ENVIRONMENTAL HEALTH & SAFETY

UNIVERSITY *of* WASHINGTON

DIVING SAFETY MANUAL

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University of Washington

Environmental Health and Safety

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PREFACE

Scientific divers face some of the most challenging occupational hazards encountered in a University setting. Recognizing the need to assure the safety of University divers, in 1972 the University of Washington's Board of Regents adopted a diving safety policy. Since that time, the University's Environmental Health and Safety Department has implemented a Diving Safety Program to oversee the safety of scientific diving and a Diving Control Board has been established to oversee the diving safety program and develop the Diving Safety Manual.

I want to recognize the extensive efforts of the members of the Diving Control Board, the University's Diving Safety Officer and Diving Officer's in the development of 202 edition of the Diving Safety Manual. With their careful work detailed research, this Manual provides important updates and the latest scientifically based, feasible and effective requirements, practices and procedures necessary for safely conducting scientific diving.

This Diving Safety Manual applies specifically to scientific diving conducted under the auspices of the University of Washington. Additionally, it incorporates the standards of the American Academy of Underwater Sciences, which form the regulatory basis for occupational safety applied to scientific diving in lieu of the State of Washington Administrative Code. In so doing, it fosters reciprocity of diver training and certification between research institutions and government agencies. All other types of diving must adhere to the State of Washington standards for commercial diving operations, Chapter 296-37, Washington Administrative Code.

To those of you using this manual, I thank you for doing your part to protect yourself and your colleagues as you conduct safe diving operations in pursuit of new knowledge.

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SECTION 1 – GENERAL POLICY

On January 21, 1972, the University's Board of Regents adopted the following policy:
The University of Washington shall maintain a diving safety program that will ensure all diving under its auspices is conducted in a manner designed to minimize accidental injury or occupational illness, and to conform to applicable rules and regulations of the Washington State Department of Labor and Industries. The President is directed to prepare, with the assistance of the Environmental Health and Safety (EH&S) Department, a guide, which shall set forth policies, responsibilities, organization, regulation, and procedures for safety in diving operations. No person shall dive under the auspices of the University of Washington without being authorized to do so by the University Diving Safety Officer (DSO).

1.1 SCIENTIFIC DIVING STANDARDS

Purpose

The University of Washington maintains a Diving Safety Manual that sets policy and provides general and specific regulations for all research diving and training. This manual also covers equipment and locations (whether University owned or not) that are diving or support related and have a direct effect on the safety of any diving operation conducted under University auspices. Examples include but are not limited to the supply of breathing air, materials, equipment, or supplies required by these regulations and the maintenance of diving equipment. Copies of this manual must be available to all personnel covered by its scope including each dive team member.

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 standards for training and certification, which will allow a working reciprocity between organizational members in AAUS. Fulfillment of these purposes shall be consistent with the furtherance of research and safety. A copy of this manual must be present at all dive locations.

The American Academy of Underwater Sciences (AAUS) is an organization comprised of representatives from university, private, and governmental scientific diving programs. This organization determines minimum standards for the establishment of AAUS-recognized scientific diving programs, organizational and individual membership, procedures for safety in scientific diving operations, and a framework for reciprocity between member organizations.

In 1982, Occupational Health and Safety Administration (OSHA) exempted scientific diving from commercial diving regulations (29 CFR Part 1910, Subpart T) 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.

The University shall maintain organizational membership in and active communications with the AAUS. It is the University of Washington's responsibility to adhere to the AAUS Standards for Scientific Diving Certification and Operation of Scientific Diving Programs. The administration of the local diving program will reside with the University of Washington's Diving Control Board (DCB).

An annual report and summary of diving activities shall be prepared and submitted to the AAUS.

A scientific diver currently certified under the auspices of one member organization in good standing shall also be recognized as such by any other member organization and will operate under the standard operating procedures of the host organization.

In the event the University ceases to be as an organizational member, a summary of organizational diving activity of the past five (5) years shall be submitted to the AAUS.

Scientific Diving Definition

Scientific diving is defined (29 CFR 1910.402) 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 guidelines (Appendix B to Subpart T):

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

Exceptions to this Manual

This manual does not cover any diving operation:

1. Performed solely for recreational purposes. Recreational dives may not in any way support the diver's occupation, academic instruction/training, or research.
2. Performed solely for search and rescue, or related public safety purposes by or under the control of a governmental agency.
3. Performed as a commercial diving operation under contract to the University. Such contracts shall provide for the requirements of the appropriate state or federal regulatory authority.
4. Governed by 45 CFR Part 46, (Protection of Human Subjects, U.S. Department of Health and Human Services) or equivalent rules or regulations established by another federal agency, which regulate research, development, or related purposes involving human subjects.

1.2 OPERATIONAL CONTROL

Deans, Directors, and administrative persons are responsible for ensuring that their faculty, staff, and students who are involved in diving operations are aware of the contents of this Manual and conform to these regulations. (University of Washington Handbook, Vol.IV-59)

University of Washington Auspices Defined

For the purposes of these standards the auspices of the University of Washington include any scientific diving operation in which the University of Washington is 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 University of Washington or employees of auxiliary organizations, in which such employees are acting within the scope of their employment, and the operations of other persons who are engaged in scientific diving for the University of Washington or are diving as members of an organization recognized by the University of Washington.

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

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

University of Washington Scientific Diving Standards and Safety Manual

The DCB and the EH&S department shall publish and maintain a scientific diving safety manual that establishes requirements for scientific diving in compliance with the AAUS scientific diving standards, which are used as minimum guidelines for the development of this manual. These scientific diving standards shall include, but not be limited to:

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

The Diving Safety Officer (DSO)

The DSO serves as a voting member of the DCB, and should be designated one of the OM Representatives to AAUS. This person should have broad technical and scientific expertise in research related diving.

1. Must be appointed by the responsible administrative officer or designee, with the advice and counsel of the DCB.
2. Must attend an AAUS DSO Orientation within one year of accepting a position at an AAUS-approved OM, unless they have served as a DSO for another current AAUS OM within the last year.
3. Must qualify as a full voting member of AAUS as defined by AAUS bylaws:
    a. Holds a diving certification from a recognized national certifying agency or equivalent, and,
    b. Has engaged in sustained or successive scientific diving activities during the past two years, or,
    c. Has completed a course in scientific diving that meets the requirements as specified by the most current edition of the AAUS Standards for Scientific Diving."

4. Must be an active SCUBA instructor from an internationally recognized certifying agency.
5. Answers, through the DCB, to the responsible administrative officer or designee, for the conduct of the University of Washington's scientific diving program. The routine operational authority for this program, including oversight of training and authorizations, approval of dive plans, maintenance of diving records, and ensuring compliance with this manual and all relevant regulations of University of Washington, rests with the DSO.
6. May permit portions of this program to be carried out by a qualified delegate, with the approval of the DCB, although the DSO may not delegate responsibility for the safe conduct of the scientific diving program.
7. Must be guided in the performance of the required duties by the advice of the DCB, but operational responsibility for the conduct of the scientific diving program will be retained by the DSO.
8. Must suspend diving operations determined to be unsafe or unwise.
9. Evaluate and survey equipment and equipment maintenance programs.
10. Establish/approve and survey training programs through which the applicants for certification can satisfy the requirements of the Diving Safety Manual.
11. Investigate and coordinate for the DCB reviews of injuries or dangerous incidents arising from University diving. In particular, \ ensure the prompt, detailed investigation and reporting of diving fatalities involving University personnel.
12. Prepare recommendations for consideration by the DCB, such as changes in policy, procedures, regulations, training programs, equipment acceptance, etc
13. Issue or revoke diving certificates.
14. Ensure that any university compressors used for filling diving cylinders meet air quality standards as described in this manual.

The Diving Control Board (DCB)

Because of the potential hazards to health that accompany scientific, research, or educational diving, and in support of State and Federal regulations, the Executive Director for Health Sciences Administration (HSA) has appointed a University of Washington DCB with the following responsibilities:

1. The DCB must consist of a majority of active scientific divers. At least one member shall be a physician or person qualified in diving medicine. Voting members include the DSO, the responsible administrative officer or his/her designee, and other representatives of the diving program such as qualified divers and members selected by procedures established by the DCB. A Chair and a Secretary may be chosen from the membership of the board according to University of Washington procedure.
2. Meetings of the DCB shall be held at least four times each year with the interval between any two consecutive meetings not to exceed six months. The time for these meetings will be scheduled at least two weeks in advance. Additional meetings of the DCB may be called by the Chair. Any member with the endorsement of two additional members may require the Chair to call a meeting by submitting the request and endorsement(s) in writing.
3. An annual meeting or group of meetings of the DCB will be held during the first half of each calendar year to receive status reports on the program and approve the board's annual report.
4. An annual report of the DCB will be submitted by the Chair as approved by the board to the HSA Executive Director. The report may include any specific additional recommendations

requested by motion and recommendations from the Chair. The annual report shall be signed by the Chair.

5. An annual report of diving activities shall be prepared and submitted to the AAUS. At this time any recommendations for modifications of the AAUS standards shall be submitted for consideration.
6. A motion shall pass when approved by more than one-half of the members. Any business conducted electronically shall require a majority vote of the membership.
7. Request to refer action to board meeting may be made for any action that is conducted electronically or normally delegated to the DSO. Such a request should be submitted to the Chair. At the discretion of the person, the previous action may be stayed pending a meeting.
8. Minutes of meetings will be prepared and distributed to all members. The minutes shall be accepted by approval of a majority.
9. Has autonomous and absolute authority over the scientific diving program's operation.
10. Must establish additional standards, protocols, and operational procedures beyond the AAUS minimums to address the specific needs and concerns of the University of Washington.
11. Must approve and monitor diving projects.
12. Must review and revise the diving safety manual.
13. Must ensure compliance with the diving safety manual.
14. Must approve the depths to which a diver has been trained and authorized to dive.
15. Must take disciplinary action for unsafe practices.
16. Must ensure adherence to the buddy system for scuba diving.
17. Must act as the official representative of the University of Washington in matters concerning the scientific diving program.
18. Must act as a board of appeal to consider diver-related problems.
19. Must recommend the issue, reissue, or the revocation of diving authorizations.
20. Must recommend changes in policy and amendments to the AAUS and University of Washington's scientific diving manual as the need arises.
21. To advise the Executive Director, HSA and the Director, EH&S with respect to such programs and facilities as are necessary to maintain an appropriate program of diving safety at the University of Washington.
22. To be responsible to the Director, EH&S, or his/her designee, for the administration of the program.
23. Must establish and/or approve training protocols or standards through which the applicants for authorization can satisfy the requirements of the University of Washington's Diving Safety Manual.
24. Must suspend diving operations considered to be unsafe or unwise.
25. Must establish criteria for equipment selection and use.
26. Must recommend new equipment or techniques.

27. Must establish and/or approve facilities for the inspection and maintenance of diving and associated equipment.
28. Must ensure that the University of Washington's air-fill station(s) meet air quality standards as described in Sec. 3.60 of this manual.
29. Must periodically review the DSO's performance and program.
30. Must sit as a board of investigation to inquire into the nature and cause of diving incidents or violations of the University of Washington Diving Safety Manual.
31. The DCB may delegate operational oversight for portions of the program to the DSO; however, the DCB may not abdicate responsibility for the safe conduct of the dive program.

Instructional Personnel

1. Qualifications - All personnel involved in diving instruction under the auspices of the University must be reviewed and authorized by the DCB and shall be qualified for the type of instruction being given.
2. Selection - Instructional personnel will be selected by the DSO, or designee, who will solicit 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. In a situation where there are multiple dives occurring simultaneously, the Lead Diver may delegate their responsibilities to another qualified Lead Diver for individual dives. The Lead Diver shall be responsible for:

1. Coordination with other known activities in the vicinity that are likely to interfere with diving operations.
2. Ensuring all dive team members possess current authorization and are qualified for the type of diving operation.
3. Ensuring dives are conducted in accordance with Section 2.2
4. Ensuring safety and emergency equipment is in working order and at the dive site.
5. Briefing the dive team members on:
    a) Dive objectives.
    b) Unusual hazards or environmental conditions likely to affect the safety of the diving operation.
    c) Modifications to diving or emergency procedures necessitated by the specific diving operation.
6. Suspending diving operations if in their opinion conditions are not safe.
7. Reporting to the DSO and DCB any physical problems or adverse physiological effects including symptoms of pressure-related injuries.

Reciprocity and Visiting Scientific Divers

1. Two or more AAUS Organizational Members engaged jointly in diving activities, or engaged jointly in the use of diving resources, must designate one of the participating DCB's to govern the joint dive project. However, responsibility for individual divers ultimately resides with the home Organizational Member.

2. A Scientific Diver from one Organizational Member must apply for permission to dive under the auspices of another Organizational Member by submitting to the DSO of the host Organizational Member a document containing all the information described in Appendix 1 (letter of reciprocity) signed by the DSO or designee of the home DCB.
3. A Visiting Scientific Diver may be asked to demonstrate their knowledge and skills for the planned diving.
4. A diver permanently entering the UW Dive Program through a Verification of Training is required to submit a copy of their current dive physical and exam results in accordance with Section 5 of this standard.
5. If a host Organizational Member denies a visiting scientific diver permission to dive, the host DCB must notify the visiting scientific diver and their DCB with an explanation of all reasons for the denial.

Waiver of Requirements

The University's DCB may grant a waiver for specific requirements of training, examinations, depth authorizations, and minimum activity to maintain authorization. This procedure will be applied on a case by case basis and may not include medical requirements. Proof of previous or alternative training must be shown for requirements to be waived.

Consequence of Violation of Regulations by Scientific Divers

Failure to comply with the regulations of the University of Washington Diving Safety Manual may be cause for the revocation or restriction of the diver's scientific diving authorization by action of the DCB.

1.3 CONSEQUENCES OF VIOLATION OF REGULATIONS BY ORGANIZATIONAL MEMBERS

Failure to comply with the regulations of this Manual may be cause for the revocation or restriction of the University of Washington's recognition by the AAUS.

1.4 RECORD MAINTENANCE

The DSO or designee must maintain consistent records for the dive program and for each individual Scientific Diver in it. The file shall include evidence of certification level, individual dive log, dive plans (project and/or individual, records of dive (project and/or individual), diver training records, diver authorization(s), results of current physical examination, dive incident reports, reports of disciplinary actions by the University's DCB, and other pertinent information deemed necessary. All personal records shall be maintained in confidence and released only with written permission from the diver or former diver.

Availability of Records:

1. Medical records must be available to an attending physician of a diver or former diver when released in writing by the diver.
2. Records and documents required by this Manual must be retained by the University of Washington for the following period:
    a) Physician's written reports of medical examinations for dive team members - five (5) years.
    b) Manual for diving safety - current document only.

c) Records of dive – one (1) year, except five (5) years where there has been an incident of pressure-related injury or diving accident.

d) Pressure-related injury assessment – five (5) years.

e) Equipment inspection, testing, and maintenance records - current entry or tag, or until equipment is withdrawn from service. In the event of an accident all records for the equipment shall be kept for five (5) years.

f) Records of hospitalization – five (5) years.

g) Whenever a diver ceases to dive under University auspices, but continues to dive under auspices of another institution, a copy of all applicable records shall be transferred to the successor institution upon request in writing.

h) If a diver ceases to dive under University auspices and plans no further research or scientific diving activities, the EH&S department will keep the diver's training and authorization records for 5 years.

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SECTION 2– DIVING REGULATIONS FOR SCUBA (OPEN CIRCUIT, COMPRESSED AIR)

2.1 INTRODUCTION

No person shall engage in scientific diving operations under the auspices of the University of Washington scientific diving program unless they are authorized pursuant to the provisions of this Manual.

Failure to comply with the regulations in this manual may be cause for the revocation or restriction of the diver's authorization unless it was necessary to prevent or minimize a situation which is likely to cause death, serious physical harm, or major environmental damage. A written report of such actions must be submitted to the DCB explaining the circumstances and justifications for such action.

2.2 PRE-DIVE PROCEDURES

Dive Plans

Complete dive plans should be submitted to the DSO for review and approval. Dives should be planned around the competency of the least experienced diver. Before conducting any diving operations under the auspices of the University of Washington, the Lead Diver for a proposed operation must formulate a dive plan to be reviewed with all divers, and should include the followin

1. Divers qualifications and the type of certificate or authorization held by each diver.
2. Emergency plan (refer to Appendix 1) with the following information:
    a) Name, telephone number, and relationship of person to be contacted for each diver in the event of an emergency.
    b) Nearest operational recompression chamber.
    c) Nearest accessible hospital.
    d) Available means of transport.
    e) Means of communication that will be used in requesting emergency services. Refer to Section 3.4, Emergency Communications.
3. Approximate number of proposed dives.
4. Location(s) of proposed dives.
5. Estimated depth(s) and bottom time(s) anticipated.
6. Decompression status and repetitive dive plans, if required.
7. Proposed work, equipment, and boats to be employed.
8. Any hazardous conditions anticipated.
9. A first-aid kit, emergency oxygen administration kit, appropriate emergency information (Appendix 5), and emergency radio or telephone communication shall be at the dive location.
10. A set of appropriate diving tables must be available at the dive location unless dive computers are used. These tables must be at least as conservative as the U.S. Navy Diving Tables. Tables shall not be used as a backup in the event of a dive computer failure.

Pre-dive Safety Checks

1. Diver's Responsibility:

a) Each Scientific Diver shall conduct a functional check of their diving equipment in the presence of the diving buddy or tender, and review emergency hand signals and techniques.

b) It is the diver's responsibility and duty to refuse to dive if, in his/her judgment, conditions are unfavorable, or if he/she would be violating the precepts of his/her training, or this manual.

2. Equipment Evaluations:

a) Each diver shall ensure that his/her equipment is in proper working order and that the equipment is suitable for the type of diving operation.

b) Each diver shall have the capability of achieving and maintaining positive buoyancy.

c) Each diver shall be trained, qualified, and authorized for the diving mode and specialized equipment being used, the diving activity to be performed, and the depths at which the diving is to be conducted

3. Site Evaluation:

a) Divers will assess the local conditions prior to entering the water to ensure safe operations.

b) Boat Tenders are required on all vessel-based dives.

4. Pre Dive Briefing:

a) Dive Buddy assignments and tasks

b) Dive objectives.

c) Maximum depth(s) and bottom time

d) Turn around pressure and required surfacing pressure

e) Entry, exit, descent and ascent procedures, perceived environmental and operational hazards, and mitigations

f) Emergency and diver recall procedures

2.3 DIVING PROCEDURES

Solo Diving Prohibition

1. All diving conducted under the auspices of the University (Refer to Section 1.2) must be planned and executed to ensure that every diver involved maintains constant, effective communication with at least one other comparably equipped and certified scientific diver in the water. This buddy system is based upon mutual assistance, especially in the case of an emergency. Dives should be planned around the competency of the least experienced diver. If separation occurs, Divers will conduct an underwater search for one (1) minute, surface, and look for the missing diver's bubbles. When found, if the bubbles are stationary, follow them down and reunite, or assist the diver. If the bubbles are moving, follow them on the surface.

Decompression Management

1. On any given dive, both divers in the buddy pair must follow the most conservative dive profile
2. A safety stop performed during the ascent phase of the dive should be conducted on any dive

that exceeds 30fsw (9.14m).

Refusal to Dive

The decision to dive is that of the diver. The ultimate responsibility for safety rests with the individual diver. It is the diver's responsibility and duty to refuse to dive, without fear of penalty, if in his/her judgment, conditions are unsafe or unfavorable, or if he/she would be violating the precepts of regulations in this Manual.

No dive team member will be required to be exposed to hyperbaric conditions against his/her will.

No dive team member may dive for the duration of any known condition, which is likely to adversely affect the safety and health of the diver or other dive team members.

Termination of the Dive

1. It is the responsibility of the diver to terminate the dive, without fear of reprisal, whenever he/she feels it is unsafe to continue the dive, unless it compromises the safety of another diver already in the water dive (refer to Section 2.2 Pre-Dive Safety Checks).
2. A dive must be terminated while there is still sufficient cylinder pressure to permit the diver to reach the surface safely with 500 PSI remaining.
3. If engaging in a special decompression dive, this 500 PSI minimum must include decompression time, or to safely reach an additional air source at the first decompression stop with 500 PSI remaining in the diver's tank.

Emergencies and Deviations from Regulations

1. Any diver may deviate from the requirements of this Manual to the extent necessary to prevent or minimize a situation likely to cause death, serious physical harm, or major environmental damage. A written report of such actions must be submitted to the DCB explaining the circumstances and justifications within 24 hours.

2.4 POST-DIVE PROCEDURES

Post-Dive Safety Checks

1. After the completion of a dive, each diver must report any physical problems, symptoms of decompression sickness, or equipment malfunctions to the dive team leader, DSO, and/or DCB and seek appropriate medical attention. Any incidents should be reported using the UW Diving Injury/Incident Report Form (Appendix 5).
2. When diving outside the no-decompression limits, the divers should remain awake for at least one hour after diving, and in the company of a dive team member who is prepared to transport him/her to a hyperbaric chamber if necessary.

2.5 EMERGENCY PROCEDURES

1. The DCB will develop emergency procedures which follow the standards of care of the community and must include procedures for emergency care, recompression and evacuation for each dive location (Appendix 4). This information must be current and included in the Dive and Emergency Plans (Appendix 1).

2.6 FLYING AFTER DIVING OR ASCENDING TO ALTITUDE (OVER 1000 FEET/304 meters)

1. Following a Single No-Decompression Dive: Divers should have a minimum preflight surface interval of 12 hours.
2. Following Multiple Dives per Day or Multiple Days of Diving: Divers should have a minimum preflight surface interval of 18 hours.

3. Following Dives Requiring Decompression Stops: Divers should have a minimum preflight surface interval of 24 hours.
4. 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.

2.7 RECORDKEEPING REQUIREMENTS

Personal Diving Log

1. Each authorized scientific diver shall log every dive made under the auspices of the University of Washington program, and is encouraged to log all other dives. Dive logs shall be entered into the designated database.
2. Dive logs must be entered online at the UW Diving Database (divers must be an Active Scientific Diver to access this site). Reciprocity Divers must record their dives with their parent institution and send a copy to the UW. The diving log shall be submitted on a monthly basis to maintain active status and include the following:
    a) Name of diver, partner, 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-related incidents or accidents must be reported as soon as possible, but no later than 24 hours to the DSO (refer to Inside front cover and Appendix 4 for Emergency Telephone Numbers for how to contact the DSO). If the DSO cannot be reached during normal working hours, contact the most senior University of Washington EH&S staff member available. After normal working hours, notify the EH&S Staff On-Call (SOC) by calling the UW Police Department (UWPD) Dispatch at (206) 685-8973 (UWPD).

Use the standard UW Diving Incident/Injury Report Form (Appendix 5) to record the incident. Be sure to include the circumstances of the incident and the extent of any injuries or illness. Additionally, you will be required to report the accident or incident to EH&S utilizing the Online Accident Reporting System (OARS) through their website.

All information must meet the following reporting requirements:

1. The University shall record and report occupational injuries and illnesses in accordance with requirements of the appropriate Labor Code section.
2. The following information shall be recorded and retained by the DSO, with the record of the dive, for a period of five (5) years:
    a) Complete AAUS Incident Report Form .
    b) Written descriptive report to include:

c) Name, address, phone numbers of the principal parties involved.

d) Summary of experience of divers involved.

e) Location, description of dive site and description of circumstances that led up to incident, including dive data and dive plan and the extent of any injuries or illnesses.

f) Description of symptoms, including depth and time of onset.

g) Description and results of treatment.

h) Disposition of case.

i) Recommendations to avoid repetition of incident.

3. The University of Washington shall investigate and document any incident of diving-related injury and prepare a report that is to be forwarded to the AAUS during the annual reporting cycle. This report must first be reviewed and released by the University's DCB.

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SECTION 3 – DIVING EQUIPMENT

3.1 GENERAL POLICY

1. All equipment for SCUBA training must meet ANSI Instructional Standards Minimum Course Content for Entry-Level SCUBA Certification and additional requirements determined by the DSO/DCB.
2. All divers are expected to perform a basic inspection of their own and their teammates' equipment prior to each dive.
3. The use of diving equipment other than open circuit SCUBA shall require prior written permission from the DSO or DCB.
4. Diving equipment shall be tested and repaired according to the manufacturer's recommended procedures and specifications and as required in this manual. If equipment is subjected to extreme usage under adverse conditions, it requires more frequent testing and repair.

3.2 EQUIPMENT

All equipment shall be tested and inspected on the schedule listed below. Servicing is different than testing and inspections. Equipment will be serviced on a schedule in accordance with manufacturer's specifications which varies by manufacturer. Records shall be in accordance with Section 3.5 with copies being sent to the DSO as required.

Regulator	Initially and every 12 months or to manufacturers recommendation
Gauges	Initially and every 12 months
SCUBA Cylinders	Annual VIP and Hydro every 5 years
Cylinder Valves	Initially and every 12 months
Masks and Helmets	Initially and every 12 months or to manufacturers recommendation
Compressors	Refor to Section 3.4
Air Storage Vessels	Refer to Section 3.4
Air Filtration Systems	Refer to Section 3.4
Buoyancy Control Devices	Initially and every 12 months or to manufacturers recommendation
Dry Suits	Initially and every 12 months or to manufacturers recommendation

Regulators

1. Only those makes and models specifically approved by the DSO and the DCB shall be used.
2. Scuba regulators must be inspected and tested prior to first use and every 12 months thereafter or according to the manufacturer's specifications.
3. Regulators will consist of a primary second stage and an alternate air source (such as an octopus second stage or redundant air supply).

Breathing Masks and Helmets

1. Shall be inspected and tested prior to first use and every 12 months thereafter. Breathing masks and helmets shall have:
2. A non-return valve at the attachment point between helmet or mask and hose, which shall close readily and positively.

3. An exhaust valve.
4. A minimum ventilation rate capable of maintaining the diver at the depth to which he/she is diving.

Scuba Cylinders

1. Scuba cylinders must be designed, constructed, and maintained in accordance with the current Department of Transportation (DOT) Regulations as outlined in CFR 49.
2. Scuba cylinders must be hydrostatically tested in accordance with DOT standards.
3. Scuba cylinders must have an internal and external inspection at intervals not to exceed 12 months.
4. Scuba cylinder valves shall be functionally tested at intervals not to exceed 12 months.

Backpacks

1. 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

1. Gauges shall be inspected and tested before first use and every 12 months thereafter.
2. All divers must have an underwater timing device, an approved depth indicator, and a submersible pressure gauge. Acoustic/wireless air pressure transmitters can be used, but divers are still required to have a submersible pressure gauge

Flotation Devices

1. Each diver must, by virtue of a buoyancy-compensating device, have the ability to float with all his or her gear on. Ideally, the ability to produce floatation (positive buoyancy) should exceed negative buoyancy by approximately 20 pounds (of lift) for an acceptable margin of safety.
2. Personal flotation systems, buoyancy compensators, dry suits, or other variable volume buoyancy compensation devices shall be equipped with an exhaust valve.
3. These devices must be functionally inspected and tested at intervals not to exceed twelve months.
4. BCDs, dry suits, or other variable volume buoyancy compensation devices must not be used as a lifting device in lieu of lift bags.
5. Buoyancy Compensator is recommended for:
    a) All dry suits, as long as it does not interfere with the operation of the dry suit's control valves. It is particularly recommended for all non-neoprene dry suits, where a severe suit failure may result in the diver being negatively buoyant even after the weight belt is ditched.
    b) For any dive that is planned for or may result in a long surface swim.
    c) For any "blue water" or mid-water column diving.
    d) For any high current dives where the diver may be swept off-station and have to float on the surface until pickup.

Equipment for Determination of Decompression Status: Dive Tables, Dive Computers

1. A set of diving tables, approved by the Diving Control Board, must be available at the dive location.
2. Each member of the buddy team must have an underwater timing device and depth indicator, or dive computer
3. Dive computers may be utilized in place of diving tables. When a diver with no dive computer is diving with a diver/s who have computers, dives must be conducted according to the dive table limits.
4. If a dive computer is used the diver must use the same computer used on repetitive dives.
5. In an aquarium or other manmade structure of a known maximum obtainable depth:
    a) A depth indicator is not required, except when a diver's decompression status must be taken into consideration on repetitive dives.
    b) Only one buddy must be equipped with a timing device.
    c) The maximum obtainable depth of the aquarium must be used as the diving
6. AAUS recommendations regarding dive computers are located in Appendix 8

Additional Equipment

1. Quick release mechanisms on all weights, backpacks, and buoyancy control devices must be designed to permit jettisoning the entire piece of gear or system. Weights should be capable of one hand release.
2. Exposure suit or protective clothing must be appropriate for the environment and the work.
3. Night dives shall require two dive lights in good working order capable of lasting longer than the planned dive.
4. A diver's knife or other cutting device (shears, trilobite, etc.) kept sharp and in proper condition for use.
5. When diving in hazardous environments such as under ice diving, dives with danger of entanglement, human powered submarine pilot diving, or other dangerous circumstances, divers should have a "bail out bottle" of appropriate size to provide sufficient air for an emergency air source. Bail out bottles require DSO or DCB approval.
6. Surface marker buoys (SMB) are required on all dives where strong currents or vessel traffic are common.

3.3 AUXILIARY EQUIPMENT

Handheld Underwater Power Tools

1. The use of surface supplied electrical, pneumatic, and hydraulic handheld tools must be approved in writing by the DSO and/or DCB. Requests should be submitted with the dive plan. Hand-held electrical tools and equipment used underwater shall be specifically designed 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 must not be supplied with power from the dive location until requested by the diver and tool on/off operation must be under the diver's control.

Note: Some tools may not be appropriate for scientists to use under the OSHA exemption for scientific diving.

2. Lift Bag operation should be sustained with an air supply that is separate from the diver's air supply. This mode of operation will prevent excessive depletion of the divers' air supply should an emergency occur later in the dive or during lift bag use.

3.4 SUPPORT EQUIPMENT

First-Aid Supplies and Communications

1. A first-aid kit adequate for the diving operation must be available at the dive location (refer to Appendix 4, Divers' First-Aid Kit Check List). When used in a hyperbaric chamber or bell, the first-aid kit shall be suitable for use under hyperbaric conditions.
2. An emergency oxygen kit, approved by the DSO and the DCB must be available at the dive site. All divers must be trained in the general administration of 100% oxygen by demand mask for diving injuries and familiar with the proper assembly and use of the specific kit at the dive site.
3. Portable emergency VHF radio or telephone (standard cellular phone) shall be available on site. Equipment must be checked for proper functioning at the dive site.
4. This manual is required to be at all dive sites. First Aid and Communications protocol and contacts are defined for the Northwest region in Appendix 4. Dives out of this area must have dive and emergency plans submitted as outlined in Section 2.2.

Diver's Flag

1. A diver's flag must be displayed prominently whenever diving is conducted under circumstances where required or where water traffic is probable.

Compressor Systems – University of Washington Controlled

Low-pressure compressors used to supply air to the diver if equipped with a high-volume tank must have a check valve on the inlet side, a relief valve, and a drain valve.

Diving air compressors used under University auspices, whether or not University-owned, shall:

1. Meet American Society of Mechanical Engineers standards and Washington State Boiler and Unfired Pressure Vessel regulations.
2. Meet the following installation requirements:
    a) Air intakes shall be provided with a filter, and be located to ensure a supply of clean air, free from contamination by fumes, smoke, exhaust or other contaminants
    b) Compressed air systems over 500 psig shall have slow-opening drain valves.
    c) Discharged compressed air shall be passed to the compressed air holder through frequently cleaned and recharged filters designed to remove dusts, oil droplets, and water, and to minimize other contaminants.
    d) Oil lubricated compressor cylinders and coolers shall be well ventilated or otherwise cooled, or the operation cycled to ensure against the high temperatures at which carbon monoxide is formed from the oil.
3. Meet the following maintenance requirements:
    a) A log shall be kept by the compressor operator showing operational hours, repair, overhaul, and filter maintenance.

b) All diving air compressors shall be inspected and maintained in accordance with the manufacturer's service policy. Records of service shall be maintained according to Section 3.5.

c) The output of air compressor systems shall be tested for air purity at intervals not to exceed six (6) months or 100 hours of operation by means of samples taken at the connection to the distribution system. Records of tests shall be kept and copies sent to the DSO.

Oxygen Safety

1. Equipment used with oxygen or mixtures containing over 40 percent (%) by volume oxygen shall be designed and maintained for oxygen service.
2. Oxygen systems over 125 psig shall have slow-opening shut-off valves.

Air Storage Vessels

All air storage vessels/cylinders must be designed, constructed, and maintained in accordance with the provisions of the applicable Unfired Pressure Vessel Safety Orders. Internal and external inspections shall be conducted in the manner and frequency specified by the Department of Transportation. Vessels exposed to unusual environmental conditions may require more frequent internal and external inspections. Records of tests shall be maintained according to Section 3.5 and copies sent to the DSO.

Record Keeping

All records of compressor systems maintenance and testing must be kept by the operator for as long as the equipment is retained for use. Records made on the proper form must be sent to the DSO

3.5 EQUIPMENT MAINTENANCE

Record Keeping

Each equipment modification, repair, test, calibration, or maintenance service must be recorded. The report shall include the date and nature of work performed, serial number of the item, and the name of the person performing the work for the following equipment:

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

Compressor Operation and Air Test Records

Gas analyses and air tests must be performed on each UW-controlled breathing air compressor at regular intervals of no more than 100 hours of operation or six months, whichever occurs first. The

results of these tests shall be entered in a formal log and be maintained by the operator with a copy of the air analysis sent to the DSO.

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

3.6 AIR QUALITY STANDARDS

Breathing air for scuba must meet the following specifications as set forth by the Compressed Gas Association (CGA Pamphlet G-7.1) and as referenced in OSHA 29 CFR 1910.134.

CGA Grade E

Component	**Maximum**
Oxygen	20 - 22%/v
Carbon Monoxide	10 PPM/v
Carbon Dioxide	1000 PPM/v
Condensed Hydrocarbons	5 mg/m3
Total Hydrocarbons as Methane	25 PPM/v
Water Vapor	NS
Objectionable Odors	None

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

Remote Operations

For remote site operations using gas sources not controlled by the University of Washington, every effort will be made to verify breathing gas meets the requirements of this standard. If CGA Grade E gas is not verifiable, then the DCB will evaluate the quality of the air sample that is the standard in that country or region.

If no air quality tests are available then the PI/Lead diver, and the person who is most experienced with compressors or tank filling, will test the air for a minimum of oxygen and carbon monoxide content prior to diving using a direct reading instrument or detector tube according to the procedure below. In cases where the compressor is owned by UW, then the gas must be tested prior to the compressor being deployed to the remote location. All tanks should be verified to be in current hydro and visual inspection prior to filling.

Remote Location Air Testing Procedure:

The Diving Safety Officer will facilitate gathering the information regarding potential use of an air supply in remote field locations. If it is found that CGA Grade E air is not verifiable in the location, the below procedures must be followed by the divers in the field.

Analysis of compressed gas breathing system(s):

1. Locate and inspect the compressor and associated equipment, i.e. compressor, air storage, fill station, and request service records for the compressor including date of last filter change.

a) Items to look for:

i. How is the compressor powered? Electric or petroleum fuel?
ii. Heavy corrosion on any parts of the system.
iii. Hazardous chemicals stored near the system, i.e. bleach, gasoline, diesel, paints, solvents, etc.

2. Identify location of air intake for the compressor, i.e. within the room, plumbing of air intake to outside of room (if housed indoors)
   a) Ensure the air intake for the compressor is not located near any hazardous materials, especially gasoline and/or diesel engine exhaust sources, any other source of burning materials or cleaning supplies like bleach.
3. Smell breathing air that is being compressed in the system, either from the air storage, fill station or from a cylinder that has been filled from the system.
   a) If ANY objectionable odor is identified, the air must not be used for breathing gas.
   b) Vent air from a storage cylinder or scuba tank onto a clean cloth for a minimum of 10 seconds, then examine any residue left on cloth for oil or particulates.
4. Analyze breathing air from system storage and from each cylinder to be used by the dive team.
   a) Identify Oxygen content (20-22% required)
   b) Identify Carbon Monoxide content (10 PPM/v maximum)

Equipment Requirements for gas analysis in the field location:

1. Oxygen Analyzer
2. Carbon Monoxide Analyzer
3. Appropriate detector tubes if applicable

Prior to mission departure, all divers must be trained in the use and function of the gas analyzing tools issued to the team(s) by the Dive Safety Office.

Documentation and Submission:

Upon completion of the inspection of compressor and associated equipment and air analysis, the dive team must produce a report for submission to the Dive Safety Office and Diving Control Board for each air system being utilized during the mission as soon as access allows.

Information to include:

1. General: Findings from inspection; images of compressor system and associated equipment, any service records.
2. Location of air intake in relation to the compressor, air storage and/or fill station.
3. Air analysis information: Oxygen content and Carbon Monoxide content, if any.

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SECTION 4 SCIENTIFIC DIVER CERTIFICATION AND AUTHORIZATIONS

This section describes the training and performance standards for AAUS Scientific Divers and represent the minimum required level of knowledge and skills presented in a generalized format. Individual diving programs are encouraged to expand upon and augment these requirements, develop or utilize appropriate educational materials, and optimize instructional programs to suit and reflect their specific needs.

4.1 PREREQUISITES

Administrative

The candidate must complete all administrative and legal documentation required by the OM.

Entry Level Diver Certification

The candidate must, at minimum, show documented proof of Diver Certification or equivalent from an internationally recognized training agency. OMs who wish to train and certify entry level divers may do so under the standards of the most current version of the RSTC/WRSTC and/or ISO entry-level diver standards. Entry level diver training is a prerequisite to scientific diver training and therefore no part of entry level training may be counted in any way toward scientific diver training.

[1] "Minimum Course Content for Open Water Diver Certification"- World Recreational Scuba Training Council (WRSTC), www.wrstc.com.

[2] "Safety related minimum requirements for the training of recreational scuba divers -- Part 2: Level 2 -- Autonomous diver". ISO 24801-2:2014- International Organization for Standardization (ISO) - www.iso.org.

Medical Examination

The candidate must be medically qualified for diving as described in Section 5. and Appendices 1-4 of this Manual. AAUS medical standards may not be waived.

4.2 TRAINING

The candidate must successfully complete prerequisites, theoretical aspects, practical training, and examinations for a minimum cumulative time of 100 hours and a minimum of 12 open water dives. Theoretical aspects must include principles and activities appropriate to the intended area of scientific study. Formats for meeting the 100 hour training requirement include OM developed formalized training course, or a combination of formalized and on the job training.

When a diver's resume provides clear evidence of significant scientific diving experience, the diver can be given credit for meeting portions of the 100 hour course requirements. The DCB will identify specific overlap between on-the-job training, previous scientific diving training/experience and course requirements, and then determine how potential deficiencies will be resolved. However, OMs cannot "test-out" divers, regardless of experience, when they have no previous experience in scientific diving.

Any candidate who does not convince the DCB, through the DSO, that they possess the necessary judgment, under diving conditions, for the safety of the diver and his/her buddy, may be denied OM scientific diving privileges.

Theoretical Training / Knowledge Development	
Required Topics:	**Suggested Topics:**
Diving Emergency Care Training • Cardiopulmonary Resuscitation (CPR) • AED • Standard or Basic First Aid • Recognition of DCS and AGE • Accident Management • Field Neurological Exam • Oxygen Administration	Specific Dive Modes (methods of gas delivery) • Open Circuit • Hookah • Surface Supplied diving • Rebreathers (closed and/or semi-closed)
Dive Rescue • To include procedures relevant to OM specific protocols. (refer to water skills below)	Specialized Breathing Gas • Nitrox • Mixed Gas
Scientific Method	Small Boat Operation
Data Gathering Techniques (Only items specific to area of study required) • Transects and Quadrats • Mapping • Coring • Photography • Tagging • Collecting • Animal Handling • Archaeology • Common Biota • Organism Identification • Behavior • Ecology • Site Selection, Location, and Re-location • Specialized Data Gathering Equipment	Specialized Environments and Conditions • Blue Water Diving • Altitude • Ice and Polar Diving (Cold Water Diving) • Zero Visibility Diving • Polluted Water Diving • Saturation Diving • Decompression Diving • Overhead Environments • Aquarium Diving • Night Diving • Kelp Diving • Strong Current Diving • Potential Entanglement/Entrapment • Live boating
Required Topics:	**Suggested Topics:**
Navigation	HazMat Training • Chemical Hygiene, Laboratory Safety (Use of Chemicals)
HazMat Training • HP Cylinders	
Decompression Management Tools • Dive Tables • Dive Computers • PC Based Software	Specialized Diving Equipment • Full face mask • Dry Suit • Communications • Dive Propulsion Vehicle (DPV) • SMBs/Lift Bags • Line Reels
AAUS Scientific Diving Regulations and History • Scientific Dive Planning • Coordination with other Agencies • Appropriate Governmental Regulations	
Hazards of breath-hold diving and ascents	
Dive Physics (Beyond entry level scuba)	Other Topics and Techniques as Determined by the DCB
Dive Physiology (Beyond entry level scuba)	
Dive Environments	
Decompression Theory and its Application	

Practical Training / Skill Development	
Confined Water	By the completion of training, the candidate must demonstrate the following in the presence of the DSO or designee. All tests are to be performed without swim aids. However, where exposure protection is needed, the candidate must be appropriately weighted to provide for neutral buoyancy. • Swim underwater for a distance of 25 yards (23 meters) without surfacing. • Swim 400 yards (366 meters) in less than 12 minutes. • Tread water for 10 minutes, the last 2 minutes without the use of hands. • Transport a passive person of equal size a distance of 25 yards (23 meters) in the water.
	At the completion of training, the trainee must satisfy the DSO or DCB-approved designee of their ability to perform the following, as a minimum, in a pool or in sheltered water: • Enter water fully equipped for diving • Clear fully flooded face mask • Demonstrate air sharing and ascent using an alternate air source, as both donor and recipient, with and without a face mask • OPTIONAL - Demonstrate stationary buddy breathing as both donor and recipient • Demonstrate understanding of underwater signs and signals • Demonstrate ability to remove and replace equipment while submerged • Demonstrate acceptable watermanship skills for anticipated scientific diving conditions
Open Water Skills	The trainee must satisfy the DSO, or DCB-approved designee, of their ability to perform at least the following in open water: • Surface dive to a depth of 10 feet (3 meters) without scuba* • Enter and exit water while wearing scuba gear* ^^ • Kick on the surface 400 yards (366 meters) while wearing scuba gear, but not breathing from the scuba unit* • Demonstrate proficiency in air sharing ascent as both donor and receiver* • Demonstrate the ability to maneuver efficiently in the environment, at and below the surface* ^^ • Complete a simulated emergency swimming ascent* • Demonstrate clearing of mask and regulator while submerged* • Underwater communications^^ • Demonstrate ability to achieve and maintain neutral buoyancy while submerged* • Demonstrate techniques of self-rescue and buddy rescue* • Navigate underwater ^ • Plan and execute a dive^ • Demonstrate judgment adequate for safe scientific diving* ^^
	Rescue Skills: • Rescue from depth and transport 25 yards (23 meters), as a diver, a passive simulated victim of an accident: surface diver, establish buoyancy, stabilize victim • Demonstrate simulated in-water mouth-to-mouth resuscitation • Removal of victim from water to shore or boat • Stressed and panicked diver scenarios • Recommendations For Rescue Of A Submerged Unresponsive Compressed-Gas Diver – Appendix 9
	Successfully complete a minimum of one checkout dive and at least eleven additional open water dives in a variety of dive sites, for a cumulative surface to surface time of 6 hours. Dives following the checkout dive(s) may be supervised by an active Scientific Diver holding the necessary depth authorization experienced in the type of diving planned, and with the knowledge and permission of the DSO

	The eleven dives (minimum) following the initial checkout dive may be conducted over a variety of depth ranges as specified by the OM DCB. Depth progression must proceed shallower to deeper after acceptable skills and judgement have been demonstrated, and are not to exceed 100 feet (30 m) during the initial 12 dive cycle
	* Checkout dive element ^^ Evaluated on all dives ^ Evaluated at some point during the training cycle

Examinations	
Equipment	The trainee will be subject to examination/review of: • Personal diving equipment • Task specific equipment • Function and manipulation of decompression computer to be employed by the diver (if applicable)
Written Exams	The trainee must pass a written examination reviewed and approved by the OM DCB that demonstrates knowledge of at least the following: • Function, care, use, and maintenance of diving equipment • Advanced physics and physiology of diving • Diving regulations • Applicable diving environments • Emergency procedures for OM-specific dive mode(s) and environments, including buoyant ascent and ascent by air sharing • Currently accepted decompression theory and procedures • Proper use of dive tables • Hazards of breath-hold diving and ascents • Planning and supervision of diving operations • Navigation • Diving hazards & mitigations • Cause, symptoms, treatment, and prevention of the following: near drowning, air embolism, hypercapnia, squeezes, oxygen toxicity, nitrogen narcosis, exhaustion and panic, respiratory fatigue, motion sickness, decompression sickness, hypothermia, and hypoxia/anoxia • Applicable theoretical training and knowledge development from the Required and Suggested Topics (above)

4.3 DIVER CERTIFICATION AND AUTHORIZATIONS

Only a person diving under the auspices of an OM that subscribes to the practices of the AAUS is eligible for a scientific diver certification.

Diver-In-Training (DIT) Authorization

This is an authorization to dive, usable only while it is current and for the purpose intended. This authorization signifies that a diver has completed and been certified as at least an entry level diver through an internationally recognized certifying agency and has the knowledge skills and experience necessary to commence and continue training as a scientific diver under supervision, as approved by the DCB. DIT status must only be used when the diver is on his/her way to becoming certified as a scientific diver. While it is recommended for DIT's to have hands-on scientific diver experience during their training, the DIT status is intended to be a temporary authorization, not a substitute for Scientific Diver Certification.

Scientific Diver Certification

Signifies a diver has completed all requirements in Section 4.2 and is certified by the AAUS OM to engage in scientific diving without supervision, as approved by the DCB through the DSO. Submission of documents and participation in aptitude examinations does not automatically result in certification. To be certified, the applicant must demonstrate to the DCB, through the DSO, that s/he is sufficiently skilled and proficient, and possess the necessary judgement for their safety and/or that of the dive team. Scientific Diver Certification is only active when required authorizations are in place and current.

Scientific Aquarium Diver Certification

Scientific Aquarium Diver is a certification authorizing the diver to participate in scientific diving solely in the aquarium environment.

All requirements set forth for Scientific Diver certification must apply, except follows:

1. Practical training must include at least 12 supervised aquarium dives for a cumulative bottom time of 6 hours.
2. Training requirements for navigation and 400-yard (366-meter) surface swim in scuba gear may be waived at the discretion of the DCB.

Temporary Diver Authorization

Only a diver not under the auspices of an AAUS OM may be granted a Temporary Diver Authorization. The individual in question must demonstrate proficiency in diving and can contribute measurably to a planned dive. A Temporary Diver Authorization constitutes a waiver of selected requirements of Section 4. and is valid only for a limited time, as approved by the DCB. A Temporary Diver Authorization must be restricted to the planned diving operation and must comply with all other policies, regulations, and standards of this Manual, including medical requirements. This authorization is not to be utilized as a repeated mechanism to circumvent existing standards set forth in this Manual.

4.4 DEPTH AUTHORIZATIONS DEPTH RATINGS AND PROGRESSION TO NEXT DEPTH LEVEL

Indicates the maximum depth in which a diver can conduct science and may supervise other divers holding a lesser depth authorization. A scientific diver requires a valid depth authorization to be considered active.

A diver may be authorized to the next depth level after successfully completing the requirements for that level. A diver may exceed his/her depth authorization when accompanied and supervised by a dive buddy holding a depth authorization greater or equal to the intended depth, but only to one greater depth authorization than they currently hold. Dives must be planned and executed with the permission of the DSO or designee. Divers may exceed their depth authorization while conducting training dives under the direct supervision of the DSO or designee.

In the event a diver within the OM does not hold an authorization at the desired next level, the DCB may authorize a required progression or procedure for a diver to attain a deeper authorization. If local conditions do not conform to traditional AAUS depth progressions, the DCB may devise a reasonable accommodation. However, the total number of dives to obtain a given depth authorization must follow the cumulative number of dives listed below.

1. Authorization to 30 Foot Depth - Initial science diver depth authorization, approved upon the successful completion of training listed in Section 4. . Cumulative minimum supervised dives: 12.
2. Authorization to 60 Foot Depth - A diver holding a 30-foot authorization may be authorized to a depth of 60 feet after successfully completing and logging 12 supervised dives to depths between 31 and 60 feet under supervision of a diver authorized by the DCB, for a minimum total time of 4 hours. Cumulative minimum supervised dives: 24.

Depth Authorizations to 100 feet and deeper require the diver to conduct a checkout dive with the DSO or their designee to that depth. It is incumbent upon the diver to convince the DSO that they are able to safely lead a lesser experienced diver on a dive to that depth.

3. Authorization to 100 Foot Depth - A diver holding a 60-foot authorization may be authorized to a depth of 100 feet after successfully completing and logging 6 supervised dives to depths between 61 and 100 feet under supervision of a dive buddy authorized by the DCB. The diver must also demonstrate proficiency in the use of the appropriate decompression profiling method. Cumulative minimum supervised dives: 30.
4. Authorization to 130 Foot Depth - A diver holding a 100-foot authorization may be authorized to a depth of 130 feet after successfully completing and logging 6 supervised dives to depths between 100 and 130 feet under supervision of a dive buddy authorized by the DCB. The diver must also demonstrate proficiency in the use of the appropriate decompression profiling method. Cumulative minimum supervised dives: 36.
5. Authorization to 150 Foot Depth - A diver holding a 130-foot authorization may be authorized to a depth of 150 feet after successfully completing and logging 6 supervised dives to depths between 130 and 150 feet under supervision of a dive buddy authorized by the DCB. The diver must also demonstrate knowledge of the special problems of deep diving and of special safety requirements. Cumulative minimum supervised dives: 42.
6. Authorization to 190 Foot Depth - A diver holding a 150-foot authorization may be authorized to a depth of 190 feet after successfully completing and logging 6 dives to depths between 150 and 190 feet under supervision of a dive buddy authorized by the DCB. The diver must also demonstrate knowledge of the special problems of deep diving and of special safety requirements. Cumulative minimum supervised dives: 48.

Diving on air is not permitted beyond a depth of 190 feet. Dives beyond 190 feet require the use of mixed gas.

7. Authorization to 250 Foot Depth - A diver holding a 190-foot authorization may be authorized to a depth of 250 feet after successfully completing and logging 6 supervised dives to depths between 190 and 250 feet under supervision of a dive buddy authorized by the DCB. The diver must also demonstrate knowledge of the special problems of deep diving and of special safety requirements.
8. Authorization to 300 Foot Depth - A diver holding a 250-foot authorization may be authorized to a depth of 300 feet after successfully completing and logging 6 supervised dives to depths between 200 and 250 feet under supervision of dive buddy authorized by the DCB. The diver must also demonstrate knowledge of the special problems of deep diving and of special safety requirements.
9. Authorizations deeper than 300 Feet – Depth authorizations deeper than 300 feet progress in 50-foot depth/6 dive increments. A diver holding a 300 foot, or deeper authorization may be authorized to the next depth authorization increment after successfully completing and logging 6 supervised dives under supervision of dive buddy authorized by the DCB. The diver must also demonstrate knowledge of the special problems of deep diving and of special safety requirements.

4.5 MAINTAINING ACTIVE STATUS

Minimum Activity to Maintain Authorizations

During any 12-month period, each scientific diver must log a minimum of 12 scientific, scientific training, or proficiency dives. At least one dive must be logged near the maximum depth, as defined by the DCB, or the diver's authorization during each 6-month period. Divers authorized to 150 feet or deeper may satisfy these requirements with dives to 130 feet or deeper and must be completed in the gear configuration and gasses similar to those the diver utilizes to complete these dives to 150 feet or deeper. Failure to meet these requirements will result in revocation or restriction of authorization by the DSO under procedures

established by the DCB.

Requalification of Authorization

Once the initial requirements of Section 4. are met, divers whose depth authorization has lapsed due to lack of activity may be requalified by procedures adopted by the DCB.

Medical Examination

All scientific divers must pass a medical examination at the intervals specified in Section 5. . A medically cleared diver experiencing any Conditions Which May Disqualify Candidates From Diving (Appendix 1) must receive clearance to return to diving from a physician before resuming diving activities. This medical examination requirement cannot be waived for any diver.

Emergency Care Training

The scientific diver must hold current training in the following:

1. Adult CPR and AED
2. Emergency oxygen administration
3. First aid for diving accidents

4.6 REVOCATION OF AUTHORIZATION

An individual's scientific diver certification can be restricted or revoked for cause by the DCB. Authorizations associated with an individual's scientific diver certification may be restricted or suspended for cause by the DSO. Restrictions or suspensions issued by the DSO may be rescinded by the DSO; these issues will be reported to and reviewed by the DCB, and the outcomes or actions resulting from this review will be documented in the diver's OM record. Violations of regulations set forth in this Manual or other governmental subdivisions not in conflict with this Manual, or demonstration of poor judgement, may be considered cause. The DCB or designee must inform the diver in writing of the reason(s) for revocation. The diver will be given the opportunity to present their case in writing to the DCB for reconsideration. Following revocation, the diver may be reauthorized after complying with conditions the DCB may impose. All such written statements and requests, as identified in this section, are formal documents, and therefore part of the diver's file.

4.7 RECERTIFICATION

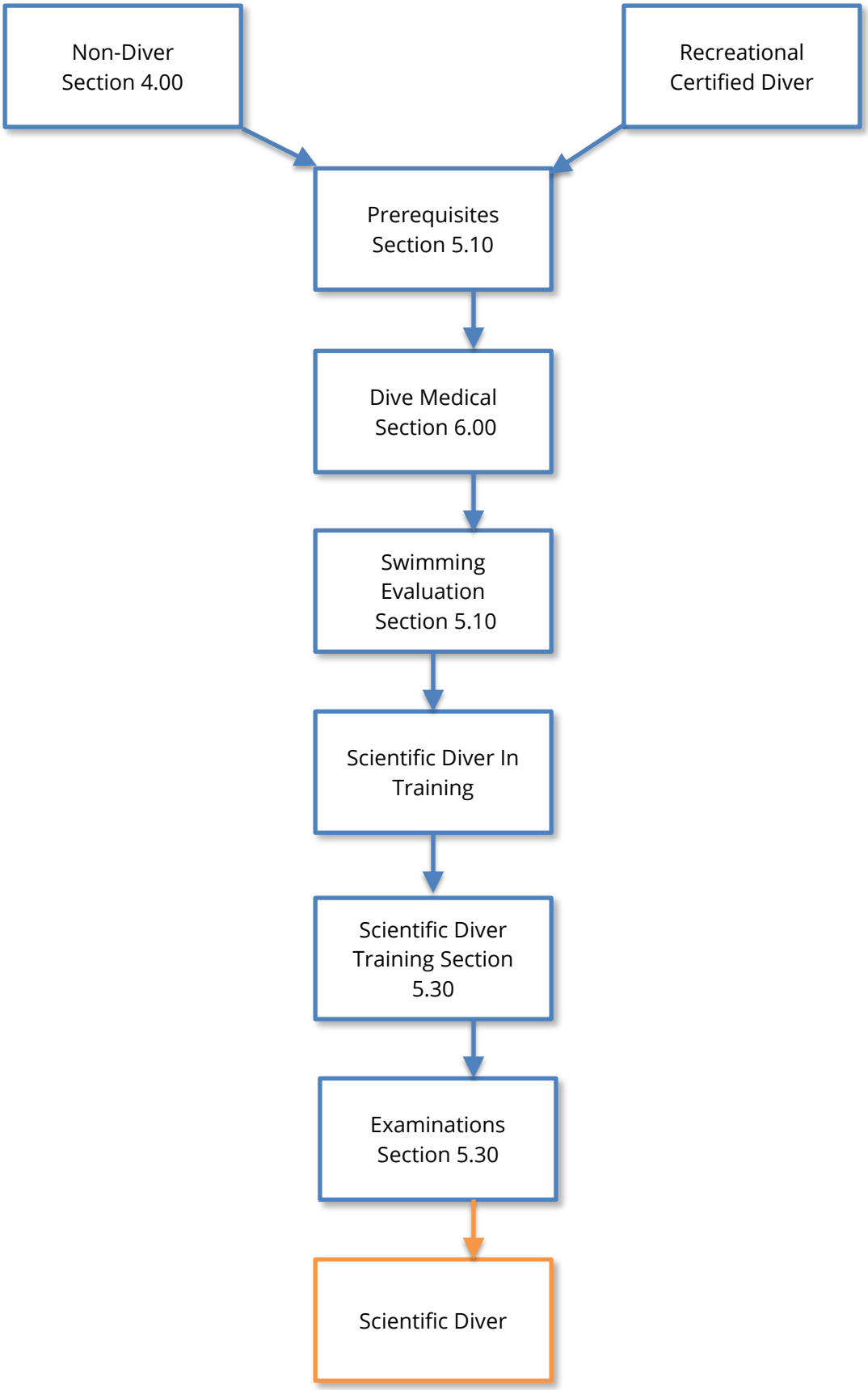
If a diver's certificate expires or is revoked, they may be re-certified after complying with such conditions as the Diving Safety Officer or the DCB may impose. The diver shall be given an opportunity to present their case to the DCB before conditions for re-certification are stipulated.

4.8 WAIVER OF REQUIREMENTS/ TEMPORARY DIVER

A temporary diver permit constitutes a waiver of the requirements of Section 4 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 and approved by the DCB. This permit is not to be construed as a repeated mechanism to circumvent existing standards set forth in this standard. The medical standards in Section 5 cannot be waived.

Requirements of Section 4 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 must be restricted to the planned diving operation and must comply with all other policies, regulations, and standards of this standard, including medical requirements.

AAUS Scientific Diver Flow Chart



SECTION 5 – MEDICAL STANDARDS

5.1 MEDICAL REQUIREMENTS

General

1. The University of Washington must determine that divers have passed a current diving physical examination and have been declared by the examining or supervising physician to be fit to engage in diving activities as may be limited or restricted in the medical evaluation report.
2. All medical evaluations required by this Manual must be performed by, or under the direction of, a licensed health care provider of the applicant-diver's choice, preferably one trained in diving/undersea medicine.
3. New applicants must contact the Employee Health Center to schedule the physical or make arrangements to receive the required paperwork. The new applicants will be directed by the Employee Health Center to the correct forms for the physical. If a physician outside the University of Washington is utilized, all requirements and medical forms must be completed and submitted to the Employee Health Center for approval.
4. The diver should be free of any chronic disabling disease and be free of any conditions contained in the list of conditions, listed on the following page and on the SCUBA Medical Overview Form, for which restrictions from diving are generally recommended.
5. In such cases where conflict arises between the outside medical provider and the UW Diving Medical Officer (DMO), final authority for determining medical clearance to dive rests with the University's DMO.

5.2 FREQUENCY OF MEDICAL EVALUATIONS

Medical evaluation must be completed:

1. Before a diver may begin diving, unless an equivalent initial medical evaluation has been given within the preceding five (5) years (three (3) years if over the age of 40, two (2) years if over the age of 60), Employee Health Services has obtained the results of that examination, and those results have been reviewed and found satisfactory by the Campus Health Services medical personnel.
2. Thereafter, at five-year intervals up to age 40, every three years after the age of 40, and every two years after the age of 60
3. Clearance to return to diving must be obtained from a health care provider following any major injury or illness, or any condition requiring hospital care or chronic medication. If the injury or illness is pressure related, then the clearance to return to diving must come from a physician trained in diving medicine. This clearance will be submitted to the Employee Health Center (EHC) and may require approval from the DMO.

5.3 Information Provided Examining Physician

The University of Washington must provide a copy of the medical evaluation requirements of this Manual to the examining physician.

5.4 CONTENT OF MEDICAL EVALUATIONS

Medical examinations conducted initially and at the intervals specified in Section 6.1 must consist of the following:

1. Applicant agreement for release of medical information to the DSO and the DCB. This can be found on the Medical Evaluation of Fitness for SCUBA Diving Report required for the physical.

2. Diving Medical History Form.
3. Diving physical examination.

5.5 CONDITIONS WHICH MAY DISQUALIFY CANDIDATES FROM DIVING (ADAPTED FROM BOVE, 1998)

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

5.6 LABORATORY REQUIREMENTS FOR DIVING MEDICAL EVALUATIONS AND INTERVALS

1. Initial examination under age 40:
    a. Medical History
    b. Complete Physical Exam, emphasis on neurological and otological components
    c. Urinalysis
    d. Any further tests deemed necessary by the physician.
2. Periodic re-examination under age 40 (every five (5) years)
    a. Medical History
    b. Complete Physical Exam, emphasis on neurological and otological components
    c. Urinalysis
    d. Any further tests deemed necessary by the physician
3. Initial exam over age 40:
    a. Medical History

b. Complete Physical Exam, emphasis on neurological and otological components
c. Detailed assessment of coronary artery disease risk factors using multiple-risk-factor assessment1,2 (age, family history, lipid profile, blood pressure, diabetic screening, smoking history). Further cardiac screening may be indicated based on risk factor assessment.
d. Resting EKG
e. Chest X-ray
f. Urinalysis
g. Any further tests deemed necessary by the physician

4. Periodic re-examination over age 40 (every three (3) years); over age 60 (every two (2) years):

    a. Medical History
    b. Complete Physical Exam, emphasis on neurological and otological components
    c. Detailed assessment of coronary artery disease risk factors using multiple-risk-factor assessment1,2 (age, family history, lipid profile, blood pressure, diabetic screening, and smoking history). Further cardiac screening may be indicated based on risk factor assessment.
    d. Resting EKG
    e. Urinalysis
    f. Any further tests deemed necessary by the physician

5.7 PHYSICIAN'S WRITTEN REPORT

1. After any medical examination relating to the individual's fitness to dive, University of Washington shall obtain a written report prepared by the examining health care provider and signed by the examining or supervising physician, which shall contain the physician's opinion of the individual's fitness to dive, including any recommended restrictions or limitations. This will be reviewed by the Employee Health Center medical staff and placed in the diver's medical file.
2. The University of Washington will make a copy of the written report available to the individual upon request.
3. University employees (faculty, staff, and graduate students) with appointments that directly require scuba diving and who are or will be actively involved in the support or conduct of scientific research operations may receive diving medical exams through the Campus Health Services at no charge to the individual. If the employee elects to go to an outside health care provider they will pay for the exam and are required to send all original test reports to Employee Health for review and final clearance. Additional testing needed to clarify abnormal exam findings will be the responsibility of the diver.
4. University employees (faculty, staff, and graduate students) whose appointments do not require research diving, undergraduate students, and visitors without reciprocity are responsible for the cost of the medical examination. Divers also must submit all the original test reports along with all required University of Washington SCUBA forms to the Employee Health Center for final review and clearance.

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SECTION 6 NITROX DIVING

This section describes the requirements for authorization and use of nitrox for Scientific Diving.

6.1 REQUIREMENTS FOR NITROX AUTHORIZATION

Prior to authorization to use nitrox, the following minimum requirements must be met:

Prerequisites

Only a certified Scientific Diver or DIT diving under the auspices of an OM is eligible for authorization to use nitrox.

Application for authorization to use nitrox must be made to the DCB. Submission of documents and participation in aptitude examinations does not automatically result in authorization to use nitrox. The applicant must convince the DCB through the DSO that they are sufficiently knowledgeable, skilled and proficient in the theory and use of nitrox for diving.

Training

In lieu of writing/promulgating AAUS specific training standards for Nitrox divers, AAUS references the standards for Nitrox diver training as defined by the WRSTC and/or ISO. AAUS programs who wish to train Nitrox divers may do so using one of the following options:

1. Under the auspices and standards of an internationally recognized diver training agency.
2. Under the auspices of AAUS using the minimum guidelines presented by the most current version of the RSTC/WRSTC and/or ISO Nitrox diver training standards.

References:

"Minimum Course Content for Enriched Air Nitrox Certification" - World Recreational Scuba Training Council (WRSTC), www.wrstc.com.

“Recreational diving services- Requirements for training programs on enriches air nitrox (EAN) diving". ISO 11107:2009 - International Organization for Standardization (ISO), www.iso.org

Practical Evaluation

1. Oxygen analysis of nitrox mixtures.
2. Determination of MOD, oxygen partial pressure exposure, and oxygen toxicity time limits, for various nitrox mixtures at various depths.
3. Determination of nitrogen-based dive limits status by EAD method using air dive tables, and/or using nitrox dive tables, as approved by the DCB.
4. Nitrox dive computer use may be included, as approved by the DCB.
5. A minimum of two supervised open water dives using nitrox is required for authorization.

Written Evaluation

1. Function, care, use, and maintenance of equipment cleaned for nitrox use.
2. Physical and physiological considerations of nitrox diving (eg.: O_2 and CO_2 toxicity)
3. Diving regulations, procedures/operations, and dive planning as related to nitrox diving
4. Equipment marking and maintenance requirements
5. Dive table and/or dive computer usage
6. Calculation of: MOD, pO_2, and other aspects of Nitrox diving as required by the DCB

6.2 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.

6.3 OPERATIONAL REQUIREMENTS

Oxygen Exposure Limits

1. The inspired oxygen partial pressure experienced at depth should not exceed 1.4 ATA.
2. The maximum allowable exposure limit should be reduced in cases where cold or strenuous dive conditions, or extended exposure times are expected.

Calculation of Decompression Status

1. . A set of DCB approved nitrox dive tables should be available at the dive site.
2. Dive computers may be used to compute decompression status during nitrox dives. Manufacturers' guidelines and operation instructions should be followed.
3. Dive computers capable of pO2 limit and fO2 adjustment should be checked by the diver prior to the start each dive to ensure conformity with the mix being used.

Gas Mixture Requirements

1. Only nitrox mixtures and mixing methods approved by the DCB may be used.
2. OM personnel mixing nitrox must be qualified and approved by the DCB for the method(s) used.
3. Oxygen used for mixing nitrox should meet the purity levels for "Medical Grade" (U.S.P.) or "Aviator Grade" standards.
4. In addition to the AAUS Air Purity Guidelines outlined in Section 3.6, any air that may come in contact with oxygen concentrations greater than 40% (i.e.. during mixing), must also have a hydrocarbon contaminant no greater than .1 mg/m3.
5. For remote site operations using compressors not controlled by the OM where this is not verifiable, the DCB must develop a protocol to mitigate risk to the diver.

Analysis Verification by User

1. Prior to the dive, it is the responsibility of each diver to analyze the oxygen content of his/her 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 fO_2 of nitrox used, if different than 21%.

6.4 Nitrox Diving Equipment

Required Equipment

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

1. Labeled SCUBA Cylinders in Accordance with Industry Standards
2. Oxygen Analyzer
3. Oxygen compatible equipment as applicable

Requirement for Oxygen Service

1. All equipment, which during the dive or cylinder filling process is exposed to concentrations greater than 40% oxygen, should be cleaned and maintained for oxygen service.
2. Any equipment used with oxygen or mixtures containing over 40% by volume oxygen must be designed and maintained for oxygen service. Oxygen systems over 125 psig must have slow-opening shut-off valves.

Compressor system

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

SECTION 7. SURFACE SUPPLIED DIVING TECHNOLOGIES

Surface supplied diving technologies include any diving mode in which a diver at depth is supplied with breathing gas from the surface.

7.1 PREREQUISITES

All surface supplied and hookah divers must be certified scientific divers or divers in training and have completed system specific training as authorized by the OM.

7.2 Surface Supplied Diving

Surface Supply Definition

A mode of diving using open circuit, surface supplied, compressed gas delivered 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, often with voice communications.

Procedures

1. Each diver must be continuously tended while in the water.
2. A diver must be stationed at the underwater point of entry when diving is conducted in enclosed or physically confined spaces.
3. Each diving operation must have a primary breathing gas supply sufficient to support divers for the duration of the planned dive including decompression.
4. For dives deeper than 100fsw (30 m) or outside the no-decompression limits:
    a) A separate dive team member must tend each diver in the water;
    b) A standby diver must be available while a diver is in the water;
5. A diver using Surface Supply may rely on surface personnel to keep the diver's depth, time and diving profile
6. Surface supplied air diving must not be conducted at depths deeper than 190 fsw (57.9 m).
7. The OM DCB is responsible for developing additional operational protocols

Manning Requirements

The minimum number of personnel comprising a surface supplied dive team is three. They consist of: a Designated Person-In-Charge (DPIC), a Diver, and a Tender. Additional dive team members are required when a diving operation or dive site is considered complex, or when the task loading of a dive team member is deemed excessive. It is the OM DCB's responsibility to define when the surface supplied dive team must be expanded beyond the minimum manning requirements.

Equipment

1. The diver will wear a positive buckling device on the safety harness to which the umbilical hose will be secured. The attachment must be of sufficient strength to prevent any strain on the helmet/full face mask hose connections and equipment must be configured to allow retrieval of the diver by the surface tender without risk of interrupting air supply to the diver.
2. Each diver must be equipped with a diver-carried independent reserve breathing gas supply containing sufficient volume to complete the ascent to the surface, including all required decompression and safety stops.

3. Masks and Helmets
4. Surface supplied and mixed gas masks and helmets must have:
    a) A non-return valve at the attachment point between the mask/helmet and hose which must close readily and positively; and
    b) An exhaust valve
    c) Surface-supplied masks and helmets must have a minimum ventilation rate capability of 4.5 actual cubic feet per minute (acfm) at any depth at which they are operated or the capability of maintaining the diver's inspired carbon dioxide partial pressure below 0.02 atmospheres absolute (ATA) when the diver is producing carbon dioxide at the rate of 1.6 standard liters per minute
5. Helmets or masks connected directly to the dry suit or other buoyancy-changing equipment must be equipped with an exhaust valve
6. Air supplied to the diver must meet the air quality standards outlined in section 3.6

Surface Supplied in Aquariums

1. In an aquarium habitat where the maximum depth is known, a pneumofathometer is not required.
2. The maximum obtainable depth of the aquarium may be used as the diving depth
3. One tender may line-tend multiple divers, provided the tender is monitoring only one air source, there is mutual assistance between divers, there are no overhead obstructions or entanglements, or other restrictions as defined by the OM DCB.
4. The OM DCB is responsible for developing additional operational protocols for surface supplied diving specific to the aquarium environment.

7.4 Hookah

Hookah Definition

Hookah is an open circuit diving mode comprised of a remote gas supply, a long hose, and a standard scuba second stage or full face mask. Hookah is generally used in shallow water (30 fsw or less), though the configuration has been used to supply breathing gas from a diving bell, habitat, or submersible/submarine.

Equipment Requirements

1. The air supply hose must be rated for a minimum operating pressure of 130psi.
2. Air supplied to the hookah diver must meet the air quality standards outlined in section 3.6
3. Hookah supply systems must be capable of supplying all divers breathing from the system with sufficient gas for comfortable breathing for the planned depth and workload.
4. Hookah system second stage should be capable of being attached to the diver in a way to avoid pulling stress on the second stage mouthpiece and affords easy release if the diver must jettison the regulator and hose.
5. An independent reserve breathing gas supplied will be carried by each hookah diver:
    a) When the diver does not have direct access to the surface or
    b) At depths or distance from alternate breathing gas source determined by the DCB.

Operational Requirements

1. Hookah diving must not be conducted beyond depths or distance from alternate breathing gas source as determined by the DCB.
2. A diver's independent reserve breathing gas supply, if worn, must contain sufficient volume to allow the diver(s) to exit to the surface or alternate breathing gas source
3. Hookah divers not supported by diving bell, or underwater habitat must not be exposed to dives that require staged decompression.
4. The OM DCB is responsible for developing additional operational protocols.

Hookah Diving in Aquariums

1. In an aquarium habitat where the maximum depth is known and planned for, a depth gauge is not required.
2. The maximum obtainable depth of the aquarium may be used as the maximum diving depth.
3. A hookah configured diver may operate without an in-water buddy in an aquarium provided the diver is tended from the surface; has visual, line pull, or voice communication with the tender; the diver carries an independent reserve breathing gas source containing sufficient volume to allow the diver to exit to the surface or alternate breathing gas source; and under other operational conditions as determined by the OM DCB.
4. The OM DCB is responsible for developing additional operational protocols for hookah diving specific to the aquarium environment.

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SECTION 8 STAGED DECOMPRESSION DIVING

Decompression diving is 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 must be observed when conducting dives requiring planned decompression stops.

8.1 Minimum Experience and Training Requirements

Prerequisites

1) Scientific Diver qualification according to Section 4. .
2) Minimum of 100 logged dives with experience in the depth range where decompression dives will be conducted.
3) Demonstration of the ability to safely plan and conduct dives deeper than 100 feet.
4) Nitrox certification/authorization according to AAUS Section 6. recommended.

Training

Training must be appropriate for the conditions in which dive operations are to be conducted. Minimum Training must 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, and omitted decompression.
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 must be conducted, emphasizing planning and execution of required decompression dives, and including practice of emergency procedures.
4. Progression to greater depths must be by 4-dive increments at depth intervals as specified in Section 4.4.
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

1. Divers must demonstrate to the satisfaction of the DSO or the DSO's qualified designee proficiency in planning and executing required decompression dives appropriate to the conditions in which

diving operations are to be conducted.

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

8.2 Minimum Equipment Requirements

1. Valve and regulator systems for primary (bottom) gas supplies must be configured in a redundant manner that allows continuous breathing gas delivery in the event of failure of any one component of the regulator/valve system.
2. Cylinders with volume and configuration adequate for planned diving operations
3. One of the second stages on the primary gas supply must be configured with a hose of adequate length to facilitate effective emergency gas sharing in the intended environment.
4. Minimum dive equipment should include:
   a) Diver location devices adequate for the planned diving operations and environment.
   b) Compass
5. Redundancy in the following components may be required at the discretion of the DCB:
   a) Decompression Schedules
   b) Dive Timing Devices
   c) Depth gauges
   d) Buoyancy Control Devices
   e) Cutting devices
   f) Lift bags and line reels

8.3 Minimum Operational Requirements

1. The maximum pO_2 to be used for planning required decompression dives is 1.6 for open circuit. It is recommended that a pO_2 of less than 1.6 be used during bottom exposure.
2. Decompression dives may be planned using dive tables, dive computers, and/or PC software approved by the DCB.
3. Breathing gases used while performing in-water decompression must contain the same or greater oxygen content as that used during the bottom phase of the dive.
4. The dive team prior to each dive must review emergency decompression procedures appropriate for the planned dive.
5. If breathing gas mixtures other than air are used for required decompression, their use must be in accordance with those regulations set forth in the appropriate sections of this Manual.
6. Use of additional nitrox and/or high-oxygen fraction decompression mixtures as travel and decompression gases to decrease decompression obligations is recommended.
7. Use of alternate inert gas mixtures to limit narcosis is recommended for depths greater than 150 feet.
8. The maximum depth for required decompression using air as the bottom gas is 190 feet.
9. If a period of more than 6 months has elapsed since the last decompression dive, a series of progressive workup dives defined by the DCB to return the diver(s) to proficiency status prior to the start of project diving operations are required.
10. Mission specific workup dives are recommended.

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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.

9.1 Minimum Experience and Training Requirements

Prerequisites

1. Nitrox authorization (Section 6).
2. If the intended use entails required decompression stops, divers will be previously authorized in decompression diving (Section 8).
3. Divers must demonstrate to the DCB's satisfaction skills, knowledge, and attitude appropriate for training in the safe use of mixed gases.

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
5. Gas management planning
6. Thermal considerations
7. END determination
8. Mission planning and logistics
9. Emergency procedures
10. Mixed gas production methods
11. Methods of gas handling and cylinder filling
12. Oxygen exposure management
13. Gas analysis
14. Mixed gas physics and physiology

Practical Training

1. Confined water session(s) in which divers demonstrate proficiency in required skills and techniques for proposed diving operations.
2. A minimum of 6 open water training dives.
3. At least one initial dive must 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 must not exceed 260 feet.
6. Diving operations beyond 260 feet requires additional training dives.

9.2 Equipment and Gas Quality Requirements

1. Equipment requirements must be developed and approved by the DCB. Equipment must meet other pertinent requirements set forth elsewhere in this Manual.
2. The quality of inert gases used to produce breathing mixtures must be of an acceptable grade for human consumption.

9.3 Minimum Operational Requirements

1. All applicable operational requirements for nitrox and decompression diving must be met.
2. The maximum pO_2 to be used for planning required open circuit decompression dives is 1.6. It is recommended that a pO_2 of less than 1.6 be used during bottom exposure.
3. Divers decompressing on high-oxygen concentration mixtures must closely monitor one another for signs of acute oxygen toxicity.
4. If a period of more than 6 months has elapsed since the last decompression dive, a series of progressive workup dives defined by the DCB to return the diver(s) to proficiency status prior to the start of project diving operations are required.
5. Mission specific workup dives are recommended

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SECTION 10 – HUMAN POWERED SUBMARINE DIVING OPERATIONS

10.1 GENERAL POLICY

University of Washington Mechanical Engineering students research, develop, and construct a Human Powered Submarine (HPS) as part of their Major course work. Scuba diving is an essential part of HPS research and safety operations. The guidelines set forth in this section outline requirements for safe HPS diving operations and must be followed by any UW diver entering the water with the submarine.

10.2 PARTICIPATN LEVELS AND BASIC REQUIREMENTS

1. Submarine Operator
    a) Definition- any individual who will enter the submarine, while submerged or on the surface, and/or use scuba diving techniques for the purposes of inspection, maintenance, repair, or operation.
    b) Training Requirements- shall meet the minimum requirements for certification as a UW Scientific Diver Certification from Section 5 of the UW Standards for Scientific Diving and shall have knowledge of and experience with the operation of all systems of the submarine.
2. Submarine Safety/Support Diver
    a) Definition- an individual whose primary purpose is to ensure the safety of Submarine Operator/Divers and will use scuba diving techniques to support or assist with aspects of vehicle inspection, maintenance, repair, or operation, while submerged or on the surface.
    b) Training Requirements-shall meet the minimum requirements for certification as a UW Scientific Diver Certification from Section 5 of the UW Standards for Scientific Diving and shall be trained in first aid and underwater rescue techniques to include in-water rescue breathing, cardiopulmonary resuscitation, basic first aid, and oxygen administration. Shall have knowledge of and experience with the operation of all emergency and egress systems associated with the submarine. Knowledge of and experience with submarine navigational and propulsion systems is recommended but not required.
3. Submarine Lead Diver
    a) Definition- the individual who directly supervises and monitors water activities associated with the submarine.
    b) Requirements- Shall meet all requirements for certification as a Submarine Safety/Support Diver and shall have completed all requirements for Scientific Diver Certification from Section 5 of the UW Standards for Scientific Diving. Knowledge of and experience with submarine navigational and propulsion systems is recommended, but not required.
4. Submarine Support Swimmer/Support Diver-in-Training

a) Definition- any individual who will enter the water for the purposes of inspection, maintenance, or repair of the submarine, or provide assistance to other members of the submarine team.

b) Requirements- Shall meet the minimum requirements for certification as a UW Scientific Diver in-Training.

5. Other

a) Any individual who will enter the water during submarine activities shall conform to UW requirements for scientific diving which most closely resemble their level of involvement (i.e. u/w photographer/videographer).

10.3 ADDITIONAL TRAINING REQUIREMENTS

In addition to the minimum requirements stated above and those required by a standard UW checkout dive, divers engaged in work with the Human Powered Submarine shall be able to demonstrate the following skills:

a) Submarine Operator

i. Equalize body air spaces while performing the tasks associated with navigating, piloting, or propelling the vehicle.
ii. Clear the face mask while performing the tasks associated with navigating, piloting, or propelling the vehicle.
iii. Remove and replace the face mask while inside the vehicle.
iv. Remove, replace, and clear the air supply while inside the vehicle.
v. Monitor the primary and reserve air supply.
vi. Monitor the rate of and conduct a safe ascent (<1 ft/sec.) while inside the vehicle.
vii. Demonstrate proper exhalation techniques during an out of control/rapid ascent.
viii. Locate and secure the reserve air supply, without the use of visual aids/cues.
ix. Execute a switch from primary to reserve air supply in a timely fashion, without difficulty.
x. Release the emergency signal float/buoy.
xi. Release the emergency egress hatch and any/all interior restraint systems while breathing from either the primary or reserve air supply.
xii. Exit the vehicle and conduct an ascent to the surface while breathing from an air source supplied by a safety/support diver.
xiii. Exit the vehicle and conduct an emergency swimming ascent to the surface.

b) Safety/Support Diver

i. Monitor the primary and reserve air supply of the operator/diver.
ii. Release the emergency egress hatch and any/all interior restraint systems.
iii. Supply an air source to an operator/diver still inside the vehicle.
iv. Conduct a normal ascent while sharing air with the vehicle operator/diver.
v. Extricate and surface with an unconscious vehicle operator/diver.
vi. On the surface, perform rescue breathing for an unconscious, non-breathing diver.
vii. Recognize and respond to a distressed vehicle operator/diver while underwater.
viii. Recognize and respond to a distressed vehicle operator/diver on the surface.
ix. Demonstrate techniques for water egress with an unconscious diver.

x. Demonstrate proper first aid procedures for victims of pressure related and/or drowning injuries.

c) Lead Diver
   i. Meet the minimum requirements of Safety/support diver.
   ii. Demonstrate proficiency in diving accident management.
   iii. Submit a Dive Plan to include names, certification levels, and emergency contact information for all diving participants.
   iv. Submit with the Dive Plan an Emergency Action Plan to include: on-site rescue procedures, dispatch procedures/response times for emergency medical services, and location of nearest hospital and hyperbaric facility.

10.4 SUBMARINE LIFE-SUPPORT SYSTEMS

1. BREATHING MEDIA

   a) All breathing media shall be compressed atmospheric air unless approved by DSO. Special air mixes such as oxygen-enriched air (Nitrox) are prohibited by ISR regulations and cannot be used during races.

2. AIR CYLINDERS

   a) All breathing air cylinders shall be approved for use with scuba equipment and possess a current hydrostatic test and Visual Cylinder Inspection with appropriate stampings and stickers.

3. PRESSURE REGULATORS

   a) All breathing air must be delivered via a scuba regulator. In accordance with UW standards, all regulators must be inspected/serviced to the manufacturer's specification by a qualified service technician and approved for use by the DSO.

4. BREATHING AIR SUPPLY

   a) The primary air supply for each operator/diver shall be carried onboard the submarine. Volume of the air supply shall be sufficient to provide breathing air for a minimum of one vehicle speed run plus 150% in reserve capacity for each crew member. Diving will be terminated when any air supply reaches ≤500 P.S.I. All air pressure gauges shall be readily accessible if not continuously visible for ease of checking by both crew and support divers.

5. RESERVE AIR SUPPLY

   a) A reserve air supply shall be carried for each submarine operator/diver. These systems shall be self-contained and worn securely on the body. Volume of the reserve air supply shall be sufficient to enable the diver to egress the submarine and surface. The reserve air supply may be utilized for entering the submarine and preparing for a run, however, diving will be terminated when any air supply reaches ≤500 P.S.I.

   b) *Note regarding air supply: The diving supervisor will have complete discretionary authority with regard to allowing divers to enter the water, especially with less than a full cylinder of air. Divers must have sufficient air to complete their task (sub race, support assignment, etc.) and return to the dive station with a sufficient reserve of air for safety.*

10.5 SUBMARINE SAFETY REQUIREMENTS

1. SUBMARINE COLOR SCHEME

a) Regarding the Body/Hull, for the purposes of easy location, each submarine shall be painted with high-visibility coloration using light colors (i.e. white, yellow, orange, etc.). Florescent or contrasting schemes are advisable to make the submarine distinct.

b) Propeller tips must be painted or marked in bright orange for easy recognition by safety/support divers.

2. EMERGENCY EGRESS

a) Any and all exits that are to be used by the vehicle crew for emergency egress shall be clearly marked at the location of the handle or release mechanism by a 4" square orange patch bearing the word 'Rescue'. If this is not possible, the handle or release mechanism should be clearly marked with florescent tape at a minimum. The handle or release mechanism shall be easily accessible from both inside and outside the submarine. Safety and support divers must be familiar with the operation of the emergency egress mechanism(s).

3. CREW RESTRAINTS

a) Any method of attachment of a crew member to the submarine, such as restraining harnesses or toe-clips, must have the release system clearly marked with orange paint or florescent tape. Safety/support divers must be familiar with the release mechanisms of any/all crew restraints.

4. CREW VISIBILITY

a) View ports, windows, canopies, etc. shall be located on the submarine so that the crew has as unrestricted a view as possible, especially forward, for navigation purposes. Additionally, the crew face and head areas shall be visible to safety/support divers at all times.

5. STROBE LIGHT

a) Each submarine shall carry a flashing white strobe light that is visible for 360 degrees in the horizontal plane. The light should flash at an approximate rate of once per second, be visible for at least thirty feet under normal visibility conditions, have sufficient power to flash for one hour at a minimum, and be operating whenever the submarine is submerged. If preferred, the design may incorporate more than one strobe light, so long as the flash is visible for all 360 degrees in the horizontal plane.

6. EMERGENCY BUOY

a) All submarines shall carry a high visibility buoy that will release from the hull and float to the surface in the event of an emergency. The float must be attached to the submarine by thirty (30) feet of strong, highly visible line, at least 1/16" thick. Each crew member shall have a dead-man type switch that will automatically release the float in the event that they are disabled. Switch safety mechanisms may be employed during staging to prevent inadvertent release, but the switches MUST be activated whenever the submarine is operating.

b) 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. 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.

10.6 SUBMARINE SAFETY INSPECTION

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:

a) Life-support systems and air supplies
b) Emergency egress hatch and crew restraints
c) Emergency signal buoy

10.7 SUPPORT PERSONNEL

1. Safety/Support Divers

    a) During vehicle deployment and operation a minimum of two (2) Safety/Support Divers shall be in the water readily available to assist the submarine crew. Additional Safety/Support Divers should be staged nearby ready to enter the water in the event of an emergency.

    b) Safety/Support Divers shall be equipped as outlined in Section 3 of the UW Diving Manual.

    c) Support divers shall be equipped with octopus regulators so as to support submarine crew activities during ingress/egress of the submarine at depth. Octopus regulator hoses must be of sufficient length to accommodate the sharing of air while the operator/diver is inside the vehicle. All support divers are required to monitor their own air supply and shall not allow their air supply to fall below 500 P.S.I.

    Note regarding air supply: The lead diver will have complete discretionary authority with regard to allowing divers to enter the water, especially with less than a full cylinder of air. Divers must have sufficient air to complete their task (sub race, support assignment, etc.) and return to the dive station with a sufficient reserve of air for safety.

2. Submarine Lead Diver

    a) A qualified Lead Diver shall be on site and readily available at all times during water activities. The Lead Diver is responsible for ensuring that divers maintain compliance with UW diving standards including proper documentation of diving activities. The Lead Diver may also act as a Safety/Support diver.

    b) The Lead Diver will ensure that emergency first aid equipment, including emergency oxygen, is available at the dive site.

    c) The Lead Diver will ensure that participating divers record their activities on a standard UW Dive Log for submission to the DSO.

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SECTION 11 – 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 members using these must have guidelines established by their DCB. Divers must comply with all scuba diving procedures in this standard unless specified.

11.1 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-057 2005).

11.2 DIVER PROPULSION VEHICLE

Divers planning to dive using a diver propulsion vehicle must be authorized in their use by the DSO or DCB.

11.3 OVERHEAD ENVIRONMENTS

Where an enclosed or confined space is not large enough for two divers, a diver must be stationed at the underwater point of entry and an orientation line must be used.

11.4 SATURATION DIVING

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

11.5 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 monitoring his/her own depth, time, and diving profile.

11.6 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.

11.7 FULL FACEMASK AND HELMET

Divers using a full facemask or diving helmet must receive training from DSO or designee in the use of that specific model of mask or helmet.

11.8 ALTITUDE DIVING

Diving in altitudes higher than 300 meters/1000 feet above sea level requires special considerations and procedures and divers must comply with the guidelines of the OM.

SECTION 12 REBREATHERS

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

1. Training and/or experience verification requirements for authorization
2. Equipment requirements
3. Operational requirements and additional safety protocols to be used
4. Application of this standard is in addition to pertinent requirements of all other sections of this *Manual*.

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

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

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

12.1 Definition

1. 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.
2. There are three classes of rebreathers:
    a. 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 limited in depth of use due to the physiological limits associated with oxygen toxicity.
    b. 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.
    c. Closed-Circuit Rebreathers: Closed-circuit mixed gas rebreathers (CCR) recycle all of the exhaled gas. Electronically controlled CCRs (eCCR) replace metabolized oxygen via an electronically controlled valve, governed by oxygen sensors. Manually controlled CCR (mCCR) rely on mechanical oxygen addition and diver monitoring to control oxygen partial pressure (ppO_2). Depending on the design, manual oxygen addition may be available on eCCR units as a diver override, in case of electronic system failure. Systems are equipped with two cylinders; one with oxygen, the other with a diluent gas source used to make up gas volume with depth increase and to dilute oxygen levels. CCR systems operate to maintain a constant ppO_2 during the dive, regardless of depth.

12.2 PREREQUISITES FOR USE OF ANY REBREATHER

1. Active scientific diver status, with depth authorization sufficient for the type, make, and model of rebreather, and planned application.
2. Completion of a minimum of 25 open-water dives on open circuit SCUBA. The DCB may require increased dive experience depending upon the intended use of the rebreather system for scientific diving.
3. For SCR or CCR, a minimum 60-fsw-depth authorization 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 authorization 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.

12.3 TRAINING

1. Specific training requirements for use of each rebreather model must be defined by DCB on a case-by-case basis. Training must include factory-recommended requirements, but may exceed this to prepare for the type of mission intended (e.g., staged decompression or heliox/trimix CCR diving). (refer to training section for details.)
2. 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.
3. Post training supervised dives are required before the Scientific rebreather diver is authorized to use rebreather for research dives. (refer to training section for details).

Individual Equipment Requirements			
Key: X = include, IA = If Applicable			
	O_2	SCR	CCR
DCB approved rebreather make and model	X	X	X
Bottom timer, and depth gauge	X	X	X
Dive computer (separate from rebreather unit)		X	X
Approved dive tables		IA	IA
SMB (surface marker buoy) and line reel or spool with sufficient line to deploy an SMB from the bottom in the training environment	IA	IA	IA
Access to an oxygen analyzer	X	X	X
Cutting implement	X	X	X
BCD capable of floating a diver with a flooded loop and/or dry suit at the Surface	X	X	X
Bailout gas supply of sufficient volume for planned diving activities	X	X	X

12.4 EQUIPMENT REQUIREMENTS

1. General
    a. Only those models of rebreathers specifically approved by DCB shall be used.
    b. Rebreathers should meet the quality control/quality assurance protocols of the
    c. International Organization for Standardization (ISO) requirements: ISO 9004:
    d. 2009 or the most current version, AND successful completion of CE (Conformité
    e. Européenne) or DCB approved third party testing.
    f. Rebreather modifications (including consumables and operational limits) that deviate from or are not covered by manufacturer documentation should be discussed with the manufacturer and approved by the DCB prior to implementation.
2. Equipment Maintenance Requirements
    a. The DCB or their designee will establish policies for the maintenance of rebreathers and related equipment under their auspices. Rebreathers should be maintained in accordance with manufacturer servicing recommendations.
    b. Field repairs and replacement of components covered in rebreather diver training is not annual maintenance and may be performed by the rebreather diver in accordance with DCB policy.
3. A maintenance log will be kept and will minimally include:
    a. Dates of service
    b. Service performed
    c. Individuals or company performing the service

12.5 OPERATIONAL REQUIREMENTS

1. Dive Plan
    a. In addition to standard dive plan components, at a minimum all dive plans that include the use of rebreathers must include:
    b. Information about the specific rebreather model(s) to be used
    c. Type of CO_2 absorbent material
    d. Composition and volume(s) of supply gasses d) Bailout procedures
    e. Other specific details as required by the DCB
2. Particular attention should be paid to using rebreathers under conditions where vibration or pulsating water movement could affect electronics or control switches and systems.
3. Particular attention should be paid to using rebreathers under conditions where heavy physical exertion is anticipated.
4. Respired gas densities should be less than 5 $g \cdot L^{-1}$, and should not exceed 6 $g \cdot L^{-1}$ under normal circumstances.
5. User replaceable consumable rebreather components should be replaced per manufacture recommendations or as defined by the DCB.

6. If performed, periodic field validation of oxygen cells should be conducted per DCB designated procedure.
7. Diver carried off-board bailout is not required under conditions where the onboard reserves are adequate to return the diver to the surface while meeting proper ascent rate and stop requirements, and the system is configured to allow access to onboard gas. These calculations must take into consideration mixed mode operations where an open circuit diver could require assistance in an out of gas situation.
8. Use and reuse of CO_2 scrubber media should be per manufacture recommendations or as defined by the DCB.
9. Planned oxygen partial pressure in the breathing gas must not exceed 1.4 atmospheres at depths greater than 30 feet, or 1.6 at depths less than 30 feet.
10. Both CNS and Oxygen Tolerance Units (OTUs) should be tracked for each diver. Exposure limits should be established by the DCB.
11. The DCB or their designee will:
    a. Establish policies for the use of checklists related to rebreather operations.
    b. Establish policies for pre- and post- dive equipment checks to be conducted by their divers.
    c. Establish policies for disinfection of rebreathers to be used by their divers.
    d. Establish policies for pre-breathing of rebreathers used by their divers
    e. Establish policies for the use of mixed mode and mixed rebreather platform dive teams under their auspices.
        i. Mixed mode and/or mixed platform dive teams are permitted.
        ii. At minimum, divers must be cross briefed on basic system operations for establishing positive buoyancy, closing a rebreather diver's breathing loop, and procedures for gas sharing.
12. Establish policies for the maximum depth of dives conducted using a particular class of rebreather within the auspices of their diving operations.
13. Establish policies for depth authorization and maintenance for divers using rebreathers.
14. Establish policies for implementing workup dives within program
    a. Pre-operation workup dives, including review and practice of emergency recognition and response skills, and management of task loading are required for operations defined by the DCB as beyond the scope of normal operating conditions.
15. Establish policies for the minimum use of rebreathers to maintain proficiency.
    a. The minimum Annual rebreather diving activity should be 12 rebreather dives, with a minimum of 12 h underwater time.

b. To count, dives should be no less than 30 min in duration. A required element of maintaining proficiency is the periodic performance and reevaluation of skills. related to in-water problem recognition and emergency procedures

   i. Establish policies for reauthorization for the use of rebreathers if minimum proficiency requirements are not met.

   ii. Reestablishment of authorization to use rebreathers must require more than just performing a dive on a particular make or model of rebreather.

   iii. At minimum demonstrated skills included in the required training elements for the level of rebreather operation must be performed and reevaluated.

12.6 REBREATHER TRAINING SECTION

Entry Level Training

1. The training area for O_2 Rebreather should not exceed 20 fsw in depth.
2. Entry level CCR and SCR training is limited in depth of 130fsw and shallower.
3. Entry level CCR and SCR training is limited to nitrogen/oxygen breathing media.
4. Divers at the CCR and SCR entry level may not log dives that require a single decompression stop longer than 10 minutes.
5. Who may teach: Individuals authorized as a CCR, SCR, or O_2 Rebreather Instructor by the DCB; in all cases, the individual authorized must have operational experience on the rebreather platform being taught, and where applicable the individual being authorized should be authorized as an instructor by the respective rebreather manufacturer or their designee.
6. Maximum Student/Instructor Ratio: 4 to 1. This ratio is to be reduced as required by environmental conditions or operational constraints.
7. Upon completion of practical training, the diver must demonstrate proficiency in pre-dive, dive, and post-dive operational procedures for the particular model of rebreather to be used.
8. Supervised dives target activities associated with the planned science diving application. Supervisor for these dives is the DSO or designee, experienced with the make/model rebreather being used.

Rebreather Entry Level Training Requirements			
Key: X = include, IA = If Applicable, ISE = If So Equipped			
	O_2	SCR	CCR
Required Training Topic			
Academic			
History of technology	X	X	X
Medical & physiological aspects of:			
Oxygen toxicity	X	X	X
Chemical burns & caustic cocktail	X	X	X
Hypoxia – insufficient O_2	X	X	X
Hypercapnia – excessive CO_2	X	X	X
Arterial gas embolism	X	X	X
Middle Ear Oxygen Absorption Syndrome (oxygen ear)	X	X	X
Hygienic concerns	X	X	X
Nitrogen absorption & decompression sickness		X	X
CO_2 retention	X	X	X
Hyperoxia-induced myopia	X	X	X
System design, assembly, and operation, including:			
Layout and design	X	X	X
Oxygen control systems	X	X	X
Diluent control systems		ISE	ISE
Use of checklists	X	X	X
Complete assembly and disassembly of the unit	X	X	X
Canister design & proper packing and handling of chemical absorbent	X	X	X
Decompression management and applicable tracking methods		ISE	X
Oxygen and high pressure gas handling and safety	X	X	X
Fire triangle	X	X	X
Filling of cylinders	X	X	X
Pre-dive testing & trouble shooting	X	X	X
Post-dive break-down and maintenance	X	X	X
Trouble shooting and manufacturer authorized field repairs	X	X	X
Required maintenance and intervals	X	X	X
Manufacturer supported additional items (ADV, temp stick, CO_2 monitor,	ISE	ISE	ISE
Dive planning:			
Operational planning	X	X	X
Gas requirements	X	X	X
Oxygen exposure and management	X	X	X
Gas density calculations		X	X
Oxygen metabolizing calculations	X	X	X
Scrubber limitations	X	X	X
Mixed mode diving (buddies using different dive modes)	X	X	X
Mixed platform diving (buddies using different rebreather platforms)	X	X	X
Problem Recognition & Emergency Procedures:			
Applicable open circuit emergency procedures for common gear elements	X	X	X
Loss of electronics	ISE	ISE	X

Partially flooded loop	X	X	X
Fully flooded loop	X	X	X
Cell warnings		ISE	X
Battery warnings	ISE	ISE	X
High O_2 warning	ISE	ISE	X
Low O_2 warning	ISE	ISE	X
High CO_2 warning	ISE	ISE	ISE
Recognizing issues as indicated by onboard scrubber monitors	ISE	ISE	ISE
Recognizing hypercapnia signs and symptoms in self or buddy	X	X	X
Excluded O_2 cell(s)	ISE	ISE	ISE
Loss of Heads Up Display (HUD)	ISE	ISE	ISE
Loss of buoyancy	X	X	X
Diluent manual add button not functioning		ISE	ISE
O2 manual add button not functioning	ISE	ISE	ISE
Exhausted oxygen supply	X	X	X
Exhausted diluent supply		ISE	ISE
Lost or exhausted bailout	ISE	ISE	ISE
Handset not functioning	ISE	ISE	ISE
Solenoid stuck open	ISE	ISE	ISE
Solenoid stuck closed	ISE	ISE	ISE
ADV stuck open	ISE	ISE	ISE
ADV stuck closed	ISE	ISE	ISE
Isolator valve(s) not functioning	ISE	ISE	ISE
Oxygen sensor validation	ISE	ISE	X
CO_2 sensor validation	IA	IA	IA
Gas sharing	X	X	X
Diver assist and diver rescue	X	X	X
Other problem recognition and emergency procedures specific to the particular unit, environment, or diving conditions	X	X	X
Practical Training and Evaluations			
Demonstrated skills must include, at a minimum:			
Use of checklists	X	X	X
Carbon dioxide absorbent canister packing	X	X	X
Supply gas cylinder analysis and pressure check	X	X	X
Test of one-way valves	X	X	X
System assembly and breathing loop leak testing	X	X	X
Oxygen control system calibration	ISE	ISE	X
Proper pre-breathe procedure	X	X	X
In-water bubble check	X	X	X
Proper buoyancy control during descent, dive operations, and ascent	X	X	X
System monitoring & control during descent, dive operations, and ascent	X	X	X
Proper interpretation and operation of system instrumentation	X	X	X
Proper buddy contact and communication	X	X	X
Use of a line reel or spool to deploy an SMB from planned dive depth and while controlling buoyancy in the water column	X	X	X
Proper management of line reel or spool, and SMB during ascents and safety or required stops	X	X	X
Unit removal and replacement on the surface	X	X	X

Bailout and emergency procedures for self and buddy, including:			
System malfunction recognition and solution	X	X	X
Manual system control	ISE	ISE	ISE
Flooded breathing loop recovery	IA	IA	IA
Absorbent canister failure	X	X	X
Alternate bailout options	X	X	X
Manipulation of onboard and off board cylinder valves	X	X	X
Manipulation of bailout cylinders (removal, replacement, passing and receiving while maintaining buoyancy control)	ISE	ISE	ISE
Manipulation of quick disconnects, isolator valves, and manual controls specific to the unit and gear configuration	ISE	ISE	ISE
Proper system maintenance, including:			
Breathing loop disassembly and disinfection	X	X	X
Oxygen sensor replacement	ISE	ISE	ISE
Battery removal and replacement or recharging	ISE	ISE	ISE
Other tasks as required by specific rebreather models	X	X	X
Written Evaluation	X	X	X
Supervised Rebreather Dives	X	X	X

Entry Level Training – Minimum Underwater Requirements

	Pool/Confined Water	Open water	Supervised Dives
O2	1 Dive, 90 – 120 minutes	4 dives, 120 minute cumulative	2 Dives, 120 minute cumulative
SCR	1 Dive, 90 – 120 minutes	4 dives, 120 minute cumulative	4 dives, 120 minute cumulative
CCR	1 Dive, 90 – 120 minutes	8 dives, 380 minute cumulative	4 dives, 240 minute cumulative

Rebreather Required Decompression, Normoxic, and Hypoxic Mix Training

1. Required Decompression and Normoxic Training may be taught separately or combined.
2. Prerequisites:
    a. Required Decompression 25 rebreather dives for a minimum cumulative dive time of 25 hours
    b. Mixed Gas:
        i. Normoxic Mixes – 25 rebreather dives for a minimum cumulative dive time of 25 hours
        ii. Hypoxic Mixes – Rebreather Required Decompression Certification and Normoxic Certification and 25 decompression rebreather dives for a minimum cumulative dive time of 40 hours on dives requiring decompression
3. Who may teach: Individuals authorized as a CCR/SRC required decompression and/or Normoxic and/or Hypoxic Mix instructor by the DCB or their designee (this is in addition to the original authorization from section A #5)
4. Maximum Student/Instructor Ratio: 2 to 1. This ratio is to be reduced as required by environmental conditions or operational constraints

5. Upon completion of practical training, the diver must demonstrate proficiency in pre-dive, dive, and post-dive operational procedures for the particular model of rebreather to be used
6. Supervised dives target activities associated with the planned science diving application. Supervisor for these dives is the DSO or designee, experienced with the make/model rebreather being used

Rebreather Required Decompression, Normoxic & Hypoxic Mix Training Requirements			
Key: X = include, IA = If Applicable, ISE = If So Equipped			
	Deco	Normoxic	Hypoxic Mixes
Required Training Topic			
Academic			
Review of applicable subject matter from previous training	X	X	X
Medical & physiological aspects of:			
Hypercapnia, hypoxia, hyperoxia	X	X	X
Oxygen limitations	X	X	X
Nitrogen limitations	X	X	X
Helium absorption and elimination		X	X
High Pressure Nervous Syndrome (HPNS)			X
System design, assembly, and operation, including:			
Gear considerations and rigging	X	X	X
Gas switching	X	X	X
Dive planning:			
Decompression calculation	X	X	X
Gradient Factors	X	X	X
Scrubber duration and the effects of depth on scrubber function	X	X	X
Gas requirements including bailout scenarios	X	X	X
Bailout gas management – individual vs team bailout	X	X	X
Gas density calculations	X	X	X
Operational Planning	X	X	X
Equivalent narcosis depth theory		X	X
Gas selection, gas mixing and gas formulas		X	X
Problem Recognition & Emergency Procedures:			
Applicable open circuit emergency procedures for common gear	X	X	X
Flooded loop	X	X	X
Cell warnings	X	X	X
Battery warnings	X	X	X
Hypercapnia, hypoxia, hyperoxia	X	X	X
Practical Training and Evaluations			
Demonstrated skills must include, at a minimum:			
Proper demonstration of applicable skills from previous training	X	X	X
Proper manipulation of DSV and/or BOV	X	X	X
Proper descent and bubble check procedures	X	X	X

Proper monitoring of setpoint switching and pO2 levels	X	X	X
Proper interpretation and operation of system instrumentation	X	X	X
System monitoring & control during descent, dive operations, and ascent	X	X	X
Demonstrate the ability to manually change setpoint and electronics settings during the dive	ISE	ISE	ISE
Demonstrate buoyancy control; ability to hover at fixed position in water column without moving hands or feet	X	X	X
Demonstrate controlled ascent with an incapacitated diver including surface tow at least 30 meters / 100 feet with equipment removal on surface, in water too deep to stand	X	X	X
Onboard and off board valve manipulation for proper use, and reduction of gas loss	X	X	X
Diagnosis of and proper reactions for a flooded absorbent canister	X	X	X
Diagnosis of and proper reactions for CO2 breakthrough	X	X	X
Diagnosis of and proper response to Cell Errors	X	X	X
Diagnosis of and proper reactions for Low oxygen drills	X	X	X
Diagnosis of and proper reactions for Flooded Loop	X	X	X
Diagnosis of and proper reactions for High Oxygen Drills	X	X	X
Diagnosis of and proper reactions for electronics and battery	X	X	X
Operation in semi-closed mode	X	X	X
Properly execute the ascent procedures for an incapacitated dive	X	X	X
Proper buddy contact and communication	X	X	X
Use of a line reel or spool to deploy an SMB from planned dive depth and while controlling buoyancy in the water column	X	X	X
Proper management of line reel or spool, and SMB during ascents and safety or required stops	X	X	X
Demonstrate the ability to maintain minimum loop volume	X	X	X
Demonstrate comfort swimming on surface and at depth carrying a single bailout/decompression cylinder/bailout rebreather	X		
Demonstrate ability to pass and retrieve a single bailout/decompression cylinder or bailout rebreather while maintaining position in the water column	X		
Demonstrate ability to pass and receive multiple bailout/decompression cylinders or bailout rebreather while maintaining position in the water column	IA	X	X
Demonstration of the ability to perform simulated decompression stops at pre-determined depths for scheduled times	X	X	X
Demonstration of the ability to perform decompression stops at pre-determined depths for scheduled times	X	X	X
Demonstrate competence managing multiple bailout cylinders, including drop and recovery while maintaining position in the water column	IA	X	X

Demonstrate appropriate reaction to simulated free-flowing deco regulator	X	X	X
Gas share of deco gas for at least 1 minute	X	X	X
Demonstrate oxygen rebreather mode at appropriate stop depth		X	X
Complete bailout scenarios from depth to include decompression obligation on open circuit	X	X	X
Written Evaluation	X	X	X
Supervised Rebreather Dives	X	X	X

Minimum Underwater Requirements			
	Pool/Confined	**Openwater**	**Supervised Dives****
Deco	1 Dive / 60 min	7 Dives / 420 min	4 Dives / 240 min.
Normoxic	1 Dive / 60 min	7 Dives / 420 min	4 Dives / 240 min.
Deco/Normoxic Combined	1 Dive / 60 min	7 Dives / 420 min 3 Normoxic Dives / 180 min	4 Dives / 240 min.
Hypoxic Mixes		7 Dives / 420 min	4 Dives / 240 min.
**A minimum of three supervised dives should comply with authorization parameters			

1. Rebreather Crossover Training
    a. Crossover training to a new rebreather platform requires a minimum of 4 training dives for a minimum cumulative dive time of 240 min.
    b. Advanced level certification on a new rebreather platform may be awarded upon successful demonstration of required skills using the new platform

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SECTION 13 – SCIENTIFIC CAVE AND CAVERN DIVING STANDARD

This standard helps to ensure all scientific diving in overhead environments is conducted in a manner that 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 must 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 University of Washington 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.

This section defines specific considerations regarding the following issues for Scientific Cavern and Cave diving:

5. Training and/or experience verification requirements for authorization
6. Equipment requirements
7. Operational requirements and additional safety protocols to be used

Application of this standard is in addition to pertinent requirements of all other sections of this *Manual*.

For cavern or cave dives that also involve staged decompression, rebreathers, and/or mixed gas diving, all requirements for each of the relevant diving techniques, modes, or gases must be met.

No diver must conduct planned operations in caverns, caves, or other overhead environments without prior review and approval of the DCB or designee. The diver must demonstrate that he/she possesses the proper attitude, judgment, and discipline to safety conduct cave and cavern diving in the context of planned operations.

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

13.1 Definition

A dive team must 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. In addition to blocking direct access to surfacing, underwater caves have additional environmental hazards including but not limited to:

1. The absence of natural light.

2. Current or flow 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.
3. The presences of silt, sand, mud, clay, etc. that can cause visibility to be reduced to nothing in a very short time.
4. Restrictions – Any passage through which two divers cannot easily pass side by side while sharing air make air sharing difficult.
5. Cave-Ins – Cave-Ins are a normal part of cave evolution; however experiencing a cave-in during diving operations is extremely unlikely.

13.2 Prerequisites

Prerequisites	Cavern: OC or Rebreather	Cave	Rebreather Cave
Active scientific diver status, with depth qualification sufficient for proposed training location(s)	X	X	X
Completion of a minimum of 25 dives.	X		
Cavern Diver Authorization		X	X

13.3 Training

Training	Cavern: OC or Rebreather	Cave OC	Rebreather Cave
Key: X = include, R = Review, IA = If Applicable, OC = Open Circuit			
Trainers must be qualified for the type of instruction to be provided. Training must be conducted by agencies or instructors approved by the DCB or their designee	X	X	X
Academic			
Policy for diving overhead environments	X	X	X
Environment and environmental hazards	X	X	X
Accident analysis	X	X	X
Psychological considerations	X	X	X
Required equipment and equipment configuration			
Single cylinder with H or Y Valve	IA	IA	
Doubles with Isolation Manifold	IA	IA	
Side Mount		IA	IA
No Mount		IA	IA
Stage Cylinder(s)		IA	IA
Off-board Bailout	IA		X
Communications	X	X	X
Diving techniques			
Body control	X	X	X
Navigation and guidelines	X	X	X
Entry and Exit Protocols (Right of Way)	X	R	R
Use of line arrows and cookies	X	X	X
Line Systems Applicable to the Area and/or Cave System	X	R	R
Line Jumps		X	X

Circuits		X	X
Dive planning			
Rule of Sixths	X	R	R
Rule of Thirds	X	R	R
Gas Matching	IA	X	X
Decompression Theory	R	R	R
Dive Tables	R	R	R
Mixed Mode Diving	IA	IA	IA
Cave geology	X	R	R
Cave hydrology	X	R	R
Cave biology	X	X	X
Emergency procedures	X	X	X
Practical Training and Evaluation			
Land Drills			
Line Reel Use	X	R	R
Techniques and Considerations for Laying a Guideline	X	X	X
Guideline Following	X	R	R
Buddy Communication	X	R	R
Team Positioning for Normal Entry and Exit	X	X	X
Zero Visibility Drills			
Line Reel Use	X	R	R
Line and Line Arrow Identification and Following	X	R	R
Bump and Go (Skills description)		X	X
Emergency Procedures			
How Far Can You Go Out Of Gas?(Skills description)	X	X	X
Team Positioning for Emergency Situations	X	X	X
In-Water			
Demonstrated skills must include, at a minimum:			
A minimum of four (4) cavern dives, preferably to be conducted in a minimum of two (2) different caverns	X		
A minimum of twelve (12) cave dives, preferably to be conducted in a minimum of four (4) different cave sites with differing conditions		X	X
Safety drill (S-drill) – Performed on every dive			
Review of Dive Plan and Turn Pressures	X	X	X
Essential Gear Identification, Positioning, and Function Check	X	X	X
Proper Valve Position Check	X	X	X
Bubble Check	X	X	X
Proper Buoyancy Compensator Use	X	X	X
Proper Trim and Body Positioning	X	X	X
Hovering and Buoyancy With Hand Tasks	X	X	X
Specialized Propulsion Techniques and Anti-Silting Techniques (modified flutter kick, modified frog kick, pull and glide, ceiling walk or shuffle)	X	X	X
Proper Light and Hand Signal Use	X	R	R
Proper Reel and Guideline Use	X	X	X

Ability to Deploy a Primary Reel and Tie Into a Main Line Under Different Conditions (Flow, Visibility, Bottom/Silt, etc.)	X	X	X
Proper Line Placement and Etiquette	X	X	X
Proper Use of Safety Reel		X	X
Proper Use of Jump/Gap Reel(s)		X	X
Use of Drop/Stage Cylinders			
Proper Placement and Retrieval of Cylinder(s) With Minimal Disturbance of Environment and Visibility		IA	IA
Ability to Deploy and Retrieve Cylinders With Minimal Loss of Forward Progress		IA	IA
Surveying	IA	IA	IA
Ability to Properly Critique Their Dives and Performance	X	X	X
Zero Visibility Drills	IA	X	X
Line Reel Use	X	R	R
Buddy Communication	X		
Line and Line Arrow Identification and Following	X	R	R
Bump and Go (Skills Description)		X	X
Emergency Procedures			
Team Positioning for Emergency Situations	X	X	X
Lost Line (Skills Description)		X	X
Lost Buddy	X	X	X
Gas Sharing While Following Guideline (Conducted with and without visibility, As Donor and Receiver)	X	X	X
Gas Sharing in a Minor Restriction Using a Single File Method As Donor and Receiver		X	X
Valve Manipulation	X	X	X
Proper Attitude, Judgment, and Discipline To Safely Conduct Dives In An Overhead Environment	X	X	X
Written Examination			
A written evaluation approved by the DCB with a predetermined passing score, covering concepts of both classroom and practical training	X	X	X

13.4 Equipment Requirements

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

Minimum Equipment	Cavern OC	Rebreather Cavern	Cave OC	Rebreather Cave
Key: X = include, R = Review, IA = If Applicable, OC = Open Circuit				
At a minimum, a single cylinder with adequate volume and configured to allow divers to exit from farthest/deepest penetration while supporting self and dive buddy equipped with a "K" valve; standard OC regulator configuration (Section 3.2); and BCD	X			

At minimum, a single cylinder equipped with an "H" or "Y" valve Or an alternate gas supply with adequate volume and configured to allow divers to exit from farthest/deepest penetration while supporting self and dive buddy			IA	
Off-board/bailout gas supply of sufficient volume and configured to allow diver to exit from farthest/deepest penetration	IA	X		X
A BCD capable of being inflated from the cylinder	X	X	X	X
Slate and pencil	X	X	X	X
A functioning primary light with sufficient burn time for the planned dive			X	X
Two functioning battery powered secondary lights	X	X	X	X
Two cutting devices	X	X	X	X
One primary reel of at least 350 feet (106 m) for each team	X	X	X	X
Safety reel with at least 150 feet (45.6 m) of line			X	X
Directional Line Markers			X	X
Cylinders with dual orifice isolation valve manifold Or independent SCUBA systems* with enough volume for the planned dive plus required reserve			X	
Two completely independent regulators, at least one of each having submersible tank pressure gauge and a low pressure inflator for the BCD			X	
One regulator to be configured with a five foot or longer second stage hose			X	
Rebreather		X		X
Off-board Bailout of sufficient capacity for the diver to exit to the surface		X		X
*Independent SCUBA systems must be configured to allow for monitoring of gas pressures in each cylinder				

13.5 Operational Requirements and Safety Protocols

Operational Requirements and Safety Protocols	Cavern	Cave
Diving must not be conducted at penetration distance into the overhead environment greater than 200 feet (60 m) from the water's surface, with a depth limit of 100 feet (30 m)	X	
Dive teams must perform a safety drill prior to each dive that includes equipment check, gas management, and dive objectives	X	X
Each team within the overhead 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	X	X
Gas management must be appropriate for the planned dive with special considerations made for; DPV's, siphon diving, rebreathers, etc.	X	X
The entire dive team is to immediately terminate the dive whenever any dive team member calls (terminates) the dive	X	X

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SECTION 14 – UNDER ICE DIVING

14.1 PURPOSE AND GENERAL COMMENTS:

The purpose of these regulations is to provide information and a framework for safe diving in the under ice environment. While these diving regulations cover special conditions, the other provisions of the UW Diving Safety Manual apply also. Additionally, Divers planning to dive under ice or in polar conditions should reference the most current NSF Division of Polar Programs, Standards for Conduct of Scientific Diving as outlined in the NSF Office of Polar Programs Safety and Occupational Health Policy.

Much of the information in this document has been gained from under ice diving experience in the Arctic. Beginning in the late 1950's, the UW conducted under ice diving in the Arctic and has continued this specialty diving up to the present day. These dives were under ice, eight (8) to 20 feet thick, in shallow water in Prudhoe Bay, up to as far as 150 to 300 miles or more offshore in the Beaufort Sea, and in recent years, during the recovery of scientific equipment at the North Pole.

Clearly, diving under a hard ice cover increases the safety risks and consequently requires special procedures and equipment. In addition, low temperature and remote locations place added risk factors on this type of Self Contained Underwater Breathing Apparatus (SCUBA) diving. In early under ice diving, before the advent of modern dry suits, divers in custom fitted wet suits lasted only about 20 minutes before their hands became so cold and stiff that they were unable to manipulate their diving equipment and emergency gear. Special diving equipment designed to function in freezing water was imported from Sweden (Poseidon diving regulators and Unisuits).

In Arctic under ice diving, the temperature of the water just below the ice may be as low as -1.8 degrees C (29 degrees F) due to the depression of the freezing point of sea water by the salt content of the water. Since this water is often already at the freezing point, heat absorption by the expansion of the compressed gas breathing medium, as it passes through the regulator first (1st) stage valve, leads to the rapid formation of a layer of ice around the casing of the 1st stage of the regulator.

This layer of ice may affect the ambient pressure reference port of the SCUBA regulator and lead to a freeze up condition with subsequent failure of the regulator, most often in "free flow" condition. This free flow condition is manifested by an increase in "intermediate pressure" causing the downstream second (2nd) stage valve to be forced open--resulting in the rapid loss of air out the 2nd stage exhaust port. This phenomenon may be intermittent and manifested by voluminous puffing of air into the divers full face mask and hood.

Consequently, this critical piece of equipment, the diving regulator, must be carefully selected and prepared for this special environment. SCUBA regulators to be used for under ice diving must have special design provisions to reduce the likelihood of freezing malfunction of the regulator 1st stage. (Refer to supplementary Information, Section 14.11 for more information). Also, to reduce the likelihood of internal freezing of 1st stage regulator mechanism, air compressors for under ice diving air are often equipped with an extra filter canister to remove excess moisture from the breathing air delivered by the compressor.

14.2. DIVE ENVIRONMENT

Under ice diving may take place in many locations—frozen lakes, under the Arctic ice cap, Antarctic ice sheets, special experimental tanks, etc. Water depths may vary from 20 feet to 4000 meters.

The diving environment under the Arctic icecap may be quite variable with respect to the morphology of the underside of the ice, smooth rolling features or fractured blocks of ice pushed

down to 100 feet below the surface by ice motion on the surface. Light conditions vary with the time of the year, ice thickness and snow cover-- often requiring the use of underwater lights. Depending on weather conditions, the ice may be actively moving and shifting, forming pressure ridges, etc. or be quiescent for days at a time.

Ice movement activity can change rapidly. Even though there may not be any local wind and the weather calm, thick plates of ice, in an ice covered ocean, may suddenly fracture due to forces transmitted over relatively long distances. In addition to the formation of rubble fields, this can result in rafting of large pieces of ice over and under each other and the closure of open leads. Always, it is safest to have more than one artificial access hole through the ice for divers. Even then, there is the risk of ice "rafting" and blocking off a diver access hole.

Generally, underwater visibility is excellent. In one instance, horizontal visibility was measured at 500 feet in crystal clear water. Divers could see clearly, a chain of Nansen water sample bottles descending into the depths from a nearby hydrographic hut on the ice. Also, vertical visibility may be excellent as evidenced by the reflection off the top of an instrument housing at 400 feet under the ice. These are the typical visibility conditions far out in the ice pack in March, and April. Later in the year, when the sun angle increases, visibility may be reduced due to a plankton bloom under the ice.

14.3 MEDICAL/PHYSICAL CONSIDERATIONS

Often, under ice diving takes place in remote locations such as in the Arctic where conditions above and below the ice are harsh and physically demanding both in terms of physical work and heat loss to the environment. Still air temperatures during February, March and April in the Arctic typically may be -37 degrees C (-35 degrees F) during the day. The effect of the wind chill can increase the heat loss rate appreciably.

Participants should be in top physical condition without any medical conditions that might require an emergency evacuation. Physical examinations for field personnel should take into account the special conditions in this type of environment.

14.4 SAFETY

These under ice diving regulations cover basic operations. Under ice diving operations vary considerably and consequently, the Dive Team Leader or DTL (with the agreement of the divers) must be prepared to respond to changing conditions in the field to ensure the diving operation is carried out in a safe manner.

Two access holes through the ice are required, especially if scientific equipment is being launched through one hole for placement, or recovery under the ice. However, in rare circumstances if the scientific equipment is such that it would not block egress of divers in any emergency situation or can be removed quickly to allow divers to exit the water, then one hole may be used for both the divers and equipment. In this case the whole must be a minimum of 48 inches in diameter.

The DTL and the divers should evaluate the situation and require a second entry hole if, in their opinion, the scientific equipment may be a potential safety problem. (Also, refer to Section 14.11 of this manual for further comments regarding diver entry holes.)

Voice communications between the divers and tenders on the surface of the ice are of paramount importance during under ice diving. Consequently, hard-wired voice communications are required for under ice diving.

All divers must be tethered with a safety and communications line during the dive. At no time may a diver unclip from the harness while under water without advising the Dive Manager (DM) on the surface that there is an emergency need to unclip from the tender/communications line.

Tenders must be familiar with under ice diving and the tasks to be accomplished on the dive. Also, they must be trained to operate the communications system in the event an emergency occurs and they need to take over operation of the communications. Tenders must be Active Scientific Divers. In the event of a complete failure of the hard wire voice communications system, the divers must abort the dive and initiate the use of their spare components for the hard wired voice communication system.

If only one diver has a communications problem, i.e. failed microphone, the DM on the surface and the divers must decide whether to abort the dive or complete their underwater task. If the diver with the communications problem elects to abort the dive, then the team must terminate the dive.

However, if they are just about to complete their task, and the communication failure only affects one diver, they might (with the concurrence of the DDM on the surface), finish up the underwater task and then terminate the dive. If it is the start of the dive operation, then they should abort and replace the malfunctioning components of the hard wired voice communication system.

As a last resort in extreme circumstances, such as total communication failure and there is a need for recovery only, the dive team may resort to “line pull” communications. It is not a recommended communications technique due to problems affecting the line at the bottom corner of the entry hole which can lead to misinterpretations of the line pull communications.

Tenders must be well versed in “line pull” signals used for underwater communications as well as how to tend the diver- i.e. when to add, hold or take up the safety line connected to the diver. Divers should carry a table sealed in plastic showing the line pull signals. There should also be a line pull signal table in the communication box available for tenders.

Refer to Section 14.11 of this manual for table with “Line Pull” communication signals

Voice communications between divers and the surface should be concise and unambiguous. Divers should use terminology such as “Diver “A” calling surface—slack my line.” This alerts the DM on the surface that a message is starting and who is talking. Often, a standard technique in voice communications is to state the name of the station being called followed by the station calling. In this case, “Surface, Diver “B”:--take up my slack” and so on. An agreed upon system for voice communications should be established and practiced prior to deployment of the diving operation.

“Slack” means the tender should let out more safety line slowly. Only the diver knows the condition of his safety line and must advise the DM regarding the condition of the diver’s safety line.

“Up Rope” means the tender should take up slack slowly until advised by the diver to “Hold”.

“Hold” means the tender should hold the line and be ready to support the weight of the diver if need be. The diver may drop down below the bottom of the ice to search for a scientific package in the distance and hence needs to be kept from sinking too deep. In under ice “blue water” dive conditions, it is difficult for the diver to judge distances and consequently may sink deeper than intended unless held in position by the dive tender.

Although Decompression Sickness (DCS) events are less probable due to typically shallow nature of under ice diving, fatigue and stress may increase the probability of a DCS event. Divers must be alert and capable of coherent, decisive action in the event of an emergency during the dive. Diver rest periods prior to diving should be included in the planning for the under ice diving operations.

In the Antarctic, the effect of a "polar low" (low barometric pressure) produces an average annual "pressure altitude" at sea level at McMurdo Station equivalent to an actual altitude of 200 meters (650 feet). During some periods, the "pressure altitude" at sea level at McMurdo may be equivalent to an actual altitude as high as 335 meters (1100 feet). Consequently, dives at or near the decompression limit are not permitted.

After long periods of arduous work on the surface helping out with the field operations on the surface, divers must take the time to be properly rested and hydrated prior to diving under the ice. They are not permitted to dive when fatigued.

Divers have the right to refuse any dive and must not be reticent to demand appropriate rest prior to diving under the ice regardless of aircraft schedules and other requirements not directly related to diving safety.

Emergency Oxygen must be available at the dive site with enough oxygen available to get the injured diver or divers to another oxygen supply or to a hospital or recompression chamber. Remote Emergency Medical Oxygen (REMO) kits or additional oxygen cylinders can address this requirement. .

Also, an extended temperature range Automatic Emergency Defibrillator (AED) kit should be available and divers trained in its use. Not all AEDs are designed for operating in the low temperatures encountered in the Arctic. Due to the low ambient temperatures, many temperature sensitive items may need to be marked “keep warm” and provided with special handling after their arrival on the ice.

14.5 DIVE OPERATION PLANNING

Anticipating under ice diving operations, the DTL must submit dive and emergency plans complete with a training schedule.

These plans must be submitted sufficiently prior to the field operation to allow evaluation by the University of Washington DSO and the DCB.

This submission of the dive plan before deployment will provide sufficient time for the DSO to evaluate the equipment and techniques to be used and for “in water” evaluation of the dive team members during the pre-deployment training of the under ice dive team.

Failure to submit Dive plans for under ice diving in a timely manner will result in denial of under ice diving activities.

All diving equipment intended for this specialized under ice diving must be reviewed and approved by the DSO.

Diving in remote areas such as the North Pole, in the Arctic or in the Antarctic requires special attention to the dive plan and emergency evacuation plan. Due to logistics considerations, aircraft or surface evacuation may be delayed by many hours or possibly days, depending on weather conditions at both the remote site and the nearest site with medical facilities to deal with dive related injuries.

Because of possible delays, provisions must be made for sufficient oxygen (and more efficient use of oxygen using the DAN REMO unit) for several days and an extended temperature range AED unit to be available.

Emergency evacuation plans must include provisions for alternate evacuation scenarios depending on weather and evacuation mechanisms (Aircraft, surface, ships, etc.) available at the time of the emergency.

Dive team organization for under ice diving must be as follows:

A DTL, who is an Active Scientific Diver, must be designated and is responsible for preparing the field operations dive plan and dive team and submitting same to the DSO. The DTL is in overall charge of the under ice diving operations in the field.

For each dive a Dive Manager or DM, who is an Active Scientific Diver, must be designated. The DM will be responsible for all aspects of that particular diving operation and in charge of the divers and tenders. Normally, the DM will operate the communications set on the surface and direct the tenders during the dive.

On the two-person diving team, a "Lead Diver" (LD) will be designated who will be in charge of the underwater work during the dive. Normally, the LD will be the most experienced under ice diver and will enter the water first.

Under ice diving operations will be controlled by availability of emergency transport by helicopter, fixed wing aircraft, or over ice/land vehicle and will be a function of the weather at both the dive site and the nearest medical facility or transfer point to reach medical facilities.

In other words, the flying weather must be satisfactory for air operations at both the dive site as well as the home base of operations where medical treatment is available. This does not mean that air craft must be at the dive site, but in the event of an emergency, must be available to respond to the situation.

14.6 DIVE EQUIPMENT

Due to the low temperature conditions encountered in under ice diving, equipment used in this type of diving must be especially prepared to minimize possible failures.

Each diver must have a complete set of equipment appropriate for the under ice dive operations. Backup or spare equipment to replace malfunctioning equipment should be included in dive planning and support equipment used in the field operation.

Under ice divers must wear a Buoyancy Control Device (BCD) and not rely on their dry suit inflation to maintain buoyancy. Normally, only a small amount of air is added to the dry suit to reduce the heat loss while diving. The primary device for buoyancy control is the standard BCD used in SCUBA diving. Dive team members should familiarize themselves with their dive buddy's BCD and the method for dumping weights prior to any under ice dive.

This equipment set must be approved by the DSO.

The best safety option is to provide uniformity of operation and diver familiarization with equipment emergency procedures. Regulators, BCD's, and weight release mechanisms for under ice diving should be identical. However, while diver preference for BCD's may allow some choice, the Safe second regulators and the emergency bailout systems should be located in the same location or side on each diver.

Breathing air regulators for under ice diving must have "anti-freeze" features designed into the regulator for cold water diving—anti-freeze caps or air bleed ports to minimize the likelihood of a 1st stage freezing malfunction. Refer to Section 14.11 of this manual.

To prevent laryngeal spasm or loss of facial muscle control, a full face mask, (AGA, Poseidon, EXO, etc.) or other suitable mask with provisions for communication system is required.

A "hard wire" voice communication system is required for all under ice dives. In the event of the failure of the primary communication system, a backup voice communications system is required—(i.e. spare cables, microphones, deck box, etc.).

Divers with BCDs with integrated weight systems must put at least half their weights on a separate weight belt equipped with over center toggle buckle or a clamp buckle with only a short amount excess belt length outside the clamp buckle. The weight belt must be able to fall free and clear of any other accessories that might be attached to the diver's lower extremities such as a knife.

Each diver must have two completely separate air systems. The two separate systems may be connected to the full face mask with a Redundant Supply Valve (RSV). If a RSV is used, there must also be an additional second stage regulator as part of the emergency backup system. This allows for "bailout" if the RSV fails.

A separate bail out mask and 2nd stage attached to the pony bottle are required. This is required even if a RSV is used.

When using RSV's, a pressure relief valve or safe second regulator must be connected to the primary air system to prevent hose failure in the event of a freezing malfunction of the primary air supply system after the diver has switched to the secondary air supply system with the RSV unit.

Dry Suits must be in good condition and suitable for under ice diving. Dry seal gloves are recommended. If neck seals, wrist seals, or waterproof zippers are questionable, they should be serviced prior to under ice diving operations. Spare seals and adhesives must be included in the on-site spare equipment supplies.

Gauntlet three finger mitts or gloves may be used instead of dry gloves. If wet gloves are used they must be at least 5mm thick.

If a member of a dive team becomes cold, (e.g. his hands become stiff) and there is the danger of being unable to function in an emergency, the dive must be aborted.

Primary SCUBA tanks must provide, at least, 120 cu. ft. of breathing medium. Other combinations such as twin 80 cu. ft. tanks may be appropriate depending on the dive operation requirements. Low pressure steel tanks are acceptable, but each diver must have a minimum of 120 cu. ft. of breathing gas in the primary cylinder.

The required separate emergency air supply may be provided by a "pony" (bail out) bottle. A minimum size of 30 cu. ft. is required, but due to increased air consumption in under ice diving with a full face mask, larger sizes may be in order depending on the under ice diving operations. Past experience has shown that divers can use up, as much as, 160 cu.ft. (twin 80 cu. ft. tanks) in short order depending on the under ice work load. Consult with the DSO for questions regarding air supplies for under ice diving.

A safety harness, separate from the tending/communications line, must be worn around the diver's body. The safety harness should be positioned around the diver's upper body under the arms and across the chest with a lead off line to the connection point between the harness and the tending line. The lead off line must long enough for manipulation by the diver, but be positioned between the diver and his tanks to provide for removal of the diver from the diving access hole, even in the event that the diver is unconscious. This harness position should enable tenders to remove the diver from a 36 inch diameter hole in the ice without the diver turning crosswise at the bottom of the hole.

The safety harness should be a "double braid" line at least ½ inch thick and attached to the diver in a "figure 8" pattern over the shoulders with the loops clipped together in the front across the chest

with a carabineer. Pre-sewn 48 inch slings are also acceptable. The release mechanism must be the same for all divers—usually, a carabineer works well.

The safety harness must be worn over the dry suit and under all other dive gear. The safety harness must be arranged so that it cannot slip off over the arms and head in the event the SCUBA equipment is removed. The diver must be able to remove all dive gear without disconnecting the safety harness. The safety harness may not be merely connected to one of the "D" rings on the divers BCD.

The tending/communications line with its hardware connection (carabineer) to the safety harness must be capable of lifting the diver out of the diving hole. (NOTE: A fully equipped under ice diver may weigh as much as 350lbs. in air).

The tending/communications line must be marked at 10 ft. intervals with distance indicators showing the distance of tending line paid out. The markers must be secured so as to prevent slippage or movement in either direction on the diver's safety line.

To eliminate potential tangles, the communications cable should be enclosed inside a braided safety/strength member.

Each diver must carry an underwater light for signaling in the event of an emergency or for use should light conditions change during the dive.

In addition the required diver's knife, cutting tools, such as special scissors, bolt cutters or notched jaw cable cutters capable of cutting whatever line or wire that may be encountered must be available to the divers.

14.7 TRAINING

Divers participating in under ice diving should be trained and thoroughly familiar with the specialized under ice diving equipment. Prior to field operations, six to 10 or more training dives with complete under ice diving equipment must be included in the dive plan. Particular attention must be paid to "bail out" practice—changing from primary air supply to back up or emergency air supply.

Each diver participating in under ice diving must be trained for the special conditions, equipment and emergency procedures required for this specialized diving.

Divers must have completed Dry Suit Training and be comfortable utilizing a dry suit.

Divers must be trained in the proper use and maintenance of the full face masks and communication system.

Full face masks provide for communications systems, but present a problem with dual air systems. Bailing out of a full face mask is not a simple task due to the manipulation of emergency backup systems and the potential of laryngeal spasm from contact with the cold water on the divers face. Back up air system may use a RSV to connect the regulator bail out, to mask and primary tank.

Each diver must participate in a sufficient number of training dives prior to deployment in the field to be comfortable with equipment and bailout procedures. If RSV's are used the diver must also be proficient in removing the full face mask and switching to a backup mask and regulator.

Additional training, for each diver, with any specialized underwater equipment is required prior to its use in the field. Any special underwater equipment must be inspected and approved by the DSO.

Tenders must be trained in proper line tending including line pull communications and when to pay out line, hold or retrieve line. Tenders must practice tending during at least two of the training dives.

14.8 EQUIPMENT PREPARATIONS

All dive equipment must be maintained in proper working order for extreme cold environments. In addition to prevention of regulator freeze up, BCD inflator mechanisms should be overhauled prior to under ice diving, sprayed with silicone spray, and checked regularly. Air 2 and similar breathing devices on BCDs must be maintained as regulators and not as inflators.

The on-site DM is responsible for checking the diver's equipment prior to each dive. The DM is responsible to check the communications system prior to diver entry into the water.

Divers and tenders both must check equipment and air supplies prior to each dive.

A heated shelter is required at the dive site for the divers and dive equipment to prevent "cold soaking" exposure of the divers and dive equipment to the very low surface temperatures. It is important to minimize exposure of the divers and their equipment to low temperatures prior to the dive.

If this shelter is helicopter transported, then the dive equipment must be secured with appropriate clamps, straps or other devices during helicopter transport.

Also, the shelter must have oxygen, first aid kit, AED tools, and spare parts kits present.

14.9 DIVING OPERATIONS

Each dive team must consist of two divers, one of which will be designated LD, two tenders, and a DM, who manages the surface dive operations and communications. Also, under special circumstances, the DM may be a tender. The communications operator at the surface must be a Scientific Diver.

If the dive operation is remote from a base camp of operations, appropriate radio communications equipment must be present at the remote dive site in order to communicate with the base camp. The base camp must be monitoring the assigned communications frequency during and after the diving operation until the DM advises that the dive is over and there is no need for emergency assistance.

The actual two-person diving team must consist of at least one well experienced under ice diver.

Divers who have no under ice diving experience must participate in a familiarization dive under the ice with an experienced under ice diver prior to commencing underwater work.

The conditions must be clear for flying at the dive site and the main base to which injured divers will be taken in case of emergency.

The diver entry hole must be designated for divers only. No equipment must prevent the divers from exiting at any time during the dive. If there is any equipment under the ice which could slide into the hole and cannot be immediately removed by hand by the tenders at the surface, then a second diver entry hole is required. No equipment which could hinder the divers' immediate exit may be placed into or released from the diver entry hole.

Each under ice diver must have a separate tender. One tender may not to serve two divers. Tenders must be active Scientific Divers.

The DM must check both diver's equipment prior to their entering the water. After initial water entry, the LD should wait near the hole for the 2nd diver to enter.

If and when the DM advises the divers that the under ice dive is to be terminated for safety reasons, the divers must return to the entry hole and end the dive.

Divers must check each other's equipment at the bottom of the hole prior to commencing the diving operations. In particular, they should check for crossed lines, clear safe second regulators and check each other's equipment, especially to ensure air tank valves are fully open according to standard procedures. During this initial check, tenders should hold "fast" the tending line to prevent the diver from sinking and allow the divers to adjust their buoyancy.

> Note: In the past while passing down through a 36 inch diameter hole, some SCUBA tank air valves were rotated slightly closed by contact with the sides of the entry hole resulting in air difficulties. If possible, tank valve handles should be positioned to prevent contact with the sides of the entry hole (i.e. rotation) during diver entry through a hole in the ice.

However, the tank valves positions should always be checked by the divers at the bottom of the hole prior to their departure to complete their underwater tasks. Once the all ready message is given by the divers, the tenders may relax their hold on the tending line according to the divers dictates and allow the divers to proceed with the dive.

On a regular basis, divers should ensure their safety line is not in danger of entanglement. Also, they must advise their tender regarding the amount of line to feed out or take in to prevent large loops in their safety line.

When commencing work around lines and cables (e.g. from vertical instrument arrays released from the ocean bottom and resting against the underside of the ice), a "notched jaw" cable cutter capable of severing the wires or Kevlar line with a single quick closure. (refer to Section 14.11 of this manual for information on this type of cutter) should be available to the divers.

> Note: These cable cutters are not the same as bolt cutter—there is a notch in one jaw of the cutter that will hold the cable and produce a quick, clean shearing separation of the cable or wire being cut. One brand is H.K. Porter, shear type cable cutters—MTN series.

To provide mutual assistance, under ice divers should stay as close to each other as possible during the dive commensurate with preventing tangling of safety lines.

Divers cannot dive more than 200 feet from the diver entry hole. Safety and communications lines must be 50 feet longer than the 200 foot limit.

When the divers return to the entry hole, prior to exiting, the most experienced diver should exit last—waiting at the bottom of the hole, while the less experienced diver exits. Divers are not to continue working or stray from the entry hole while the other diver exits. Divers must exit the water with no less than 500 psig in their primary cylinder.

If voice communications fail or divers have to switch to emergency backup air supply, the divers must abort the dive and return to the surface immediately.

14.10 FIELD OPERATIONS

When divers are in the water, the dive operation takes precedence over all other field operations until the divers are out of the water. If helicopters are used for diver support they may not be "borrowed" for other field operations when divers are in the water.

14.11 SUPPLEMENTARY INFORMATION

Any requests for a variance of these regulations for special circumstances must be submitted in writing to the UW DSO well in advance of the dive project. Such requests will be reviewed by the DSO, and possibly, by the DCB.

Regulator Freezing Mechanism

Most persons are aware of the basic physics effect that occurs when a compressed gas is expanded through a nozzle or valve (such as a diving regulator). The expansion of the gas absorbs heat from the surrounding area and leads to a rapid drop in temperature within the valve or nozzle. When diving in water that is already at or below the freezing point of fresh water, this can lead to a rapid buildup of ice around the 1st stage and to some extent is a potential problem in the second stage. However, due to the large pressure drop from the tank pressure to the pressure at the 2nd stage valve, the predominant manifestation of this phenomenon is seen in the thick layer of ice that may form around the casing of the first stage of the SCUBA diving regulator.

To allow a diver to breathe, SCUBA diving regulators have to maintain a set pressure over the ambient pressure in the hose between the 1st and 2nd stage of the regulator. Typically, they have a pressure reference port which allows for automatic adjustment of the pressure in the hose to the 2nd stage, maintaining this set value above the ambient pressure. This set pressure is often referred to as the "intermediate pressure" setting of the regulator.

Although intermediate pressures are variable depending on the regulator design, they often range from 125 to 180 PSI above the ambient pressure at any particular depth.

One technique used to provide this automatic adjustment of the pressure is to use a spring/diaphragm mechanism. When the regulator is turned on and quiescent, the forces on the diaphragm are balanced by air pressure on one side and the spring on the other side (water side).

As the diver descends in the water column, the pressure on the spring side of the diaphragm increases due to an increase in ambient pressure, the diaphragm moves inward and forces open the high pressure valve. The air pressure increases and pushes the diaphragm outward until the high pressure valve closes when the pressure on the air side equals the set pressure plus the ambient.

Piston type regulators work in the same way with the spring pushing on a piston with an O-ring seal. Changes in pressure allow the spring to push open the piston allowing the air pressure inside the regulator to balance the water pressure on the outside of the regulator.

If the spring is not protected from ambient water at the "ice point", ice will form between the coils of the spring preventing it from closing the high pressure valve which leads to an ever increasing intermediate pressure with subsequent free flowing of air at the 2nd stage of the regulator. Consequently, regulators must have provisions for anti-freeze first stages. This is for both the primary and secondary regulators used on the main tank and pony bottle.

Recommended regulators are the Poseidon Xstream, and Poseidon Jet Stream regulators, which have proven themselves in extreme diving conditions encountered in under ice diving.

Special Tools for Under Ice Diving

H.K. Porter notched jaw cable cutters (refer to above, section 14.9)

Extendable boat hook:

Safety device for use by tenders in an emergency.

Diver Entry Hole

Cutting a diver entry hole in sea ice is not a trivial operation. We have tried many different methods, from explosives to special melter devices. For thin ice, (up to about 36 inches thick), a chain saw with a long blade is usually convenient, albeit quite dangerous for obvious reasons.

Explosives might sound like a suitable mean for opening a dive and equipment hole in the ice for diving, but usually the safety concern for handling and transporting explosives are not worth the trouble vs. the efficiency of this method. When blasting through ice, the ice usually is blown skyward and then returns to the place it left, requiring considerable work to "muck" out the slush and fragments of the original ice. In addition, we have experience dealing with "sensitized" explosives that did not detonate in the initial blast and consequently are very dangerous to handle afterwards.

A simple method for diver entry holes in thick ice is to use a thermal melter. Basically, this device is a diesel fuel fired boiler that melts an annular hole in the ice, cutting at a rate of about six (6) feet per hour (with a 36 inch diameter cuter ring). After the melter cuts through to seawater, it is removed and the floating ice plug is extricated using a tripod, ice chisels and chainsaws to separate the plug into sections that can be lifted with a tripod and chainfall. To cut through 6 feet of ice with a 36 inch diameter melter ring and remove the plug requires about two (2) to 2 ½ hours.

A 36 inch diameter hole is about as small a hole as one might want to use for access through thick ice. A fully equipped diver with twin tanks, bail out tank and full arctic diving gear pretty much fills up that hole—his face mask is only a few inches from the side of the hole during entry.

SCUBA Diving Line Pull Signals	
2-2-2 Pulls	I am fouled and need assistance of another diver
3-3-3 Pulls	I am fouled but can clear myself
4-4-4 Pulls	Haul me up immediately
All signals are to be answered as received except for the emergency signal 4-4-4.	

Tender to Diver	
1 Pull	"Are you alright?" When descending, one pull means "Stop."
2 Pulls	"Going down." During ascent, 2 pulls means "You have dome up too far- go back down until we stop you."
3 Pulls	"Stand by to come up."
4 Pulls	"Come up."
2-1 Pulls	"I understand."

Diver to Tender	
1 Pull	"I am alright" or "I am on bottom."
2 Pulls	"Lower or give me slack."
3 Pulls	"Take up my slack."
4 Pulls	"Haul me up."
2-1 Pulls	"I understand."
3-2 Pulls	"More air."
4-3 Pulls	"Less air."

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APPENDIX 1 – DIVING FORMS

Diving forms are available online:

Diving Safety

- Diving Registration Form (pdf)
- Consent and Understanding of Risk Form (pdf)
- Dive log form (Requires Log-in)(Fill-in online)

For medical forms please contact the Employee Health Center at emphlth@uw.edu. For more information regarding the medical approval process please refer to the Medical section.

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APPENDIX 2 – RECOMMENDED PHYSICIANS WITH EXPERTISE IN DIVING MEDICINE

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

1. _Divers Alert Network_____

   Name

   The Peter B. Bennett Center, 6 West Colony Place, Durham, NC 27705 USA

   Address

   _Non-emergency medical questions 1-919-684-2948_____

   Telephone

2. _____

   Name

   _____

   Address

   _____

   _____

   _____

   Telephone

3. _____

   Name

   _____

   Address

   _____

   _____

   _____

   Telephone

_____

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APPENDIX 3 – DEFINITION OF TERMS

AAUS - American Academy of Underwater Sciences is an organization that provides a forum for the regular exchange of ideas and experiences among underwater scientists. It is recognized by OSHA as the scientific diving standard setting organization.

Acfm - Actual cubic feet per minute.

AGE - Arterial Gas Embolism

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

ATA(s) - Abbreviation for "Atmospheres Absolute", defines as the total pressure exerted on an object, by a gas or mixture of gases, at a specific depth or elevation, including normal atmospheric pressure.

ASME - American Society of Mechanical Engineers.

Blue-Water Diving - Specific diving technique where the divers are suspended in the water column without visual reference to the bottom. This technique is normally used for in-the-environment observation, manipulation and sampling of planktonic organisms.

Boat Tender - A qualified individual who will operate small boats for divers in areas of high current, night, or blue water diving.

Bottom Time - The total elapsed time in minutes from the time the diver leaves the surface in descent to the time the diver begins ascent.

Bounce Dive - A dive of relatively short duration. Generally less than 10 minutes.

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

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

Buddy Diver - Second member of the dive team.

Buddy system -Two comparably equipped scuba divers in the water in constant communication, and close enough to render assistance if needed.

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

Buoyancy Control Device (BCD) - A floatation type vest that will allow the diver to establish neutral buoyancy in the water column. (Refer to Section 3.2 Flotation Devices)

Burst Pressure - The 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 recognized certifying agency.

Certified Scientific Diver - A diver who is recognized by the University as having current proficiency and medical qualifications to perform diving operations under the auspices of the University within provisions of the Diving Safety Manual.

Compressor - A machine used to compress air or gas to elevated pressures. This gas is normally stored in cylinders for diver use.

Commercial Diver - A diver hired for underwater work that is engaged in commercial diving operations and must adhere to OSHA regulations.

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

Cylinder - An unfired pressure vessel for the storage of compressed gases.

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

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

Decompression Meter - A Dive Computer which has the design capabilities to provide decompression dive planning schedules, to provide data on safe decompression stops during the dive and on the ascent to the surface, and to provide a missed decompression or ascent rate warning. (Refer to also Dive Computer)

Deeper Spike Dive - A diving technique where the deepest part of the dive does not occur at the beginning of the dive.

Designated Person-in-Charge - Supervision requirement for Surface Supplied diving mode. An individual designated by the OM DCB or designee with the experience or training necessary to direct and oversee surface supplied diving operations.

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

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

Dive Computer - A microprocessor based device which computes a diver's theoretical decompression status, in real time, by using pressure (depth) and time as input to a decompression model, or set of decompression tables, programmed into the device.

Dive Location - A vessel, structure, shore base, or physical location from which a diving operation is conducted.

Dive Plan - A pre-arranged sequence of underwater events constituting the anticipated dive. The dive plan must incorporate emergency planning. (Refer to Emergency Plan)

Dive Physician - UW, EH&S designated board certified hyperbaric physician.

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

Dive Teams - Divers and immediate support persons who are exposed to hyperbaric conditions or control the exposure of others in diving operations, including the designated person-in-charge.

Dive Timer - A dive watch or other suitable timing device worn by each member of a dive team.

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

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

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

Diving Control Board (DCB) - The group of individuals who act as the official representative of the University of Washington in matters concerning the scientific diving program (refer to Section 1.2). The Executive Director of Health Sciences will appoint the members of the diving control board.

Diving Manager (DM) – Responsible for all aspects of particular diving operations and is in charge of the communications, divers and tenders.

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

Diving Officer (DO) - A staff member of Friday Harbor Laboratories responsible for overseeing diving operations at the field station.

Diving Safety Officer (DSO) - A staff member of EH&S that is responsible for the Diving Safety Program. (Refer to Section 1.2 of this manual).

Dive Team Leader (DTL) - who is an Active Scientific Diver, must be designated and is responsible for preparing the field operations dive plan and dive team and submitting same to the DSO. The DTL is in overall charge of the diving operations.

EAD - An abbreviation for Equivalent Air Depth (see below).

EH&S - Environmental Health and Safety Department

Embolism - Dispersion of alveolar gas into the pulmonary venous system as a result of an over pressurization.

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

Emergency Communications - A telephone or VHF-FM radio located at the dive site for contacting emergency medical and transportation personnel (EMS) in the event of an accident. Portable telephones and radios shall have the wattage needed to reach the nearest EMS available to the intended dive site location (typically the highest wattage available).

Emergency Medical Services (EMS) - Local city, county, state, or military agency that provides emergency medical and transportation assistance.

Emergency Oxygen - A portable oxygen system, capable of being used to ventilate a non-breathing diver or used to administer O_2 to an injured breathing diver, shall be available at each dive site. Training is required for usage of emergency oxygen equipment.

Emergency Plan - A pre-arranged plan for providing on-site emergency first aid, contacting the nearest EMS, and arranging transportation to the nearest emergency facility or operational hyperbaric recompression chamber.

Enriched Air Nitrox (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” (refer to Section 7).

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

fN2 - fraction of nitrogen in a gas mixture, expressed as either a decimal or percentage, by volume.

fO2 - fraction of oxygen in a gas mixture, expressed as either a decimal or percentage, by volume.

FSW - Feet of seawater, or equivalent static head.

Hookah Diving - 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.

Hyperbaric Chamber – Refer to decompression chamber.

Hyperbaric Conditions - Pressure conditions in excess of normal atmospheric pressure.

In-water Stage - A suspended underwater platform that supports a diver in the water.

Lead Diver (LD) - The certified scientific diver with experience and training to conduct the diving operations and who has been designated to be in charge of the diving operation.

Line-Tended Diving - A diving technique where the diver is tethered by a line or umbilical to a tender on the dive platform. (refer to Tender)

Live-boating - The practice of supporting a diver from a vessel that is underway.

MAST – Military Assistance to Safety and Traffic

Maximum Allowable Working Pressure - The maximum pressure to which a containment device may be exposed under operating conditions.

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

MOD - Maximum Operating Depth, usually determined as the depth at which the pO2 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 or EANx.

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 - Time and depth limits that will permit the diver to ascend directly to the surface, without required decompression stops for off gassing excess nitrogen.

Normal Ascent - An ascent made with an adequate air supply at a rate not to exceed thirty feet per minute.

Octopus Regulator – Refer to Safe Second Regulator.

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

Oxygen Clean - All combustible contaminants have been removed.

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

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

Oxygen Toxicity - Any adverse reaction of the central nervous system ("acute" or "CNS" oxygen toxicity) or lungs ("chronic", "whole-body", or "pulmonary" oxygen toxicity) brought on by exposure to an increased (above atmospheric 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 – Refer to cylinder.

pN2 - Inspired partial pressure of nitrogen, usually expressed in units of atmospheres absolute.

pO2 - Inspired partial pressure of oxygen, usually expressed in units of atmospheres absolute.

Psi (g) - Pounds per square inch (gauge).

Reciprocity - The process, subject to local ground rules, under which divers from one agency or institution, are normally granted equivalent diving privileges by another agency or institution under equally acceptable training and certification standards.

Recompression Chamber - A pressure vessel for human occupancy, such as a surface recompression chamber, or deep diving systems used to decompress divers and to treat decompression sickness.

Reverse Dive Profile – A dive profile that has a deeper dive preceded by a shallow dive.

Safe Second Regulator - An extra second stage regulator and low-pressure hose attached to a SCUBA regulator's first stage. This extra regulator is used in an emergency to share air as an alternative to buddy breathing.

Safety Stop - A two (2) to three (3) minute stop at 20 feet, during a no-decompression ascent at the end of a dive. During this stop, the diver's tissue gas load is reduced thereby reducing the possibility of bubble formation.

Scientific Diver-in-Training - A diver who has completed all of the initial certification requirements and is approved for diving under University auspices while accompanied by a University certified scientific diver. The diver must log 12 dives with certified scientific divers to complete the certification process.

Scientific Diving - Scientific Diving is defined (29 CFR 1910.402) 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 (SCUBA).

Spike Dive - A single dive profile with the shallow part of the dive prior to the deep dive of short duration.

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

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

Swimming Ascent - An ascent that can be done under normal or emergency conditions accomplished by simply swimming to the surface. May be aided by some positive buoyancy control device.

Tank - A pressure vessel for the storage of gases. (Refer to Cylinder)

Tender - A surface support person responsible for handling a single diver's umbilical and for maintaining voice and/or standard line signal communications. The tender's attention must be solely on the diver while he/she is in the water. The tender must be an active Scientific Diver who is familiar with the required emergency equipment and plan, available at the site.

Tethered Diving - The diver is connected to the surface, drop line, or dive buddy via a line or umbilical. (Refer to Line Tended Diving)

Treatment Table - A depth, time and breathing gas profile designed for recompression chamber treatment of pressure related injuries.

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

University Auspices - University sanction of diving involving the use of University property, equipment, facilities, or support in connection with occupation, research, academic instruction or training, and certification for University diving.

Visiting Diver Certification - Short-term authorization to dive. This certification is valid only for the period specified.

Volume Tank - A pressure vessel connected to the outlet of a compressor and used as an air reservoir.

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

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APPENDIX 4 – DIVING EMERGENCY MANAGEMENT PROCEDURES

A. GUIDELINES FOR FIELD MANAGEMENT DECISION MAKING

1. Accurate diagnosis is sometimes difficult for a diving accident; signs and symptoms may be equivocal, difficult to define, wax and wane, and change in location and nature and sometimes in character.
2. Decompression sickness tends to progress from minor to major involvement, however, may diminish in severity or show no change.
3. Several independent problems are often present together.
4. Delays in treatment bring risk of further involvement, render existing conditions more difficult to resolve, and may contribute to reoccurrence of symptoms after treatment.
5. The magnitude of exposure (or closeness to table limits) is not a reliable guide to the severity of the potential involvement. Even dive profiles well within the decompression limits have resulted in decompression sickness.
6. Denial or fear of potential hassle, embarrassment, errors in judgment, etc. precipitate many unnecessary delays.

B. RECOGNITION OF DECOMPRESSION SICKNESS

Symptoms will appear **50%** of the time within **1 hour** after the dive.

Symptoms will appear **90%** of the time within **6 hours** after the dive.

Symptoms will appear **99%** of the time within **12 hours** after the dive.

Symptoms may appear within **24 - 48 hours** after the dive, however this is rare. Symptoms occurring after this delay often result in non-recognition of their cause.

C. DOCUMENTATION

With pencil and paper reconstruct dive profiles and unusual occurrences, note significant medical history, and note current medications.

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APPENDIX 5 – DIVING EMERGENCY MANAGEMENT PROCEDURES

I. DIVING FIRST AID AND TREATMENT

A. GENERAL

When administering first aid, it is essential to evaluate the victim's condition accurately and elect an appropriate course of action. The information available from either the patient or the bystanders, the diagnostic signs, the physical mechanisms of injury, or an emergency medical alert card or tag may all have to be evaluated rapidly. Two rapid evaluations, primary and secondary, must be performed. The primary search is for immediate life-threatening problems, while the secondary examination is an evaluation of other injuries that do not pose a threat to life. Though several conditions can be considered life threatening, two in particular require immediate attention: respiratory arrest (cardiac arrest) and severe bleeding.

An important factor in administering first aid, and one often overlooked, is the attitude of the persons administering the aid. They should help to inspire confidence by presenting a panic-free appearance. In serious injuries, victims should not be told the extent of their injuries. Knowing the actual extent of the injuries could cause unnecessary excitement and panic and lead to complications and deepening shock.

B. INJURY SURVEY

1. Primary Survey Sequence

* Check for adequate breathing; establish an open airway.
* Check for pulse; if none, begin CPR.
* Check for severe bleeding injury.

2. Secondary Survey Sequence

The purpose of the secondary survey is to find any additional unseen injuries that might cause serious complications if aggravated by mishandling. The secondary survey is a careful and cautious head-to-toe examination, during which the victim is checked very carefully for wounds, blood, swelling, fractures, nerve damage, neck and back injury.

C. FIRST AID

1. **Hypothermia**

As cold exposure continues both in and out of the water, hypothermia (loss of body heat) causes progressive symptoms. This progression will affect the diver's memory, time estimation and judgment causing him/her to be unreliable, particularly in an emergency situation. Frequently the diver may not realize the condition he/she is in. As always, prevention is the key.

Signs and Symptoms: shivering, confusion, lack of coordination, lack of consciousness, dilated pupils, irregular heartbeat.

The near-drowning victim may only appear to be dead. The cold-immersed victim may be cold to the touch, have apnea (no breathing), cyanosis (blue skin), fixed and dilated pupils, and barely or impalpable pulses. Clinically, the victim appears dead.

Treatment - Recoveries have been reported in cold-water submersions (near-drowning) after victims have spent as long as 40 minutes under water. Standard CPR should be administered and continued throughout the rewarming period in a medical facility. This may require as long as one (1) to two (2) hours.

An effective rewarming technique consists of providing warmed air or gas for inhalation. This can be done by mouth-to-mouth resuscitation, even if the diver is still breathing spontaneously.

If a shower or bath is available use the following techniques:

- Do not remove the suit, but instead, carry the dressed victim to the showers.
- Direct the shower spray to the trunk, trying not to get hot water on the extremities.
- The water temperature should be about 110 F, which is readily tolerated.
- For a bath, leave the diving suit on and place the victim in the bath with the extremities outside the bath.
- As recovery begins, the vital signs should be monitored.
- When noticeable improvement has occurred, remove the victim from the bath or shower and wrap in a blanket for further rewarming.

Watch closely for recurring symptoms, the release of cold blood from the extremities during rewarming can cause a dangerous fall in body core temperature.

In less severe cases, hot beverages can be given and while this will provide negligible amounts of heat, it will help to correct dehydration.

2. **Vertigo**

True vertigo is a disorder of spatial orientation characterized by a sense that either the individual or the surrounding is rotating. Vertigo can result from cold water entering the external ear canal, unequal ear clearing during ascent or descent, inner ear barotrauma, ear drum rupture with cold water entering the middle ear, or injury to the central nervous system.

Signs and Symptoms: nausea, vomiting, visual disturbance, fainting, generalized sweating, ear pain, hearing loss, ringing.

Treatment - When under water, the diver's response to true vertigo should be to immediately stabilize by grasping a firm object for tactile orientation and then establish which way is the surface.

Once dizziness is experienced during diving, examination by a specialist is necessary before any further diving is attempted.

3. **Carbon Monoxide (CO) Poisoning**

While there are usually no symptoms prior to unconsciousness, there may be the following:

Signs and Symptoms: headache, nausea, dizziness, weakness, feeling of tightness in the head, confusion, clumsiness, shortness of breath, abnormal redness or blueness of lips,

fingernails and skin, unconsciousness, cessation of breathing

The classic sign, "cherry-red" lips, may or may not be seen, and is therefore not a reliable diagnostic aid.)

Treatment - A source of fresh air or CPR should be provided for the victim, and, if available, oxygen. Some after effects such as a headache and nausea may persist after exposure. If a recompression chamber is available, treatment using U.S. Navy Treatment Table 5 or 6 is indicated.

4. **Lung Over-pressure Accidents**

Lung (pulmonary) over-pressure accidents occur when the breath is held during ascent or when local air is trapped in a part of the lung and expands during ascent. When the gas pressure in the air sacs of the lung (alveoli) exceeds ambient water pressure by about 100 mmHg, air is forced from the alveoli into the lung tissue (mediastinal and subcutaneous emphysema), through a tear in the pleura (pneumothorax), or into pulmonary veins (gas embolism). A pressure of 100 mmHg represents only about 4 fsw. Thus, lung over-pressure accidents have occurred in surprisingly shallow depths.

a) **Gas Embolism**

When divers hold their breath or have local air trapping in their lungs during ascent, the pressure-volume relationships discussed above can occur. Alveoli can rupture or air can somehow be forced across apparently intact alveoli. If air bubbles enter the pulmonary veins, they are swept to the left side of the heart and pumped out into the aorta. Bubbles can enter the coronary arteries supplying the heart muscle, but more commonly are swept up the carotid arteries causing an embolism the brain. As the bubbles pass into smaller arteries, they reach a point where they can move no further, and they begin to stop circulation. Symptoms of gas embolism thus occur immediately or within three (3) to five (5) minutes after surfacing. This is an absolute medical emergency and requires immediate treatment. One, a few, or all of the symptoms may be present. Both gas embolization and decompression sickness are disorders that affect the whole body. Symptom-producing organs may vary, but the whole body is nonetheless involved.

Signs and Symptoms: Visual disturbances such as blurring, dizziness, chest pain, cough or shortness of breath, numbness and tingling, headache, sudden unconsciousness (usually immediately after surfacing, possibly before surfacing), bloody, frothy sputum, loss of sensation over part of body, blindness (partial or complete), confusion, cessation of breathing, paralysis or weakness.

Treatment - A potential rescuer must consider the fact that most embolism victims are also near-drowning victims and that the victim may need stabilization and medical management at the nearest medical facility.

100 % oxygen should be administered, if available, and the patient should be moved, as rapidly as possible, to a recompression chamber with a 6-ATA capability.

This is a minute-to-minute emergency transfer. The speed and the effectiveness of the patient's recovery from the injury decreases with each minute lost in getting him/her under pressure. If air transportation is required, the patient must not be exposed to decreased cabin pressure; an aircraft capable of being pressurized to sea

level must be used. If a helicopter or unpressurized aircraft is used, it must not exceed a few hundred feet of altitude.

Always proceed as rapidly as possible to the nearest adequate facility. Cases have been reported of excellent results, even after several hours delay. Early oxygen therapy is vital and may reduce symptoms, but this must not change the treatment plan. Subtle symptoms may remain or return in the future. Victims are not to be taken back into the water for treatment.

b) **Mediastinal Emphysema**

Mediastinal emphysema (air under the skin of the chest) may result from a ruptured pleural bleb or injury to the lung, esophagus, trachea, or main stem of the bronchus. Though not serious in itself, it demonstrates that the lung has been over-pressurized and close examination for gas embolism symptoms or signs is required.

Signs and Symptoms: pain under the breastbone (which may radiate to the neck, neck, bone, or shoulder), shortness of breath, faintness, blueness or cyanosis of the skin, lips, or fingernails, difficult breathing, shock, swelling around the neck, A brassy quality to the voice, A sensation of pressure on the windpipe, swollen area beneath the skin that feels like crumpled cellophane.

Treatment - Unless air embolism is also present, recompression is not necessary for mediastinal emphysema. Seek medical assistance and administer oxygen if necessary.

c) **Subcutaneous Emphysema**

Subcutaneous emphysema has the same cause as gas embolism but is not nearly as serious. This condition results when air escapes into the tissues just under the skin (subcutaneous), normally in the area of the neck and collarbone.

Signs and Symptoms: feeling of fullness in neck area, change in sound of voice, swelling or inflation around the neck, crackling sensation when skin is moved, difficulty in breathing or swallowing.

Treatment - Unless complicated by air embolism, recompression is not necessary. Seek medical assistance and administer oxygen if breathing is impaired.

d) **Pneumothorax**

A pneumothorax is the result of air between the lung and the inner wall of the chest cavity. As the air expands during ascent there is partial or total collapse of the lung. In serious cases, the heart may be displaced. Even without pressure from expanding gas, the ruptured lung may partially collapse interfering with the normal respiratory process.

Signs and Symptoms: sudden onset of cough, shortness of breath, sharp pain in the chest usually made worse by breathing, swelling of neck veins,

blueness (cyanosis) of skin, lips and fingernails, pain in chest (usually high on the side under the arm), A tendency to bend the chest toward the side involved, rapid, shallow breathing, irregular pulse.

Treatment - Unless complicated by air embolism, recompression is not necessary. Transport to the nearest health care facility for insertion of a chest tube. Severely limit activity levels and if breathing is impaired, administer oxygen.

APPENDIX 6 – VISITOR DIVING REGULATIONS

All visitors intending to engage in diving under University of Washington auspices must apply for and receive permission to dive from the:

Diving Safety Officer (DSO) – William Love

Environmental Health & Safety
Box 357165
1705 N.E. Pacific St
Magnuson Health Sciences Center T-287
Seattle, WA 98195
Phone (206) 616-3776 or FAX (206) 221-3068
E-mail wlove@uw.edu

Or

Diving Officer (DO) – Pema Kitaeff

Friday Harbor Laboratories
620 University Rd.
Friday Harbor, WA 98250
Phone (206)543-0876 (360) 378-2165 or FAX 543-1273
E-mail pema@u.washington.edu

Visitors intending to engage in diving at the University's FHL must indicate this on their application forms and receive approval to dive.

In addition to receiving approval from the Marine Superintendent and vessel captain, visitors intending to engage in diving from University research vessels must complete their University diving certification process before arriving at the vessel.

Visiting divers, from an institution with a diving safety program that is in compliance with OSHA's requirements for commercial or scientific diving or is an organizational member of the American Academy of Underwater Sciences, may receive a reciprocity waiver of some of the certification requirements.

A. VISITING DIVER WITHOUT RECIPROCITY

Application - The applicant must provide written evidence of sponsorship by an appropriate University organizational unit. This should be accomplished at least 30 days prior to any diving activity.

Certified Diver Training - The applicant must provide evidence of diving proficiency for the intended diving activity. This evidence can usually be supplied by submitting the completed University Diving Registration and Consent Form (refer to Appendix 1), a copy of a recognized SCUBA certification card, and a copy of diving logs (last 12 dives).

Certified First Aid and CPR Training - The applicant must also provide evidence of training in First Aid including Oxygen administration for diving accidents and CPR.

Physical Examination - The applicant must also provide evidence of current physical fitness for diving equal to that required for the University diver (refer to Section 6). It is expected that this physical examination will be furnished by the applicant or by the applicant's parent institution.

If the physical examination is not completed before arrival or if the examination is incomplete then the applicant may arrange to complete the examination through with the Employee health Center. In this event, the applicant should be prepared for a two-week processing time for the physical examination results.

Arrival and Check-Out - The applicant will present his credentials upon arrival at the University or its field station. If all documents are in order, the visitor will be informed of the requirements for diving in accordance with University regulations, and if not already accomplished, will execute the Diving Registration form. The applicant may be required to complete a written exam (testing for basic SCUBA safety, diving related first aid and emergency procedures, and University diving operations) and an open water check-out dive.

B. VISITING DIVER WITH RECIPROCITY

Application - The applicant must provide written evidence of sponsorship by an appropriate University organizational unit. This should be accomplished at least 30 days prior to any diving activity.

Scientific Diver Certification - The diver presents a card or letter indicating current scientific diver certification at the parent institution. This or attached document must indicate the date of the latest medical examination and be signed by the DSO or a member of the DCB.

Reciprocity - The diver has a Letter of Reciprocity completed and signed by their home organization's DSO or DCB.

Arrival and Check-Out - Before or upon arrival at the University campus, University research vessel, or FHL, the visitor must present the reciprocity form plus proof of certification from the parent institution. The diver will then complete the Diving Registration, receive a brief orientation to the local environment, to shipboard operations and to the university safety procedures and, at the discretion of the DSO, have an open water dive to review skills and rescue techniques.

C. DIVING REGULATIONS AND PROCEDURES

Visiting divers must, at a minimum, adhere to regulations and procedures in the University of Washington Diving Safety Manual. Should there be a conflict between the requirements of the parent institution's and the UW's policy and procedure, this should be brought to the attention of the DSO or DO at FHL.

D. DIVING EQUIPMENT

The University's regulations require that all equipment used by the visiting diver meet the regulations set forth in the Diving Safety Manual. Diving cylinders must bear registration numbers, current hydrostatic and internal inspection test dates. The diver should be equipped with an adequate personal flotation device, depth gauge, submersible pressure gauge, dive timer, knife, wet or dry suits, etc., as required for the particular diving activity and this environment.

E. DIVE LOGS

All visiting divers will observe the University diving log out procedures and file logs of all dives under University auspices with the University vessel captain, the DO, or the DSO before departing.

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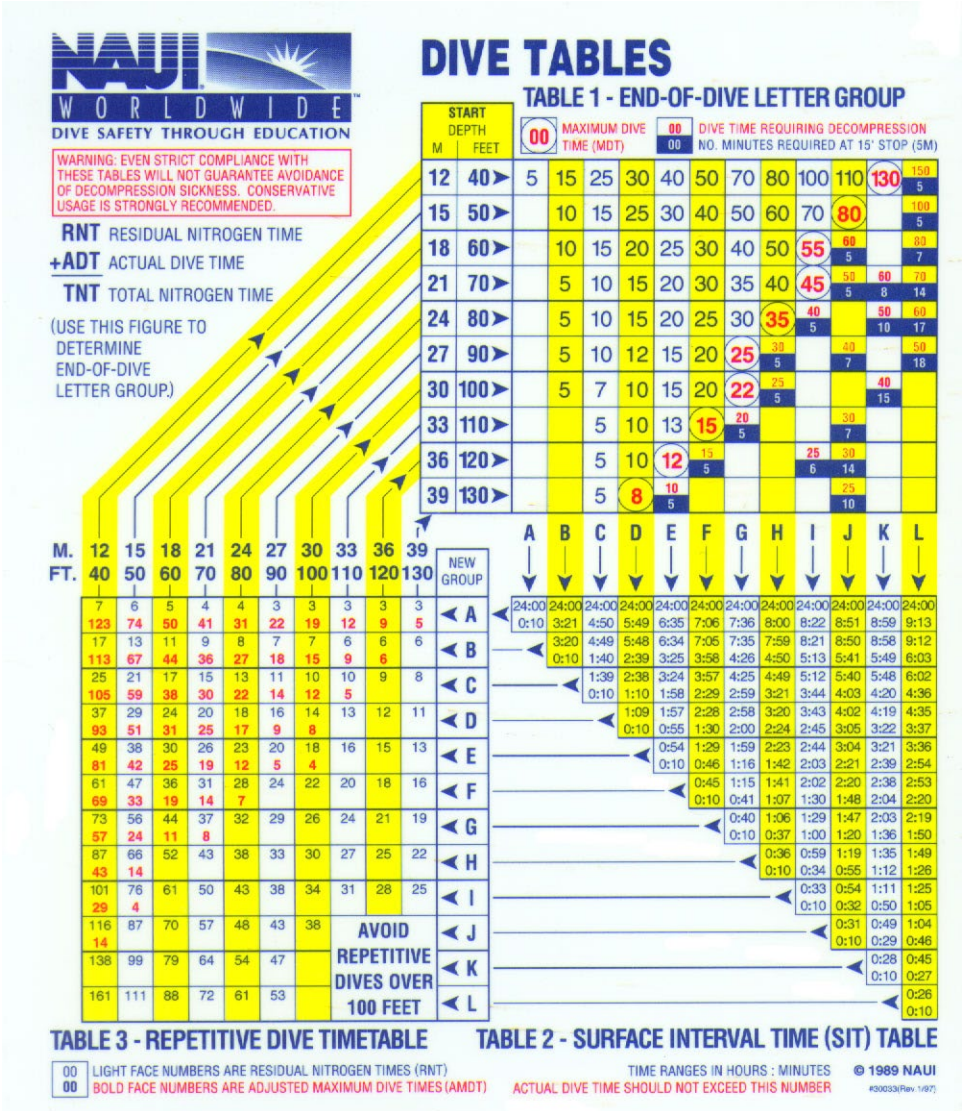
APPENDIX 7 – DIVE TABLES AND DIVE COMPUTER WORKSHOP GUIDELINES

A. REPETITIVE DIVING TABLES

A set of dive tables, either the ones contained in this section or others approved by the DSO, are required at every dive site.

Rules during ascent

1. Always ascend at a rate of 30 fpm (20 seconds per 10 fsw). Minor variations in the rate of travel between 20 and 40 fsw/min are acceptable.
2. If the rate of ascent is greater than 30 fpm, Stop the Ascent and allow the time to catch up to your depth, then continue.
3. If the rate of ascent is less than 20 fpm, add the ascent time to the bottom time of the dive.



APPENDIX 8 – DIVE COMPUTER GUIDELINES

1. Only those makes and models of Dive Computers specifically approved by the DCB 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 DCB, complete an appropriate practical training session and pass a written examination.
3. Each diver relying on a Dive Computer to plan dives and indicate or determine decompression status must have his/her own unit.
4. 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 new Dive Computer used it to control their diving. This is required to clear residual nitrogen, out of the diver's system, to match the zero nitrogen uptake of the new Dive Computer.
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.

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APPENDIX 9: NON-EXEMPT SCIENTIFIC DIVES

In some instances, diving operations under University auspices may be necessary in support of the research and education mission that do not meet the requirements for conduct under the OSHA Commercial Diving Regulations' Scientific Diving Exemption (29 CFR Part 1910, Subpart T, Paragraph B). In such cases, the following additional requirements shall be implemented. The following measures are in addition or variance to applicable measures specified in previous sections of this manual.

1. Staffing

All participating personnel shall be Active-status Scientific Divers in good standing, qualified for the planned activity and their role therein.

1.1 Designated Person In Charge (DPIC)

a. A DPIC shall be topside and on site during the conduct of diving operations. The DPIC shall perform the duties of the project Lead Diver (Sec. 1.2), including:

i) Overseeing operations to comply with applicable sections of this standard, and the approved dive plan (Sec. 2.2.)

ii) Confirming participating divers have a current diving medical clearance meeting the Medical Clearance requirements for Commercial Divers specified in the Washington Administrative Code 296-37-525.

iii) Conducting the pre-dive briefing and safety checks and post-dive briefings (Sec. 2.2., 2.4.)

iv) Managing any required response to an accident or injury.

1.2 Response Diver

a. A Response Diver shall be on standby at the dive site, equipped and ready to respond to a diver in distress in a timely fashion upon direction of the DPIC.

1.3 Divers

a. Divers shall operate in strict adherence to the buddy system, unless line-tended.

2 Equipment

Each diver shall be equipped with the following, in addition or variance to other requirements of this manual (Sec. 3).

2.1 Reserve Air Supply (RAS)

a. Each Diver shall carry an independent reserve air supply.

i) The RAS shall contain sufficient volume to safely return the diver to the surface or to other adequate reserve breathing supply, according to established standard safe ascent procedures.

ii) The RAS shall have a diver-activated on/off valve capable of preventing inadvertent emptying while in reserve. The valve shall be in the "OFF" position when the diver is not breathing from the RAS.

2.2 Buoyancy Compensator

a. A buoyancy compensator capable of floating an unconscious diver in a face up position without other support;

3 Procedures

The following procedures are in addition or varied from those otherwise stated in the previous chapters of this manual

3.1 Dive Manual and Checklists

a. A full copy of the diving safety manual and dive plan will be available on site.

i) The dive plan, having been approved by the DCB or their designee, will contain current status reports for each participating diver, and a detailed hazard risk assessment and management plan including any changes to SOP for daily operations.

ii) The dive plan will be reviewed by the DPIC with the dive team before the start of the day's diving operations.

b. Project pre-dive and post-dive checklists will be developed and used, including a daily dive log.

3.2 Communication

a. Contact and communication must be maintained between the divers and the Tender/Response Diver through the use of communications equipment or line pulls.

i) Scuba divers swimming free will strictly adhere to the buddy system and keep continuous contact with topside personnel.

b. Divers shall be line-tended during any dives

i) Conducted by a single diver

ii) On dives deeper than 100fsw; or

iii) In currents exceeding 1 knot.

3.3 Staffing

a. The minimum number of dive staff required for a single, line-tended diver is three: DPIC; Response Diver/Line Tender, and Diver.

i) The DPIC must be equipped and prepared to serve as tender in the event that the Response Diver must deploy.

b. The minimum number of dive staff required for a pair of scuba divers is four: DPIC, Response Diver and two divers.

i) A buddy pair may be line tended by one tender with a single line to the primary diver, if a buddy line is used between the divers, and there is no risk of entanglement.

c. In the event of a diver in distress or loss of contact or communication, the Response Diver/Tender will notify the DPIC and deploy to assist the diver(s). The DPIC will take the role of the Tender, while the Response Diver deploys.

d. An approved recompression chamber shall be on site during any diving operation:

i) Conducted to depths in excess of 100fsw

ii) Requiring decompression stops (other than precautionary stops)

iii) Using breathing gases other than air.

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APPENDIX 10 – UW DIVING EMERGENCY TELEPHONE NUMBERS – 911

All University of Washington

Medical Emergency	911
UW Police	(206) 685-8973
Diving Safety Officer – Will Love	(206) 616-3776
Employee Health Center (Mon-Fri)	(206) 685-1026

Friday Harbor Laboratories

Emergency	911
FHL Office	(360) 378-2165 or (206) 616-0699
Pema Kitaeff - FHL Dive Officer	(206) 543-0876 (Cell) (206) 349-9977
Kristy Kull - FHL Boating Officer	(206) 543-0876 (Cell) (562) 972-6229
Megan Dethier - FHL Director	(206) 543-8096 (cell) (360) 298-2018

Virginia Mason Hospital

Emergency Room	(206) 583-6433
Hyperbaric Unit 24-Hour Consultation	(206) 583-6543

Coast Guard

Rescue Coordination. Center Washington, Oregon	(206) 220-7001
Rescue Coordination. Center Juneau, Alaska	(907) 463-2000

British Columbia

Rescue Coordination. Center (Victoria)	(800) 567-5111 250-363-2333
Divers Alert Network (DAN)	(919) 684-9111

EMERGENCY RADIO FREQUENCIES

Coast Guard	VHF Channel 16
Canadian Coast Guard	VHF Channel 16
Citizen Band (CB)	Channel 9

RECOMPRESSION CHAMBERS

Alaska

Anchorage Regional Hospital	(907) 264-1583
Bartlett Memorial Hospital, Juneau	(907) 586-2611
Ketchikan General Hospital, Ketchikan	(907) 225-5171
American Hyperbaric Center	(907) 562-5420

British Columbia

Fleet Diving Unit Pacific, Victoria	(250) 363-2379
Vancouver General Hospital, Vancouver	(604) 875-4111

Oregon

Providence Hospital, Portland	(503) 215-1111

Washington

Virginia Mason Hospital, Seattle	(206) 583-6543
Diver's Institute of Technology, Seattle	(206) 783-5543
U.S. Naval Station, Keyport	(360) 396-2552 (24 hrs) (360) 296-2111
St. Joseph's Medical Center, Tacoma	(253) 426-6630

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APPENDIX 11 – DIVING CONTROL BOARD MEMBERS

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