits incorporated into the dive plan.

Dual Valve Manifold with Isolator Valve - A manifold joining two diving cylinders, that allows the use of two completely independent regulators. If either regulator fails, it may be shut off, allowing the remaining regulator access to the gas in both of the diving cylinders.

Gas Management - Gas planning rule which is used in cave diving environments in which the diver reserves a portion of their available breathing gas for anticipated emergencies

Guideline - Continuous line used as a navigational reference during a dive leading from the team position to a point where a direct vertical ascent may be made to the surface.

Jump/Gap Reel -Spool or reel used to connect one guide line to another thus ensuring a continuous line to the exit.

Knife/Line Cutter – An accessible small, sharp blade capable of easily cutting a guideline

Lava Tube - Type of cave or cavern formed by the surface hardening of a stream of flowing molten rock, which may later become flooded due to static sea level changes.

Line Marker - Anyone of several types of markers attached to a guideline, which provides additional navigational information to the dive team, most commonly the direction out to the nearest surface.

Mine Diving - Diving in the flooded portions of a man-made mine. Necessitates use of techniques detailed for cave diving.

Penetration Distance - Linear distance from the entrance intended or reached by a dive team during a dive at a dive site.

Primary Reel - Initial guideline used by the dive team from open water to maximum penetration or a permanently installed guideline.

Restriction - Any passage preventing two divers from passing side by side while sharing air.

Rule of Thirds - Gas planning rule which is used in cave diving environments in which the diver reserves 2/3's of their breathing gas supply for exiting the cave or cavern

Rule of Sixths - Air planning rule which is used in cave or other confined diving environments in which the diver reserves 5/6's of their breathing gas supply (for DPV use, siphon diving, etc.) for exiting the cave or cavern

Safety Drill- ("S" Drill) - Short gas sharing, equipment evaluation, dive plan, and communication exercise carried out prior to entering a cave or cavern dive by the dive team.

Safety Reel - Secondary reel used as a backup to the primary reel, usually containing 150 feet of guideline that is used in an emergency.

Scientific Cave or Cavern Diver In Training - Authorized to dive in the cave or cavern environment under the direct supervision of qualified instructional personnel for training purposes only.

Scientific Cavern Diver - Authorization to dive in an overhead environment as defined in cavern.

Scientific Cave Diver - Authorization to dive in an overhead environment as defined in cave.

Side-mount Diving - A diving mode utilizing two independent SCUBA systems carried along the sides of the diver's body; either of which always has sufficient air to allow the diver to reach the surface unassisted.

Siphon - Cave into which water flows with a generally continuous in-current.

Solution Cave - Cave formed in carbonate or carbonate-cemented bedrock, formed by the dissolution of the rock by groundwater.

Spring - Cave with water flowing with a generally continuous outflow.

Sump - An area in a dry cave that can no longer be negotiated without the use of diving equipment.

Well- A vertical or nearly vertical shaft, usually manmade, through which a diver can access a dive site.

## **12.2 Cave and Cavern Environment Hazards**

Current/Flow - Underwater caves have currents that vary in strength and direction. Of particular note is a condition known as siphoning. Siphoning caves have flow or current directed into the cave. This can cause poor visibility as a result of mud and silt being drawn into the cave entrance.

Silt - The presences of silt, sand, mud, clay, etc. on the cave floor can cause visibility to be reduced to nothing in a very short time.

Restrictions - Any passage through which two divers cannot easily pass side by side while sharing air make air sharing difficult.

Cave-ins - Cave-ins are a normal part of cave evolution; however experiencing a cave-in during diving operations is extremely unlikely.

## **12.3 Cavern Diver Training Requirements**

### **a) Cavern Diver Prerequisites**

1. The applicant for training shall have met the requirements in Section 5.00 of the AAUS *Standards for Scientific Diving Certification and Operation of Scientific Diving Programs*, and hold as a minimum a scientific diver permit.

### **b) Cavern Training**

1. Classroom Lecture and Critique
  - a. Policy for cavern diving, cavern environment and environmental hazards
  - b. Accident analysis
  - c. Psychological considerations
  - d. Equipment
  - e. Body control
  - f. Communications
  - g. Cavern diving techniques
  - h. Navigation and guidelines
  - i. Dive planning
  - j. Cave geology
  - k. Cave hydrology



- 1. Cave biology
  - m. Emergency procedures.
- 2. Land Drills
  - a. Using the guideline and reel
  - b. Laying a guideline
  - c. Guideline following
  - d. Buddy communication
  - e. Emergency procedures.
- c) Cavern Dives
  - 1. A minimum of four (4) cavern dives, preferably in a minimum of two different caverns.
  - 2. Skills the applicant should demonstrate include:
    - a. Safety drill (S-drill)
    - b. gear matching
    - c. bubble check prior to entering the cavern on each dive
    - d. proper buoyancy compensator use
    - e. proper trim and body positioning
    - f. hovering and buoyancy with hand tasks,
    - g. specialized propulsion techniques (modified flutter kick, modified frog kick, pull and glide, ceiling walk or shuffle)
    - h. proper guideline and reel use
    - i. ability to follow the guideline with no visibility
    - j. sharing air while following a guideline
    - k. sharing air while following the guideline with no light and hand signal use
    - l. ability to comfortably work in a cavern without assistance.
- d) Cavern Written Examination –
  - 1. A written evaluation approved by the DCB with a predetermined passing score, covering concepts of both classroom and practical training is required.

## **12.4 Cave Diver Training Requirements**

### **a) Cave Diver Prerequisites**

1. The applicant for training shall hold as a minimum a cavern diver permit.

### **b) Cave Training**

#### **1. Classroom Lecture and Critique**

- a. Review of the topics listed in cavern diver training
- b. Differing techniques and procedures used in cave diving
- c. Additional equipment procedures used in cave diving
- d. Cave diving equipment configurations
- e. Diving operations involving complex navigation and use of line markers
- f. Advanced gas management and a thorough review of dive tables
- g. Decompression tables
- h. Decompression theory.

### **c) Land Drills**

1. Refresh above water included in cavern training
2. Emphasize proper use of the reel in lost diver procedures
3. Surveying Line placements and station locations.

### **d) Cave Dives**

1. A minimum of twelve cave dives in a minimum of four (4) different cave sites with differing conditions.
2. Demonstrate Skills
  - a. Review of skills listed in cavern training
  - b. Buoyancy control
  - c. Referencing and back-up navigation
  - d. Single –file air sharing in a minor restriction
  - e. Special propulsion techniques in heavy outflow
  - f. Anti-silting techniques
  - g. Line jumping techniques and protocols
  - h. Surveying
  - i. Ability to critique their dives
  - j. Emergency procedures training shall include proficiency in lost line, lost diver, gas sharing, light failure, valve manipulation, and no/low visibility situations.

### **e) Written Examination**

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

## **12.5 Equipment Requirements**

Equipment used for SCUBA in cave or cavern diving is based on the concept of redundancy. Redundant SCUBA equipment shall be carried whenever the planned penetration distances are such that an emergency swimming ascent is not theoretically possible.

- a) Cavern Diving Equipment (In addition to standard open water gear):
  - 1. At minimum, a single tank equipped with an “H” valve or an alternate air supply.
  - 2. A BCD capable of being inflated from the tank.
  - 3. Slate and pencil.
  - 4. Two battery powered secondary lights of an approved type.
  - 5. Knife or line cutter.
  - 6. One primary reel of at least 350 feet for each team.
  - 7. No snorkel shall be worn while inside underwater cave or cavern
- b) Cave Diving Equipment (In addition to cavern diving gear):
  - 1. Cylinders with dual orifice isolation valve manifold or independent SCUBA systems each capable of maintaining enough gas for the diver during exit and surface ascent.
  - 2. Two completely independent regulators, at least one of each having submersible tank pressure gauge, a five foot or longer second stage hose, low pressure inflator for the BCD.
  - 3. A primary light with sufficient burn time for the planned dive.
  - 4. Safety reel with at least 150 feet of line.
  - 5. Appropriate submersible dive tables and/or dive computer (computers w/ backup tables).
  - 6. Line markers.
  - 7. No snorkel shall be worn while inside underwater cave or cavern

## **12.6 Operational Requirements and Safety Protocols**

All members of the dive team must have met the applicable all sections of Volume One and applicable sections of Volume Two of the AAUS manual and be authorized for that type of diving by the DCB before conducting scientific cave dives.

- a) Cavern Diver Procedures
  - 1. Cavern diving shall not be conducted at depths greater than 100 feet.
  - 2. Dive teams shall perform a safety drill prior to each cave or cavern penetration that includes equipment check, gas management, and dive objectives.
  - 3. Each team within the cavern zone must utilize a continuous guideline appropriate for the environment leading to a point from which an uninterrupted ascent to the surface may be made.
  - 4. Gas management must be appropriate for the planned dive with special considerations made for DPY's, siphon diving, rebreathers, etc.
  - 5. The entire dive team is to immediately terminate the dive whenever any dive team

member feels an unsafe condition is present.

b) Cave Diving Procedures

1. Dive teams shall perform a safety drill prior to each cave or cavern penetration that includes equipment check, gas management, and dive objectives.
2. Diver teams must run or follow a continuous guideline from the surface pool to maximum penetration.
3. Gas management must be appropriate for the planned dive with special considerations made for DPY's, siphon diving, rebreathers, etc.
4. Each diver must carry one primary and two back up lights.
5. Divers utilizing side mount diving or other dual independent diving systems must have the approval of the Diving Safety Officer or his/her designee.
6. The entire dive team is to immediately terminate the dive whenever any dive team member feels an unsafe condition is present.

## **SECTION 13**

### **DIVING FOR HUMAN-POWERED SUBMARINE TEAM**

(National or International Human Powered Submarine Races)

The University of Michigan School of Engineering (primarily Naval Architecture) participates in the research, development, and construction of human-powered submarines for competition in national or International Submarine Races (ISR). Guidelines for the scuba diving associated with these activities have not been defined by the AAUS. Since this program involves both University of Michigan students and scuba diving, the university requires that students who scuba dive in this activity meet requirements similar to those involved with scientific diving. Within the scientific diving guidelines, students are issued a restricted authorization ... diving is allowed only in the confined waters of the university tow tank facility and competition facilities/events.

#### **13.1 Diving Team Members**

- a) Submarine operator/pilot
  1. Definition- any person who will enter, the submarine, while submerged or on the surface, and/or use scuba diving techniques for the purposes of operating the submarine.
  2. Training Requirements:
    - a. Current all non-open water training/certifications associated with scientific diving at the University of Michigan.
      1. C-Card as a basic scuba diver (or higher)
      2. ARC (or equivalent) Adult CPR
      3. ARC (or equivalent) Standard First Aid
      4. DAN Oxygen Provider
      5. U of MI Medical Authorization to dive
    - b. Pool Evaluation of in-water scuba comfort by the DSO
  3. Knowledge of and experience with the operation of the university's human-powered submarine.
  4. Knowledge and experience with submarine related emergency egress procedures
  5. Propels the submarine in competitive events.
- b) Submarine safety/support diver
  1. Definition- any person whose primary purpose is to ensure the safety of Submarine Operator/Pilot or will use scuba diving techniques for vehicle inspection, maintenance, repair, or operation, while submerged or on the surface.
  2. Training Requirements
    - a. all non-open water training/certifications associated with scientific diving at the University of Michigan.
      1. C-Card as a basic scuba diver (or higher)
      2. ARC (or equivalent) Adult CPR
      3. ARC (or equivalent) Standard First Aid

4. DAN Oxygen Provider
  5. U of MI Medical Authorization to dive
  - b. Pool Evaluation of in-water scuba comfort by the DSO
  - c. Knowledge and experience with submarine related emergency egress procedures.
  - d. Knowledge of submarine operating systems is recommended, but not required.
- c) Submarine Diving Team Captain/Supervisor
1. Definition- the individual who directly supervises and monitors water activities associated with the submarine.
    - a. Bears responsibility for insuring divers have ample air for their assigned task
    - b. Ensures that first aid kit, DAN O<sub>2</sub>, and other emergency kits are on the dive site
    - c. Ensures team dive logs are kept and submitted to the DSO
  2. Training Requirements:
    - a. Current all non-open water training/certifications associated with scientific diving at the University of Michigan.
      1. C-Card as a basic scuba diver (or higher)
      2. ARC (or equivalent) Adult CPR
      3. ARC (or equivalent) Standard First Aid
      4. DAN Oxygen Provider
      5. U of MI Medical Authorization to dive
    - b. Pool Evaluation of in-water scuba comfort by the DSO
  3. Knowledge of and experience with the operation of the university's human-powered submarine.
  4. Knowledge of and experience with submarine related emergency egress procedures
- d) Submarine Support Swimmer
1. Definition- anyone who routinely enters the water for the purposes of inspection, maintenance/repair of the submarine, or provides in-water assistance to other members of the submarine team
  2. Training Requirements:
    - a. Current all non-open water training/certifications associated with scientific diving at the University of Michigan.
      1. C-Card as a basic scuba diver (or higher)
      2. ARC (or equivalent) Adult CPR
      3. ARC (or equivalent) Standard First Aid
      4. DAN Oxygen Provider
      5. U of MI Medical Authorization to dive
    - b. Pool Evaluation of in-water comfort by the DSO

## 13.2 ADDITIONAL TRAINING REQUIREMENTS

In addition to the minimum requirements stated above, divers operating the submarine shall be able to demonstrate the following scuba skills while piloting the submarine:

- a) Submarine operator/pilot
  1. Equalize ear air pressures while operating the submarine
  2. Clear a flooded face mask
  3. Remove and replace the face mask while inside the submarine.
  4. Remove, replace, and clear the air supply mouthpiece while inside the vehicle.
  5. Monitor the primary and reserve air supply.
  6. Switch from primary to secondary air supply.
  7. Release the emergency signal float/buoy.
  8. Demonstrate an emergency egress.
- b) Submarine safety/support diver
  1. Monitor the primary and reserve air supply of the operator/diver.
  2. Release the emergency egress hatch and any/all interior restraint systems.
  3. Supply an air source to an operator/pilot still inside the vehicle.
  4. Conduct a normal ascent while sharing air with the submarine pilot.
  5. Extricate and surface with an unconscious submarine pilot.
  6. On the surface, perform rescue breathing for an unconscious, non-breathing diver.
  7. Recognize and respond to a distressed vehicle operator/diver while underwater.
  8. Recognize and respond to a distressed vehicle operator/diver on the surface.
  9. Demonstrate techniques for water egress with an unconscious diver.
  10. Demonstrate proper first aid procedures for victims of pressure related and/or drowning injuries.
- c) Submarine Diving Team Captain/Supervisor
  1. Meet the minimum requirements of safety/support diver.
  2. Demonstrate proficiency in diving accident management.
  3. Maintain records of team members with a minimum :
    - a. names,
    - b. certification levels, and
    - c. emergency contact information for all diving participants.
  4. Submit to the university DSO an Emergency Action Plan for to include:
    - a. On-site rescue procedures
    - b. dispatch procedures
    - c. estimated response times for emergency medical services

### **13.3 SUBMARINE LIFE-SUPPORT SYSTEMS**

- a) Breathing Media
  - 1. All breathing media shall be compressed atmospheric air.
  - 2. Special air mixes such as oxygen-enriched air (Nitrox) are prohibited by the ISR.
- b) Scuba Cylinders shall have evidence of:
  - 1. Current hydrostatic test
  - 2. Current Visual Cylinder Inspection
- c) Scuba Regulators
  - 1. All breathing air must be delivered via a scuba regulator.
    - a. With evidence of annual inspection/tuning
    - b. Serviced by factory authorized service technician
  - 2. Rebreather devices are prohibited by ISR regulations.
- d) Volume of Breathing Gas Supply
  - 1. Shall be carried onboard the submarine.
  - 2. Shall be sufficient to provide breathing air for a minimum of one vehicle speed run plus 150 % in reserve capacity for each crew member.
  - 3. Diving will be terminated when any air supply reaches 500 psig.
  - 4. Air pressure gauges shall be continuously visible for ease of checking by both crew and support divers.
- e) Reserve Air Supply
  - 1. Shall be carried for each submarine crew member
  - 2. Shall be self contained and worn securely on the body.
  - 3. Volume of the reserve air supply shall be sufficient to enable the diver to egress the submarine and surface. (Small, 7 ft<sup>3</sup> ,pony bottles are recommended)
  - 4. ISR regulations allow the reserve air supply to be used for entering the submarine and preparing for a run, however, diving will be terminated when any air supply reaches 500 psig.

### **13.4 SUBMARINE SAFETY REQUIREMENTS**

ISR advises that, for the purposes of easy location, each submarine be painted with high-visibility coloration using light colors (i.e. white, yellow, orange, etc.). Fluorescent or contrasting schemes are advisable to make the submarine distinct. ISR also recommends that the contestants feature the team or submarine name prominently on the hull. The listing of sponsors, affiliates, or team members is also acceptable.

- a) Propeller
  - 1. Propeller tips must be bright orange for easy recognition by safety/support divers.



b) Emergency Egress

1. All emergency egress exits shall be clearly marked at the location of the handle or release mechanism by a 4 in<sup>2</sup> orange patch bearing the word "Rescue".
2. If this is not possible, the handle or release mechanism should be clearly marked with florescent tape.
3. The handle or release mechanism shall be easily accessible from both inside and outside the submarine.
4. Safety and support divers must be familiar with the operation of the emergency egress system.

c) Crew Restraints

1. Any method of attachment of a crew member to the submarine must have the release system clearly marked with orange paint or florescent tape.
2. Safety/support divers must be familiar with the release mechanisms of all crew restraints.

d) Crew Visibility

1. View ports, windows, canopies, etc. shall be located on the submarine so that the crew has an unrestricted forward view'
2. Facial area of all crew members shall be visible to safety/support divers.

e) Strobe Light

1. Each submarine shall carry a flashing white strobe light
  - a. Visible for 360 degrees in the horizontal plane.
  - b. Flash at an approximate rate of once per second.
  - c. Visible for at least thirty feet under normal visibility conditions
  - d. Have sufficient power to flash for a minimum of one hour
  - e. Operate whenever the submarine is submerged.

f) Emergency Buoy

2. Each submarines shall carry a high visibility buoy
  - a. Release from the hull and float to the surface in the event of an emergency.
  - b. Attached to the submarine by a 30' of highly visible line, at least 1/16" thick
  - c. Each crew member shall have a dead-man type switch that will automatically release the float in the event that they are disabled.
  - d. Buoy release will initiate an emergency rescue by the safety divers whose primary interest will be removing the crew member(s) from the submarine and to the surface as quickly as possible.
  - e. If a buoy is released inadvertently, crew members should make every attempt to indicate visually to the safety divers using the diver's OK signal.

### **13.5 SUBMARINE SAFETY INSPECTION**

During ISR competition, the vehicle shall receive a safety inspection prior to entering the water. A second safety inspection shall be conducted in the water prior to crew entry. At minimum the safety inspection shall consist of an inspection and functional test of the following components:

1. Life-support systems and air supplies
  2. Emergency egress hatch and crew restraints
  3. Emergency signal buoy
- a) Support Personnel
1. Safety/Support Divers
    - a. Minimum of two (2) Safety/Support Divers in the water readily available to assist the submarine crew.
    - b. Additional Safety/Support Divers should be staged nearby ready to enter the water in the event of an emergency.
  2. Equipment Requirements
    - a. Safety/Support Divers shall be fully equipped for open water
    - b. Octopus regulator hoses must be of sufficient length to accommodate the sharing of air while the operator/pilot is inside the vehicle.

8.



### **AAUS Appendices**

**These are individually available from the DSO as PDF files**

**The pages are not numbered to facilitate copying**

## **List of AAUS Appendices**

**The appendices are not page numbered so individual forms can be directly copied**

These Forms are Copy-Ready

- Appendix 1 Diving Medical Exam Overview for The Examining Physician
- Appendix 2 Medical Evaluation of Fitness For Scuba Diving Report
- Appendix 3 Diving Medical History Form
- Appendix 4 Recommended Physicians with Expertise In Diving Medicine
- Appendix 5 Definitions of Terms
- Appendix 6 AAUS Request For Diving Reciprocity Form
- Appendix 7 Diving Emergency Management Procedures
- Appendix 8 Dive Computer Guidelines
- Appendix 9 AAUS Statistics Collection Criteria and Definitions

## DIVING MEDICAL EXAM OVERVIEW FOR THE EXAMINING PHYSICIAN

### TO THE EXAMINING PHYSICIAN:

This person \_\_\_\_\_ requires a medical examination to assess their fitness for certification as a Scientific Diver for the University of Michigan. Their answers on their 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 concerns about diving medicine or the University of Michigan standards. Thank you for your assistance.

\_\_\_\_\_  
(Diving Safety Officer)(

\_\_\_\_\_  
Date)

\_\_\_\_\_  
(Printed Name)

\_\_\_\_\_  
(Phone Number)

\_\_\_\_\_  
(email Address)

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 that usually restrict candidates from diving.

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

### CONDITIONS WHICH MAY DISQUALIFY CANDIDATES FROM DIVING

1. Abnormalities of the tympanic membrane, such as perforation, presence of a monomeric membrane, or inability to auto inflate 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>. [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 and cardiac defibrillators (ICD). [39,40]
20. Inadequate exercise tolerance. [34]
21. Severe hypertension. [35]
22. History of spontaneous or traumatic pneumothorax. [45]
23. Asthma". [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]

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### 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.

1. 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>
2. Alert Diver Magazine; Articles on diving medicine  
<http://www.diversalertnetwork.org/medical/articles/index.asp>
3. "Are Asthmatics Fit to Dive?" Elliott DH, ed. 1996 Undersea and Hyperbaric Medical Society, Kensington, MD.
4. "Assessment of Cardiovascular Risk by Use of Multiple-Risk-Factor Assessment Equations." Grundy et. al. 1999. AHA/ACC Scientific Statement.  
<http://circ.ahajournals.org/cgi/reprint/circulationaha;100/13/1481>
5. DIVING MEDICINE, Third Edition, 1997. A. Bove and I. Davis. W.B. Saunders Company, Philadelphia
6. DIVING AND SUBAQUATIC MEDICINE, Third Edition, 1994. C. Edmonds, C. Lowery and J. Pennefather. Butterworth-Heinemann Ltd. Oxford
7. MEDICAL EXAMINATION OF SPORT SCUBA DIVERS, 1998. Alfred Bove, M.D., Ph.D. (ed.). Medical Seminars, Inc. San Antonio, TX
8. NOAA DIVING MANUAL, NOAA. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.
9. U.S. NAVY DIVING MANUAL. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.
10. "Are Asthmatics Fit to Dive?" Elliott DH, ed. 1996 Undersea and Hyperbaric Medical Society, Kensington, MD.
11. "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/riskI999.pdf>

## MEDICAL EVALUATION OF FITNESS FOR SCUBA DIVING REPORT

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

\_\_\_\_\_  
(Date - Mo/Day/Y ear)

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 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  
(age, lipid profile, blood pressure, diabetic screening,  
smoker) Note: Exercise stress testing may be  
indicated based on risk factor assessment'

**[ ] 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 tests deemed necessary by the physician

**Additional testing for over age 40**

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

**RECCOMENDATION:**

[ ] APPROVAL. I find no medical condition(s) that I consider incompatible with diving.

[ ] RESTRICTED ACTIVITY APPROVAL. The applicant may dive in certain 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

"Assessment of Cardiovascular Risk by Use of Multiple -Risk-Factor Assessment Equations." Grundy et. al. 1999.

AHA/ ACC Scientific Statement. <http://www.acc.org/clinicalconsensus/risk/risk1999.pdf>

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/clinicalguidelines/exercise/exercise.pdf>

## REMARKS:

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### 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.

\_\_\_\_\_, MD 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 the University of Michigan Diving Safety Officer and Diving Control Board or their designee at the University of Michigan on (date ) \_\_\_\_\_.

Signature of Applicant \_\_\_\_\_



## DIVING MEDICAL HISTORY FORM

(To Be Completed By Applicant-Diver)

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

Sponsor \_\_\_\_\_ Date \_\_\_\_/\_\_\_\_/\_\_\_\_

(Dept /Project/Program/School, etc.)

(Month/ Day / Year)

### 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 they 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, their 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 they are 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?	Yes	No	Comments
I.	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.			
II.	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 (i.e. patent foramen ovale. Valve issues, etc)			
16.	Heart rhythm problems.			
17.	Need for a pacemaker.			
18.	Difficulty with exercise.			
19.	High Blood Pressure			
20.	Collapsed lung.			
21.	Asthma.			

22	Other lung disease.			
22	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, and environmental?			
29	Do you smoke?			
30	Do you drink alcoholic beverages?			
31	Is there a family history of high chole sterol?			
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.

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

\_\_\_\_\_  
(Signature)

\_\_\_\_\_  
(Date)

## RECOMMENDED PHYSICIANS WITH EXPERTISE IN DIVING MEDICINE

List of local Medical Doctors that have training and expertise in diving or undersea medicine:

1	Name
	Address
	Phone
	email
2	Name
	Address
	Phone
	email
3	Name
	Address
	Phone
	email

## DEFINITIONS OF TERMS

**Air sharing** - Sharing of an air supply between divers.

**ATA(s)** - "Atmospheres Absolute", 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** - 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** - Pressure at which a pressure containment device would fail structurally.

**Certified Diver** - A diver who holds a recognized valid certification from an organizational member or internationally recognized certifying agency.

**Controlled Ascent** - Anyone 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 decompression 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.

**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** - Physical location of a diver during a dive.

**Dive 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.

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

**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.

**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.

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

**Diving Control Board (DCB)** - Group of individuals who act as the official representative of the membership organization in matters concerning the scientific diving program (Section 1.24).

**Diving Safety Officer (DSO)** - Individual responsible for the safe conduct of the scientific diving program of the membership organization (Section 1.20).

**EAD** - Equivalent Air Depth (see below).

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

**Enriched Air (EANx)** - 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" (Section 7.00).

**Equivalent Air Depth (EAD)** - 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 or saltwater, 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.

**FFW** - Feet of fresh water, or equivalent static head.

**FSW** - Feet of seawater, or equivalent static head.

**Hookah** - While similar to Surface Supplied in that the breathing gas is supplied from the surface by means of a pressurized hose, the supply hose does not require a strength member, pneumofathometer hose, or communication line. Hookah equipment may be as simple as a long hose attached to a standard scuba cylinder supplying a standard scuba second stage. The diver is responsible for the monitoring his/her own depth, time, and diving profile.

**Hyperbaric Chamber** - See decompression chamber.

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

**Lead Diver** - Certified scientific diver with experience and training to conduct the diving operation.

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

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

**Mixed Gas** - MG

**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** - 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 60 feet per minute or less.

**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 Unit – OTU

**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 levels) partial pressure of oxygen.

**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** - Unit of pressure, "pounds per square inch.

**Psig** - Unit of pressure, "pounds per square inch gauge.

**Recompression Chamber** - see decompression chamber.

**Scientific Diving** - Scientific diving is defined (29CFR1910A02) as diving performed solely as a necessary part of a scientific, research, or educational activity by employees whose sole purpose for diving is to perform scientific research tasks.

**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 - Surface Supplied: Dives where the breathing gas is supplied from the surface by means of a pressurized umbilical hose. The umbilical generally consists of a gas supply hose, strength member, pneumofathometer hose, and communication line. The umbilical supplies a helmet or full-face mask. The diver may rely on the tender at the surface to keep up with the divers' depth, time and diving profile.

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

**Umbilical** - 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** - Normal pressure at which the system is designed to operate.

**AAUS REQUEST FOR DIVING RECIPROCITY FORM  
VERIFICATION OF DIVER TRAINING AND EXPERIENCE**

Diver: \_\_\_\_\_ Date: \_\_\_\_\_

This letter serves to verify that the above listed person has met the training and pre-requisites as indicated below, and has completed all requirements necessary to be certified as a (*Scientific Diver / Diver in Training*) as established by the University of Michigan Diving Safety Manual, and has demonstrated competency in the indicated areas. The University of Michigan is an Organizational Member of the AAUS and meets or exceeds all AAUS training requirements.

The following is a brief summary of this diver's personnel file regarding dive status on \_\_\_\_\_  
(Date)

Date	Requirement		Expiration Date
	Original Diving Authorization		
	Written Scientific Diving Exam		
	Last Diving Medical Exam		
	Most Recent Checkout Dive		SAV
	Scuba Regulator Service D		
	CPR Training		
	Oxygen Administration		
	First Aid		
	Last Dive	Depth	

Total Number of Dives (Last 12 Months) \_\_\_\_\_ Depth Certification \_\_\_\_\_ fsw

Total Number of Dives (Career) \_\_\_\_\_

Any Diving Restrictions (Y / N) \_\_\_\_ If yes, explain:

Pertinent Specialty Certifications:

**Emergency Contact Information:**

Name: \_\_\_\_\_ Relationship: \_\_\_\_\_

Telephone: \_\_\_\_\_ (work) \_\_\_\_\_ (Home)

Address: \_\_\_\_\_

This is to verify that the above individual is currently a certified scientific diver at the University of Michigan

\_\_\_\_\_  
(Diving Safety Officer Signature) \_\_\_\_\_ (Date) \_\_\_\_\_ (Telephone)

\_\_\_\_\_  
(Diving Safety Officer Printed Name)

\_\_\_\_\_  
(email address)

# **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
3. Administer 100% oxygen, if appropriate (in cases of Decompression Illness, or Near Drowning).
4. Call local Emergency Medical System (EMS) for transport to nearest medical treatment facility.
  - a) Explain the circumstances of the dive incident to the evacuation teams, medics and physicians.
  - b) 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 and the AAUS (Section 2.70 Required Incident Reporting).

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

## **Available Procedures**

Emergency care:

Recompression:

Evacuation:

## **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



## **DIVE COMPUTER GUIDELINES**

1. Only those makes and models of dive computers specifically approved by the Diving Control Board may be used.
2. Any diver desiring the approval to use a dive computer as a means of determining decompression status must apply to the Diving Control Board, complete an appropriate practical training session and pass a written examination.
  - a) Each diver relying on a dive computer to plan dives and indicate or determine decompression status must have his/her own unit.
  - b) On any given dive, both divers in the buddy pair must follow the most conservative dive computer.
5. If the dive computer fails at any time during the dive, the dive must be terminated and appropriate surfacing procedures should be initiated immediately.
6. A diver should not dive for 18 hours before activating a dive computer to use it to control their diving.
7. Once the dive computer is in use, it must not be switched off until it indicates complete out gassing has occurred or 18 hours have elapsed, whichever comes-first.
8. When using a dive computer, non emergency ascents are to be at a rate specified for the make and model of dive computer being used.
10. Whenever practical, divers using a dive computer should make a stop between 10 and 30 feet for 5 minutes, especially for dives below 60 fsw.
11. Multiple deep dives require special consideration.

## **AAUS STATISTICS COLLECTION CRITERIA AND DEFINITIONS**

### **COLLECTION CRITERIA:**

The "Dive Time in Minutes", The Number of Dives Logged", and the "Number of Divers Logging Dives" will be collected for the following categories.

- a) Dive Classification
- b) Breathing Gas
- c) Diving Mode
- d) Decompression Planning and Calculation Method
- e) Depth Ranges
- f) Specialized Environments
- g) Incident Types

Dive Time in Minutes is defined as the surface to surface time including any safety or required decompression stops.

A Dive is defined as a descent into water, an underwater diving activity utilizing compressed gas, an ascent/return to the surface, and a surface interval of greater than 10 minutes.

Dives will not be differentiated as open water or confined water dives. But open water and confined water dives will be logged and submitted for AAUS statistics classified as either scientific or training/proficiency.

A "Diver Logging a Dive" is defined as a person who is diving under the auspices of the University of Michigan. Dives logged by divers from another AAUS Organization will be reported with the diver's home organization. Only a diver who has actually logged a dive during the reporting period is counted under this category.

Incident(s) occurring during the collection cycle. Only incidents occurring during, or resulting from, a dive where the diver is breathing a compressed gas will be submitted to AAUS.

### **DEFINITIONS:**

#### Dive Classification:

Scientific Dives: Dives that meet the scientific diving exemption as defined in 29 CFR 1910.402.

Diving tasks traditionally associated with a specific scientific discipline are considered a scientific dive. Construction and trouble-shooting tasks traditionally associated with commercial diving are not considered a scientific dive.

Training and Proficiency Dives: Dives performed as part of a scientific diver training program, or dives performed in maintenance of a scientific diving certification/authorization.

#### Breathing Gas:

Air: Dives where the bottom gas used for the dive is air.

Nitrox: Dives where the bottom gas used for the dive is a combination of nitrogen and oxygen other than air.

Mixed Gas: Dives where the bottom gas used for the dive is a combination of oxygen, nitrogen, and helium (or other "exotic" gas), or any other breathing gas combination not classified as air or nitrox.

#### Diving Mode:

Open Circuit Scuba: Dives where the breathing gas is inhaled from a self contained underwater breathing apparatus and all of the exhaled gas leaves the breathing loop.

Surface Supplied: Dives where the breathing gas is supplied from the surface by means of a pressurized umbilical hose. The umbilical generally consists of a gas supply hose, strength member, pneumofathometer hose, and communication line. The umbilical supplies a helmet or full- face mask. The diver may rely on the tender at the surface to keep up with the divers' depth, time and diving profile.

Hookah: While similar to Surface Supplied in that the breathing gas is supplied from the surface by means of a

pressurized hose, the supply hose does not require a strength member, pneumofathometer hose, or communication line. Hookah equipment may be as simple as a long hose attached to a standard scuba cylinder supplying a standard scuba second stage. The diver is responsible for the monitoring his/her own depth, time, and diving profile.

Rebreathers: Dives where the breathing gas is repeatedly recycled in the breathing loop. The breathing loop may be fully closed or semi-closed. Note: A rebreather dive ending in an open circuit bailout is still logged as a rebreather dive.

#### Decompression Planning and Calculation Method:

Dive Tables

Dive Computer

PC Based Decompression Software

#### Depth Ranges:

Depth ranges for sorting logged dives are 0-30, 31-60, 61-100, 101-130, 131-150, 151-190, and 191->. Depths are in feet seawater. A dive is logged to the maximum depth reached during the dive.

Note: Only "The Number of Dives Logged" and "The Number of Divers Logging Dives" will be collected for this category.

#### Specialized Environments:

Required Decompression: Any dive where the diver exceeds the no-decompression limit of the decompression planning method being employed.

Overhead Environments: Any dive where the diver does not have direct access to the surface due to a physical obstruction.

Blue Water Diving: Open water diving where the bottom is generally greater than 200 feet deep and requiring the use of multiple-tethered diving techniques.

Ice and Polar Diving: Any dive conducted under ice or in polar conditions. Note: An Ice Dive would also be classified as an Overhead Environment dive.

Saturation Diving: Excursion dives conducted as part of a saturation mission are to be logged by "classification", "mode", "gas", etc. The "surface" for these excursions is defined as leaving and surfacing within the Habitat. Time spent within the Habitat or chamber shall not be logged by AAUS.

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. (Not a swimming pool)

#### Incident Types:

Hyperbaric: Decompression Sickness, AGE, or other barotraumas requiring recompression therapy.

Barotrauma: Barotrauma requiring medical attention from a physician or medical facility, but not requiring recompression therapy.

Injury: Any non-barotrauma injury occurring during a dive that requires medical attention from a physician or medical facility.

Illness: Any illness requiring medical attention that can be attributed to diving.

Near Drowning/ Hypoxia: An incident where a person asphyxiates to the minimum point of unconsciousness during a dive involving a compressed gas. But the person recovers.

Hyperoxic/Oxygen Toxicity: An incident that can be attributed to the diver being exposed to too high a partial pressure of oxygen.

Hypercapnea: An incident that can be attributed to the diver being exposed to an excess of carbon dioxide.

Fatality: Any death accruing during a dive or resulting from the diving exposure.

Other: An incident that does not fit one of the listed incident types

Incident Classification Rating Scale:

Minor: Injuries that the OM considers being minor in nature. Examples of this classification of incident would include, but not be limited to:

Mask squeeze that produced discoloration of the eyes.

Lacerations requiring medical attention but not involving moderate or severe bleeding.

Other injuries that would not be expected to produce long term adverse effects on the diver's health or diving status.

Moderate: Injuries that the OM considers being moderate in nature. Examples of this classification would include, but not be limited to:

DCS symptoms that resolved with the administration of oxygen, hyperbaric treatment given as a precaution.

DCS symptoms resolved with the first hyperbaric treatment.

Broken bones.

Tom ligaments or cartilage.

Concussion.

Ear barotrauma requiring surgical repair.

Serious: Injuries that the OM considers being serious in nature. Examples of this classification would include, but not be limited to:

Arterial Gas Embolism.

DCS symptoms requiring multiple hyperbaric treatment.

Near drowning.

Oxygen Toxicity.

Hypercapnea.

Spinal injuries.

Heart attack.

## **University of Michigan Appendices**

**These are individually available from the DSO as PDF files**

**Spreadsheets are available as Excel or Open Office Executables**

## **List of University of Michigan Appendices**

**The appendices are not page numbered so individual forms can be directly copied**

These Forms are Copy-Ready

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## **CHECKLIST FOR SCUBA DIVING AUTHORIZATION**

NAME \_\_\_\_\_ ID No. \_\_\_\_\_

### **Obtain Prior to Skill/Knowledge Interview with the Diving Safety Coordinator**

- ☐ Application for Diving
- ☐ Personal Diving Information
- ☐ Copy of Basic & Highest Scuba Certification Cards
- ☐ Copy of Current CPR Certification
- ☐ Copy of Current ARC Standard First Aid (or Equivalent)
- ☐ Copy of Current DAN O<sub>2</sub> Provider Certification
- ☐ Copy of University of Michigan Medical Authorization to Scuba Dive
- ☐ Copy of Logbook for Review
- ☐ Record of Regulator Inspection (if using personal regulator)
- ☐ Record of Cylinder Inspection (if using personal cylinder)

### **After Skill/Knowledge Interview with the Diving Safety Coordinator**

**Date of Interview** \_\_\_\_\_

- ☐ Signed Acknowledgment of Risk
- ☐ Signed Statement of Understanding
- ☐ Pool Skill Evaluation (if required by Diving Safety Coordinator)
- ☐ Open Water Skill Evaluation (if required by Diving Safety Coordinator)
- ☐ Diving Theory Written Examination (if required by Diving Safety Coordinator)

Additional Information:

Date Completed \_\_\_\_\_

## APPLICATION FOR UNIVERSITY DIVER AUTHORIZATION

### PERSONAL INFORMATION

(Please Print)

<b>NAME</b> (LAST, FIRST, MIDDLE)				<b>DATE</b>	
<b>SOCIAL SECURITY NO or MI Driver's License.</b>			<b>DATE OF BIRTH</b>		<b>AGE</b>
<b>UM EMPLOYEE:</b>  <input type="checkbox"/> Full Time <input type="checkbox"/> Part Time <input type="checkbox"/> Faculty <input type="checkbox"/> Staff		<b>STUDENT:</b>  <input type="checkbox"/> Graduate <input type="checkbox"/> Undergraduate		<b>OTHER:</b>  <input type="checkbox"/> Visiting Scientist <input type="checkbox"/> Volunteer Diver <input type="checkbox"/> Other (Specify)	
<b>EMPLOYMENT UNIT</b>			<b>SUPERVISOR</b>		<b>SUPERVISOR TELEPHONE No.</b>
<b>HOME ADDRESS:</b> NUMBER, STREET, APARTMENT No.					
<b>CITY, STATE, ZIP CODE</b>				<b>HOME TELEPHONE</b>	
<b>CAMPUS OFFICE</b> (ADDRESS INCLUDING CAMPUS ZIP CODE)				<b>OFFICE TELEPHONE</b>	
<b>STUDENT CAMPUS ADDRESS</b> (NUMBER, STREET, CITY, ZIP CODE)				<b>CAMPUS TELEPHONE</b>	
<b>COLLEGE/SCHOOL/DEPARTMENT</b>				<b>MAJOR</b>	
<b>SCHOOL YEAR</b>	<b>GRADUATION EXPECTED</b>	<b>GRADUATE ADVISOR</b> (IF DIVING TO BE USED IN GRADUATE STUDIES)			
<b>PERSONAL CHARACTERISTICS</b>		Height	Weight	Color of Eyes	Color of Hair
<b>PERSON TO NOTIFY IN CASE OF ACCIDENT</b> (MUST BE RELATIVE OR LEGAL GUARDIAN)				<b>RELATIONSHIP</b>	
<b>ADDRESS</b>				<b>TELEPHONE</b> (AREA CODE/NUMBER):	

### TRAINING & CERTIFICATION

TYPE OF TRAINING/CERTIFICATION	DATE	LOCATION/INSTRUCTOR



## PERSONAL DIVING SUMMARY

<b>NAME</b>			<b>SOCIAL SECURITY NO. or MI Driver's License</b>		
<b>HAVE YOU HAD A UNIVERSITY OF MICHIGAN DIVING MEDICAL EXAMINATION? (YES/NO)?</b>					
<b>DATE (MOST RECENT MEDICAL EXAM)</b>		<b>LOCATION OF EXAMINATION</b>		<b>PHYSICIAN</b>	
<b>DIVER TRAINING &amp; EXPERIENCE</b>					
<b>COURSE</b>	<b>DATE CERTIFIED</b>	<b>LOCATION</b>	<b>INSTRUCTOR</b>	<b>AGENCY</b>	<b>VERIFICATION (OFFICIAL USE ONLY)</b>
Open Water Scuba Diver					
Advanced Open Water Scuba Diver					
ARC First Aid Or Equivalent					
ARC CPR Or Equivalent					
ARC Life Saving/Water Safety					
DAN Oxygen Provider					
Rescue Diver					
Specialty Diver					
Night					
Deep					
Navigation					
Boat Diving					
Other Specialty Training (List)					
Divemaster					
Assistant Instructor					
Instructor					

**DIVING EXPERIENCE: NUMBER OF DIVES**

	<b>DEPTH: 0-30 FT</b>	<b>DEPTH: 31 TO 60 FT.</b>	<b>DEPTH: 61 TO 100 FT.</b>	<b>DEPTH: &gt;100 FT.</b>	<b>TROPICAL OCEAN</b>	<b>NON- TROPICAL OCEAN</b>	<b>FRESH WATER</b>
Since Training							
Past 5 Years							
Past 12 Months							

Can you provide logbook documentation of diving experience? (Yes/No)

**PERSONAL DIVING EQUIPMENT**

<b>ITEM</b>	<b>DATE OF MOST RECENT PROFESSIONAL MAINTENANCE</b>	<b>PROOF OF MAINTENANCE</b>	<b>VERIFICATION (FOR OFFICIAL USE ONLY)</b>
Regulator			
Buoyancy Control Device			
Cylinders			
Dive Computer			

**GENERAL INFORMATION**

	<b>YES</b>	<b>NO</b>	<b>COMMENT</b>
What dive table do you plan to use? PADI Recreational Dive Planner, NAUI, SSI. or Other (Please Specify Under Comments)			
Do you feel that you are prepared to complete a test on the use of your dive table at this time?			
Do you plan to use a dive computer? If so, give make and model (Please Specify Under Comments).			
Did your training course (s) include specific instruction in recognition of and first aid for arterial gas embolism and decompression sickness?			
Do you feel that you are prepared to complete an essay test on first aid for common pressure-related diver injuries at this time?			
Are you willing to complete a review of basic diving skills in confined water prior to being granted a diver authorization?			

**ADDITIONAL INFORMATION:**



**UNIVERSITY OF MICHIGAN AUTHORIZED DIVER  
RELEASE AND ACKNOWLEDGEMENT OF RISK**

I openly and willfully acknowledge that I am well aware and thoroughly informed of the inherent hazards and risks associated with underwater diving, related surface support activities, and pressurization in a hyperbaric chamber. I am aware that I could sustain serious and life-threatening injuries as a result of participating in underwater diving and related surface swimming and pressurization in a hyperbaric chamber including, but not necessarily limited to, temporary or permanent partial or complete paralysis, sexual dysfunction, short term or lifelong disability, near drowning, drowning, or death from some other diving-related cause. Further, I am aware that injuries can occur that require treatment in a hyperbaric chamber. I further understand that diving activities, which are a necessary part of my diving training or employment-related diving, may be conducted at sites that are remote, either by time or distance or both, from hyperbaric chambers and competent medical assistance, and nonetheless I agree to proceed with diving and related training activities.

I hereby personally assume all risk in connection with underwater diving, associated surface swimming, pressurization in a hyperbaric chamber, and related medical intervention for any harm, injury, or death that may befall me as a result of participation in such activities or associated activities, whether foreseen or unforeseen. Further, I elect to participate in underwater diving and associated activities in spite of the possible absence of a hyperbaric chamber or competent medical assistance in proximity of the dive site.

I acknowledge that I have informed my family and loved ones (including my spouse or partner, as appropriate) of the risks associated with diving and the potential consequences of injury from diving including, but not necessarily limited to, short term or lifelong disability, loss of sexual partnership, and death.

By executing this document, I acknowledge and agree that I release the Diving Control Board, the Diving Safety Coordinator, the University designated instructors, and the Regents of the University of Michigan, a Michigan constitutional corporation, from any and all claims arising from or related to my underwater diving and associated surface swimming, diver support activities, pressurization in a hyperbaric chamber, and related medical assistance that may result in injury, damage, or death to me or my family, heirs, estate, or assigns; that I waive on my behalf and on behalf of my family, heirs, estate, or assigns any and all claims of any nature whatsoever against the aforementioned individuals and entities related in any way to my diving; that in consideration for being allowed to participate in diving activities, I hereby personally assume all risks in conjunction with such activities for any and all injuries, damage, or death that may befall me while I am participating in such activities, including all risk connected therewith, whether foreseen or unforeseen; and further that I save and hold harmless the aforementioned individuals and entities from any and all claims by me and my family, estate, heirs, or assigns, arising out of my participation in underwater diving, associated surface swimming, diver support activities, pressurization in a hyperbaric chamber, and related medical assistance. The release in this paragraph applies to any and all diving related claims, known and unknown, contingent and otherwise, except to the extent claims arise from the gross negligence or willful misconduct of others.

Further, I am aware that I have the right to refuse to dive if, in my opinion, the conditions are unfavorable or unsafe for diving; I am experiencing physical or emotional problems that may be a contraindication to safe participation in diving; the diving equipment, task requirements, or environmental conditions exceed my level of training or experience; or participating in a dive would violate the dictates of proper diving safety procedures.

I further state that I am of lawful age and legally competent to sign this affirmation and release; that I understand the terms herein are contractual and not a mere recital; and that I have signed this document of my own free act.

It is my intention in signing this instrument to fully exempt and release the Diving Control Board, the Diving Safety Coordinator, University designated instructors, and the Regents of the University of Michigan from any and all liability for personal injury, property damage, or wrongful death in connection with my diving activities except to the extent arising from the gross negligence or willful misconduct of others.

***I have fully informed myself of the contents of this affirmation and release by reading it before I signed it.***

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Witness Signature

Date

Employee/Student Signature

Date



## UNIVERSITY OF MICHIGAN AUTHORIZED DIVER STATEMENT OF UNDERSTANDING

As an employee or student of the University of Michigan engaging in diving and/or hyperbaric chamber activities under the auspices of the University, I agree to abide by the standards and regulations established by the Diving Control Board and the Diving Safety Coordinator. I understand that these standards and regulations are necessary to meet the requirements specified by the State of Michigan and University Ocean Laboratory System as well as the American Academy of Underwater Sciences. *I further understand that my diving privileges may be restricted, suspended, or revoked for failure to comply with the established standards and regulations of the University or for conduct that is considered unsafe by my supervisor, the Diving Safety Coordinator, Diving Control Board, or other authorized divers and support personnel.*

**I understand that it is my personal responsibility to maintain myself in good physical condition and at a high level of diving proficiency. Accordingly, I agree to:**

- Abide by the standards and regulations for diving as designated by the Diving Control Board and published in the *University of Michigan Occupational Safety and Health Standard for Scientific Diving Operations*.
- Submit to *annual medical examination* for divers as prescribed by Act No. 154 of the Public Acts of 1974 as amended (Occupational Health Standard).
- Attend periodic evaluation, training, and update workshops as specified by the Diving Control Board for purposes of demonstrating, maintaining, and upgrading my diving proficiency and knowledge.
- Comply with the annual re-qualification requirements as designated by the Diving Control Board and published in the *University of Michigan Occupational Safety and Health Standard for Scientific Diving Operations*.
- Maintain diving activity and equipment records as required by the University and State of Michigan.
- Submit an annual record of diving to the Diving Safety Coordinator.

**I understand that I have the right, indeed the responsibility, to refuse to dive if, in my judgment:**

- Conditions are unfavorable or unsafe for diving.
- I am experiencing physical or emotional problems that may be a contraindication to safe participation in diving.
- The diving equipment, task requirements, or environmental conditions exceed my University authorization, training, experience, or personal limitations.
- Participation in the dive would violate the dictates of proper diving safety procedures or the University's standards or regulations.

I understand that in accepting University diver authorization I am incurring obligations for safety, training, record keeping, and adherence to specific standards and regulations as well as the inherent risks associated with diving, swimming, and hyperbaric chamber activities and a potential lack of competent medical assistance at the remote locations where dives may occur. I willingly accept these risks and responsibilities for my actions as a diver or diving support person. I understand the Diving Safety Coordinator and the Diving Control Board will make the final judgment as to my competency to be awarded a University of Michigan Diver Authorization and I agree to abide by their decision.

By signing this form, I attest that I am of good physical condition to dive and that I will comply with all responsibilities and obligations stated and referenced above as long as I dive through the auspices of the University of Michigan.

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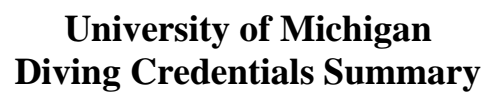
Witness Signature

Date

Employee/Student Signature

Date

[illegible]





**University of Michigan  
ANNUAL DIVING ACTIVITY REPORT**

**Name:**

**Year :**

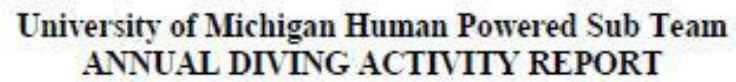
Depth Range (feet)	Scientific	Training	Personal	Total Dives	Freshwater	Ocean	Dry Suit	EANx	Mixed Gas	Overhead	Full-Face Mask	Deco (Tables)	Deco (Computer)	Deco (PC Based)
<30														
31-60														
61-100														
101-130														
131-160														
161-190														
>190														
<b>Totals</b>														
<b>% Dives</b>														



**Instructions:**

Enter your dive totals for each Depth / Category (no need to enter 0)  
 The spread sheet will calculate your total dives (Sum of Scientific, Training & Personal)  
 The spreadsheet will also display the percentage of total for each category

The other categories are for statistical reporting to the AAUS



Year :




A small, blue and yellow biplane is displayed in a museum. The aircraft is mounted on a metal stand and is positioned in front of a brick wall. The biplane has a blue fuselage and yellow wings. The number '1' is visible on the side of the fuselage. The aircraft is a single-engine, open-cockpit model.



**I am Certified ... Why Not Authorized?**  
**This is an overview of the Authorization Process**

**"I am Certified"**

By  
Larry "Harris" Taylor, Ph.D.  
Diving Safety Coordinator  
University of Michigan

divegeek@earthlink.net  
lpt@umich.edu

**"Why Not Authorized"**

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**Your Instructor**

U of MI Diving Safety Coordinator  
AAUS sanctioned Diving Safety Officer  
Internationally rated 3 - star instructor (CMAS)  
National Master Scuba Instructor (President's Council)  
> 100 Diving Certifications  
> 100 Diving Publications  
> 1,200,000 visitors to "Diving Myths & Realities" web site  
Library: one of the best resources in North America  
Scuba Diver since 1977  
Scuba Instructor since 1980  
DAN Instructor since 1991  
EAN, Instructor since 1992  
Ph.D. Biochemistry

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**"Scientific Diving" is NOT about Diving**

*"Scientific diving is diving performed solely as a necessary part of a scientific, research, or educational activity by employees whose sole purpose for diving is to perform scientific research tasks."*



**It is about Data Collection**

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Since diving is just a mode of transportation,  
Skill level must exceed recreational training



'cause diver  
needs to focus  
on the mission/science



In-water skills/comfort must be a given

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**We are land-walking,  
Air-breathing critters**

**We do NOT breathe water**



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**Primitive Brain:  
Beyond Conscious Control  
Responsible For "Survival"**



**When Threat "Perceived"  
(As Opposed To Actual)  
Initiates  
"Fight or Flight!"**



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**Primitive Brain Notes:**

Cannot Breathe  
Vision Blurred  
Water Dense  
Speech Difficult  
Water Chills  
Equipment Heavy

So,  
Descent Alerts Defenses

"Escape to surface"  
(Can be fatal)



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Scuba Training  
SHOULD BE  
"Behavioral Modification"  
To Convince "Primitive Brain"  
That It Can Not Only Survive,  
But Enjoy The Underwater World

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**My Training "Quantum Point"**



Point when student emerges with a "Cheshire Cat" grin

Tells me the student:

Is comfortable in the water

"Primitive Brain" beginning to accept being underwater  
Wants to repeat the experience



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## Conditioning Takes Time!



**“Quantum Point”**

**NEVER  
LESS THAN**



***16 hours pool time  
100 minutes open water***

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## Adaptation



**The shorter the training,  
The further from desired behavior,  
The less likely to adapt  
And  
The more likely to drop-out**

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## It's What You Don't Know That Hurts You!



**“The It Won't Happen to me Syndrome”  
Somers (1976), U of MI**

**Divers not being informed of risks  
Morgan (1995), WI Sea Grant (NSF)**

**“incompetent people cannot recognize just how  
incompetent they are,” (Dunning-& Kruger, 1999)**

**>90 % of people can't cope with emergencies  
(Leach, 2007)**

**Inability to control buoyancy now a factor in European scuba deaths  
(BSAC, 2007)**

**Many accidents result from degradation of training standards  
(Gilliam, 2010)**

**Many (>40%) dive fatalities are novice (<1 yr) divers  
(DAN, 2010 - 2013)**



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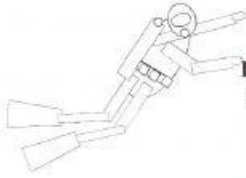
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### Today's Diver Often:



Drop-Out Rate  
Estimated at > 95 %

Non-knowledgeable  
Poor Fitness  
Over-weighted  
Inadequate Buoyancy Skills  
Oriented Towards Surface  
Bicycle Kick  
Fins Too Stiff  
Covered With Dangles  
Excessive Hand Movements

Not Self-Reliant:  
Relies on Equipment

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### Recreational Training Necessary, But Not Sufficient



### For "Mission-Oriented" Diving



Poorly trained diver:  
Safety risk to self & others  
Liability to project

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### C-Cards Are Not Reliable Skill Indicators

#### Advanced Diver



C-Cards sold  
Animals Certified  
Given As Rewards  
"Battle Royale"  
28 Days to Become Instructor  
Specialty Newbie Today;  
Instructor Tomorrow

Agencies start by selling instructor cards through the mail  
Some specialty instructor authorizations require only fee payment

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**Given that C-Cards Are Not Reliable Skill Indicators:  
Scientific Diver Authorization Requires:**

Documentation of training (c-cards)  
Documentation of experience (log book)  
Documentation of knowledge (exams)



**In-water evaluation for everyone by qualified DSO  
(regardless of c-card level /experience)**



**The Lesson of History:  
This process has created  
one of the Planet's Best Safety Records!**

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AMERICAN ACADEMY OF  
UNDERWATER SCIENCES

**Began As Means to Federal Exemption  
Sets Standards For Academic Diving  
One of World's Best Safety Records  
Reference Resource  
Reciprocity**



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AMERICAN ACADEMY OF  
UNDERWATER SCIENCES

**Reciprocity**

**Allows diving at other institutions  
Allows diving on NOAA vessels**

**In Jeopardy:  
NOAA deaths  
US Coast Guard deaths  
Increased academic Incidents**



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AMERICAN ACADEMY OF  
UNDERWATER SCIENCES

**Standards For Academic Diving**

Historically, based on 15 weeks (semester):

30 hours lecture (basic diver)

30 hours lecture (in-water scientific techniques)

30 hours pool

Plus: First Aid, CPR, DAN O<sub>2</sub> & Hazmat

First Open Water Weekend: 5 dives (250 + minutes)

Additional water training:

rescue, navigation, night, deep, EANx, etc

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ROBERTS & CREASENS  
OCCUPATIONAL SAFETY & ENVIRONMENTAL HEALTH  
UNIVERSITY OF MICHIGAN

**Michigan Diving Authorization**

**Purpose:**

Ensure Health & Safety of Divers

Provide Liability Protection For PI's

Provide Liability Protection For University

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**Michigan Diving Authorization Requirements:**



1. Certified Diver
2. Current ARC/AH Adult CPR
3. Current ARC Standard First Aid
4. Current DAN O<sub>2</sub> (OSEH provides)
5. University Physical Exam
6. Complete Application / Legal Forms  
(Interview with DSO)
7. In-water evaluation by university DSO

Valid as long as  
all certifications are current

12 dives per year

Expires: Any lapse



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### Authorization Checklist

Obtain Prior to Skill Knowledge Instruction with the Diving Safety Coordinator

- ☐ Application for Diving
- ☐ Personal Diving Information
- ☐ Copy of Basic or Higher Scuba Certification Card
- ☐ Copy of Current CPR Certification
- ☐ Copy of Current ALC Student First Aid or Equivalent
- ☐ Copy of Current OAS 9, Airway Certification
- ☐ Copy of University of Michigan Medical Authorization Scuba Dive
- ☐ Copy of Logbook Review
- ☐ Record of Respirator Inspection (if using personal regulator)
- ☐ Record of Cylinder Inspection (if using personal cylinder)

After Skill Knowledge Instruction with the Diving Safety Coordinator

Days of Instruction \_\_\_\_\_

- ☐ Signed Acknowledgment of Risk
- ☐ Signed Statement of Understanding
- ☐ Pool Skill Evaluation (if required by Diving Safety Coordinator)
- ☐ Open Water Skill Evaluation (if required by Diving Safety Coordinator)
- ☐ Diving Theory Written Examination (if required by Diving Safety Coordinator)

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### Michigan Diving Authorization Types:

**Restricted**  
**Open-Water**  
 60 fsw  
 90 fsw  
 120 fsw

Specialties: night, dry suit, EANx, full-face mask, etc.  
(Involve dive with DSO)

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### Bottom-line for Authorization/Certification:

#### The "Loved-One Rule"

**Would I Allow/Certify This Person**  
**To Dive With The Person I Love the Most?**

Was once basis for all scuba certifications




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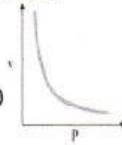
### Michigan Sub-team Diving Authorization

So, what's the big deal?

Operating in shallow water

Maximum gas expansion (volume / depth)

Maximum area of barotrauma risk



Intense aerobic activity

Most common cause of shallow-water lung injury:

Forced inhalation with poorly performing regulator

Student Divers = Highest Risk Student Activity

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### Michigan Diving Authorization

Has been recognized world-wide

As the among the "leaders and best"

Behavior other than the "best"

Raises eyebrows

Increases surveillance

Impacts entire scientific diving community

Recreational deaths at Gilboa focus local attention

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### It's OK TO DIVE" ?????



Off-campus authorizations protect THEM, not you!

Diving without umich authorization:

Removes you from umich liability blanket

(You, not umich, pay legal costs & judgments)

Wayne County (Detroit)

Largest awarding jury in the nation



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## **Additional Notes**