BUREAU OF RECLAMATION

Diving Safe Practices Manual

Underwater Inspection Program

U.S. Department of the Interior

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Diving Safe Practices Manual

Underwater Inspection Program

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1 Introduction

The Bureau of Reclamation (Reclamation) conducts a variety of underwater inspection and maintenance programs that include the use of divers. In order to ensure employee safety and regulatory compliance, Reclamation has developed this Diving Safe Practices Manual (DSPM). This manual is intended to be the baseline for diving policy and is designed to address the most common Reclamation diving activities. For operations extending beyond the scope of this manual, additional specific instructions must be prepared and maintained by the dive team performing diving operations, subject to approval of the Regional Diving Advisory Committee (RDAC) and the Reclamation Diving Safety Advisory Board (RDSAB).

1.1 Use of this Manual

The DSPM is intended to provide details of procedures and requirements necessary to safely and efficiently conduct Reclamation diving operations. The procedures and requirements presented in this manual have been established to comply with applicable government regulations and standard professional diving practices and related support operations. Rules and regulations established by Occupational Safety and Health Administration (OSHA), U.S. Coast Guard (USCG), and U.S. Navy (USN), as well as those established by state and local governments, have been used as guidelines in preparing the DSPM. This manual is published to meet the requirements of OSHA [29 CFR 1910, Subpart T], USCG [46 CFR 197, Subpart B], and *Reclamation Safety and Health Standards* (2009 rev.). If reference regulations change or safer and more effective operational methods are developed, it is the responsibility of all divers to notify the appropriate Regional Dive Team Leader and provide input to the RDSAB to effect changes to this document.

A copy of the DSPM shall be at every dive site. All divers shall have access to this manual. Reclamation divers shall study this manual and have a working knowledge of the policies and procedures contained within.

1.2 Diving Safety

Safety is of primary importance in all of Reclamation's diving operations. It is Reclamation's policy to conduct diving operations in a manner that provides maximum safety to all personnel involved in diving operations. Reclamation divers are considered professional divers. Compliance with commercial diving industry standards will enhance safety in the workplace for Reclamation personnel. With this in mind, Reclamation diving shall be conducted in a manner consistent with OSHA Commercial Diving Regulations [29 CFR 1910, Subpart T] and *Reclamation Safety and Health Standards*, "Requirements for Reclamation Diving Operations" [section 29.2]; divers will follow safe commercial diving practices, use good operational judgment, use well-maintained equipment, and have a professional attitude.

Diving by its very nature is physically demanding. Divers should maintain themselves in good physical condition and health. Environmental conditions should be evaluated carefully in each job hazard analysis.

In the final analysis, each diver is responsible for his/her own safety and for each other. Each diver is responsible for knowing his/her own limitations and physical condition, and should inform the diving supervisor immediately when a task or conditions are beyond the diver's capability or training.

2 Diving Policy

2.1 Purpose

Reclamation has requirements for expert underwater engineering, geotechnical, and biological examinations and investigations of Reclamation-owned or contracted facilities and associated features; inspection of underwater construction projects, facility foundations, and geologic conditions; investigation of fisheries facilities and aquatic environments; underwater specification review; safe-practices review of potential and actual contract diving operations; and other program-related underwater services. To meet these requirements, technically oriented Reclamation Underwater Inspection Teams have been established to provide this expertise in a concise, scientific manner. The underwater inspection teams, also referred to in this document as dive teams, consist of competent, designated Government employees (not full-time divers) performing collateral duties.

2.2 Regulatory Requirements and Operational Control for Underwater Inspection Program

This *Diving Safe Practices Manual* complies with the requirements of the Code of Federal Regulations (CFR) [29 CFR 1910 Subpart T], "Commercial Diving Operations," wherever applicable, and the *Reclamation Safety and Health Standards*, section 29, "Marine and Diving Operations," where applicable.

It is the Regional Director's responsibility to ensure compliance with all applicable dive safety regulations and requirements within each region.

2.3 Reclamation Diving Safety Advisory Board

The Reclamation Diving Safety Advisory Board (RDSAB) was established in accordance with the *Department of Interior Safety and Health Handbook* (DM 485), Chapter 27, "Underwater Diving Safety." The RDSAB establishes Reclamation-wide procedures and requirements that will ensure consistent standards and operational coordination for all dives. The purpose of the RDSAB is to ensure the highest level of oversight in the diving safety program; specifically, to provide administrative safety guidance and oversight to ensure all underwater diving operations are conducted in a uniform manner. Membership of the RDSAB, with the majority of its members being active divers, consists of the following:

- A Reclamation Safety and Occupational Health professional appointed by Reclamation's Designated Agency Safety and Health Official (DASHO).

- An active diving representative from each participating region and the Technical Service Center.

- An RDSAB chairperson elected by Board majority from the membership.

- Ex-officio members – Director, Technical Service Center, and the Manager, Reclamation Safety and Health, who also represents the DASHO.

2.3.1 RDSAB Functions

The RDSAB shall be responsible for the following functions:

- Elect one of the Regional Dive Team Leaders to serve as Chair, RDSAB.

- Submit and maintain a written Diving Safety Program.

- Submit an action plan to the Reclamation Safety and Health Manager that addresses Reclamation-wide implementation of the administrative, safety, and operational requirements of the program.

- Develop, revise, and maintain a *Diving Safe Practices Manual* for diving operations.

- Review and evaluate relevant diving incidents or accidents.

- Submit to the Reclamation safety and health office an annual consolidated Reclamation-wide report of all diving incidents or accidents that cause, lead to, or may have led to an injury. The report will contain an analysis of the circumstances contributing to each incident or accident as well as actions taken to prevent recurrence.

- Promulgate guidance to regional diving advisory committees.

- Evaluate requests for variances to Reclamation diving standards. Variances must be reviewed by the RDSAB.

- RDSAB meetings will be held annually or more frequently as needed.

2.4 Scope and Objectives

The scope of the DSPM includes all diving operations conducted by Reclamation's underwater inspection teams. It includes all diving locations: pools, lakes, oceans, rivers, customer facilities, piers, and remote locations. This manual also serves as a training and procedures manual to achieve the following objectives:

- Facilitate administration of the underwater inspection (diving) program.

- Ensure the safety of Reclamation divers in all diving-related operations.
- Establish minimum standards for Reclamation divers and diving equipment.
- Protect Reclamation and its employees from liability.

Reclamation is a Federal agency conducting diving operations that are specifically described in this manual. Some diving operations conducted by Reclamation can be classified as *scientific* diving. The guidelines for scientific diving relate to academic institutions, which have established diving safety programs that meet specific regulatory requirements in the support of scientific data collection.

Reclamation dives that do not meet the criteria for scientific diving should be considered *professional* diving. Reclamation does not conduct *commercial* diving operations. Commercial diving is usually defined as construction-type working dives where divers operate equipment (welders, hydraulic tools, salvage gear, etc.). All dives will be conducted following the guidelines of the DSPM, whether the dives are for the collection of data (scientific), or completion of underwater tasks (professional).

Deviations from the practices and rules of this manual are authorized in true emergency conditions to the extent necessary to save lives, prevent serious physical harm, or prevent major environmental damage. If Dive Supervisors, divers, or the persons-in-charge deviate for any of the above reasons, the Reclamation RDSAB will be notified of the incident.

ADOPTED SAFETY AND HEALTH STANDARDS

Reclamation dive teams shall adopt and include the following regulatory and industry standards in the DSPM. In the event of a conflict between these regulations and standards, the most stringent will apply.

- *Reclamation Safety and Health Standards*, 29.2 "Requirement for Reclamation Diving Operations"
- OSHA 29 CFR 1910 Subpart T, "Commercial Diving Operation"
- Department of Interior (DOI) Manual, Part 485, Chapter 27, "Underwater Diving Safety"
- American Academy of Underwater Sciences*, Standards for Scientific Diving*, "Certification, and Operation of Scientific Diving Programs"

DISCIPLINARY POLICY – All Reclamation divers are responsible for compliance with the procedures recommended in these guidelines. Failure to comply after a written warning from a Dive Supervisor or Regional Dive Team Leader may result in suspension of diving privileges or expulsion from the dive team.

2.5 Regional Diving Advisory Committee

In those regions with a diving program, the Regional Director shall appoint a Regional Diving Advisory Committee (RDAC), with the majority of its members being active divers, for the purpose of implementing this manual at the regional level, and to assure an efficient and safe underwater examination and inspection program. The committee members, in carrying out these functions, shall be responsible to the RDAC chairman elected by RDAC membership. The chairperson shall report directly to the Regional Director or the designated program manager. The RDAC shall advise the Regional Director in formulation and control of the region's underwater inspection program practices.

The RDAC shall consist of at least five members and shall include the Regional Safety Manager and the Regional Dive Team Leader.

2.5.1 RDAC Functions

The RDAC shall be responsible for the following specific functions:

- Establish regional practices for the operations of the underwater inspection program by the underwater inspection team.
- Administer the underwater inspection program.
- Designate Regional Dive Team Leaders. Provide evaluation and approval of nominees as dive team members. Candidates selected for the team must meet the physical and psychological requirements of the diving medical examination criteria and have suitable professional technical expertise prior to acceptance as a dive team member.
- Select a qualified physician, preferably one who has been trained in hyperbaric medicine, to perform physical examinations of team members.
- Evaluate and approve team and individual diver training programs that will fulfill the requirements of these regulations and standards.
- Establish and administer the diving safety program to ensure compliance with Reclamation requirements.
- Develop appropriate operational safety requirements to ensure safety precautions are instituted.
- Provide periodic review and recommend revisions of the *Diving Safe Practices Manual* to the RDSAB.
- Evaluate equipment requirements and make recommendations for the dive team.
- Review and approve written dive plans and dive hazard and safety analysis prior to initiating a site-specific diving operation.

- Review and evaluate incidents that occur during Reclamation dives within the regional area of responsibility. The review and conclusions shall be made available to the RDSAB.

- Review and authorize reciprocity agreements and requests for diving services from other Federal, State, county, or local governmental agencies.

- Document and review team-related disciplinary action for unsafe practices or failure to maintain standards, such as suspension or removal from team.

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3 Diving Responsibilities

This section details the responsibilities of employees directly involved in diving operations. It does not cover the general responsibilities of all employees to ensure safety and complete all jobs in a professional manner.

3.1 Regional Dive Team Leader

The Regional Dive Team Leader will be a senior dive team member who has the experience and training necessary to ensure that the diving operations are conducted safely and within Reclamation policy and regulatory requirements. He or she must have the experience and formal training in dive planning, diving procedures, CPR, first aid, etc. to conduct assigned diving operations. In addition, he or she must have experience in conducting underwater inspections of Reclamation structures and adequate expertise to manage dive operations. The Regional Dive Team Leader must have a working knowledge of Reclamation Diving Standards, this *Diving Safe Practices Manual*, Reclamation management policies, and appropriate local and state regulations. Specific responsibilities of the Regional Dive Team Leader are:

- Managing the diving and operation of the dive team.
- Reviewing potential candidates' qualifications for participation on the dive team. Periodically reviews each diver's suitability and adherence to Reclamation Policy and Safety requirements and makes recommendations to the RDAC.
- Ensuring all divers are qualified to dive in the mode being used and trained on the tasks to be performed during the operation.
- Ensuring the safety of the dive team and compliance with the Reclamation diving policy by reviewing the prepared dive plan and dive hazard analysis prior to commencement of diving operations.
- Reporting serious accidents or injuries in accordance with Reclamation diving policy and accident reporting procedures.
- Ensuring that a copy of the DSPM is available to all dive team members.
- Maintaining dive team records and ensuring required individual dive logs are kept current and accurate.
- Providing an annual written report to the RDAC and RDSAB summarizing the previous calendar year's diving activities, training, and accidents or near-miss accidents.

- Reviewing all dive team reports for operational and technical compliance and adequacy.
- Appointing journeyman divers to status of Dive Supervisor.
- Designating a Dive Supervisor for each diving activity.
- Shutting down diving operations at any time due to unsafe conditions or refusing work if divers are exposed to unmitigated hazards or unacceptable risk levels.

3.2 Dive Supervisor

Dive Supervisors are experienced divers, trained extensively in dive operations, dive planning, diving emergency procedures, and dive safety. *Dive Supervisors* are journeymen divers and are responsible for a specific diving activity as assigned by the Regional Dive Team leader. Specific Dive Supervisor responsibilities are:

- Scheduling, planning and executing diving activities in a safe manner and in accordance with this *Reclamation Diving Safe Practices Manual* and *Reclamation Safety and Health Standards*.
- Establishing initial contact and coordination with personnel who will be onsite.
- Ensuring hazardous energy control and confined space procedures have been initiated and coordinated with the responsible facility representative.
- Conducting and documenting the pre-dive briefing and safety meeting of the dive team.
- Ensuring pre-dive equipment checks are made, and performing pre- and post-dive checks in accordance to Reclamation diving standards.
- Preparing and submitting a hazard or safety analysis to the Regional Dive Team Leader and safety manager for approval prior to the assigned diving activity and checking the validity of all contact information on the emergency response plan.
- Supervising the actual diving operations.
- Ensuring a log record of the dive is kept and submitted – depth, bottom time, decompression, etc.
- Documenting dive operations, including observations, findings, inspection reports, etc.
- Coordinating and keeping the facility representative fully informed on the diving operation.
- Notifying the facility representative of any diving-related accident or injury.

- Maintaining professional competence by refresher training, re-qualification diving and recertification of skills and knowledge.
- Serving as the focal point for any dive team member's concerns about the safety of the operation.
- Verifying the physical and mental condition of each diver prior to and after each dive.
- Shutting down diving operations at any time due to unsafe conditions.
- Designating a journeyman diver as Dive Supervisor prior to a dive.

3.3 Journeyman Diver

Journeyman divers are experienced divers with the following qualifications and experience:

- Participated actively for a minimum of three (3) years on the Reclamation Dive Team.
- Attended a minimum of two (2) Reclamation-sponsored diving training courses.
- Demonstrated to the Regional Dive Team Leader a high level of diving skills, proficiency, and good judgment regarding safety.
- Is familiar with and adheres to the Reclamation Diving Standards and *Reclamation Diving Safe Practices Manual.*
- Maintained professional competence and certification in CPR, First Aid, Dive Rescue Techniques, and Oxygen Administration for Diving Emergencies.
- Certified as a Rescue Diver by a nationally recognized training agency.
- Trained and experienced in the use, operation and maintenance of Surface Supplied Air (SSA) diving.

3.4 Diver

Diver refers to diving employees (including journeyman diver, divers, standby divers, lead diver and Dive Supervisors) who participate in diving activities or are exposed to hyperbaric conditions. Divers perform job tasks underwater. Before a dive buddy team enters the water, one diver shall be designated as lead diver, responsible for the safe conduct of the dive and completion of tasks. Specific diver responsibilities are:

- Conducting individual diving activities in accordance with the *Reclamation Diving Safe Practices Manual.*

- Reporting to the Regional Dive Team Leader or Dive Supervisor any problems associated with safety in diving operations.

- Conducting pre- and post-dive checks of diving equipment and systems.

- Reporting all accidents, diving symptoms, or physical ailments to the Regional Dive Team Leader or Dive Supervisor before and after each dive.

- Conducting the diving task within the scope of his or her experience and training. This policy applies to dive modes, depths, conditions, and any other factors that affect the safety of the dive team.

Reclamation will not require a diver to be exposed to hyperbaric conditions against the employee's will, except when necessary to complete decompression or treatment procedures. Reclamation will not require a diver to dive or otherwise be exposed to hyperbaric conditions for the duration of any temporary physical impairment or condition which is known to Reclamation and is likely to adversely affect the health of a dive team member.

3.5 Dive Tenders

A *dive tender* is a member of the dive team who tends a tethered diver, operates controls for a surface supplied diver, and otherwise assists divers from the surface in ways that directly affect the health and safety of the diver. Normally, dive tenders are fully qualified divers; however, in some operations the use of non-divers to line-tend a tethered diver is permitted. Regional Dive Team Leaders or Dive Supervisors using non-diver tenders will ensure the tender is trained to perform assigned duties. Tenders report to the Dive Supervisor and assist divers. Specific dive tender responsibilities are:

- Conducting diving support activities in accordance with the Reclamation Diving Standards and *Reclamation Diving Safe Practices Manual*, and reporting to the Dive Supervisor any problems associated with safety in diving operations.

- Following the instructions of the Dive Supervisor for each diving operation.

- Reporting accidents, equipment failures, or line-pull communication to the Dive Supervisor.

- Monitoring surface conditions, such as weather, current, or vessel traffic that could adversely affect the safety of the divers.

4 Diver Qualifications

Reclamation conducts diving operations that have varying levels of complexity. It is the policy of Reclamation to conduct dives only when the tasking of each dive team member is commensurate with the individual diver's experience and training.

The Regional Dive Team Leader is responsible for verifying and documenting that Reclamation employees have the training and experience for their dive team assignments. Dive Team Leaders will categorize dive team members according to their level of diving training and expertise. This information will be used when assigning dive team responsibilities in the dive plan. A file will be maintained on each diver, listing training, experience, and qualifications.

Diving within Reclamation is job and task related, not diving level related. Regional Dive Team Leaders will ensure that divers are trained in detail on work tasks or jobs to be completed underwater.

There are times when divers from other agencies or contractor personnel have a need to participate in a Reclamation sponsored dive or training. Personnel meeting the minimum diver qualifications and requirements outlined in this manual may be allowed to dive with Reclamation teams after a signed reciprocity agreement has been approved by the RDAC.

4.1 Training and Experience

Employee Divers engaged in SCUBA or surface supply diving shall possess the necessary training, experience, and proficiency to safely perform assigned work. Divers must be at least 21 years of age. The Regional Dive Team Leader must have some method of documenting experience or training to ensure that divers:

- Exposed to hyperbaric conditions are trained in diving-related physics or physiology [29 CFR 1910.410(a)(4)].
- Are trained in SCUBA or surface supplied (assigned diving mode) diving techniques and procedures [29 CFR 1910.410(a)(2)(ii)].
- Have knowledge of SCUBA or surface supplied diving operations emergency procedures [29 CFR 1910.410(a)(2)(iii)].
- Are trained in use of tools, equipment, and systems relevant to assigned tasks [29 CFR 1910.410(a)(2)(i)].

4.1.1 Entry Level Training

Divers must demonstrate completion of a basic SCUBA certification course by a nationally recognized dive training agency that is approved by the RDSAB, i.e., PADI, NAUI.

4.1.2 Checkout Dive

Before a job, a diver must make a checkout dive with the Regional Dive Team Leader in a pool or other benign environment. The Regional Dive Team Leader should ensure the diver is able to checkout his or her equipment, properly don all equipment, do proper ingress/egress, and possess a working knowledge of emergency SCUBA diving procedures.

4.1.3 Dive Rescue Training

Dive rescue training and certification are required and must be kept current with periodic refresher training.

4.1.4 Advanced Training

The objective of advanced dive training is to continually build on the skills, safety, knowledge, and proficiency of each dive team member. Each diver should strive to reach a higher level of diving certification, such as advanced SCUBA diver, Dive Supervisor, or master SCUBA diver.

4.1.4.1 Required Periodic Diving-Related Training

Each member shall participate in a minimum of 40 hours of diving-related training over any three-year period. At least 16 hours shall be in-water activities. At least 24 hours of the training received during any three-year period must be conducted by a certified diving instructor.

4.1.5 First Aid and CPR Training

All dive team members shall be trained in first aid [29 CFR 1910.410 (a) (3)], CPR at the level of American Red Cross Standard First Aid or the equivalent, and AED.

4.1.6 Oxygen Provider Training

All dive team members shall be trained in oxygen provider at the level of Diver's Alert Network or equivalent.

4.2 Documentation of Diver Training and Qualifications

A training record will be maintained by the Regional Dive Team Leader for each qualified regional dive team member. The training record will include:

- Copies of all dive related training courses (certifications, professional diving courses, scientific diving training, special medical training, military training, equipment training, etc.) and work experience
- Documentation of first aid and CPR training

- Emergency training
- Oxygen provider
- Diving equipment factory schools or training, 485 DM 27.3. B (6)

Records will be kept at the Reclamation location or region sponsoring the diver or dive team.

4.2.1 Drug Testing

All dive team members must take a drug test administered in accordance with 370 DM 792.9 and 370 DM 792.10 and receive a negative drug test prior to appointment. Dive team members are subject to the Department of the Interior's random drug testing program.

4.2.2 Lightweight Surface Supplied Air (SSA) Diving

Professional SSA training is required from a Reclamation approved instructor. Divers who have graduated from an accredited commercial or military diving school or scientific training programs are considered trained in diving-related physics and physiology as required by CFR [29 CFR 1910.410 (a)(2)]. Divers who have not performed dives in years and have not kept current must be carefully evaluated prior to being placed in an active diving status. The Regional Dive Team Leader must document specific training in the following areas:

- Diving re-qualification (see Section 4.3), diving procedures and responsibilities
- Training for specific job responsibilities and diving modes to be used (i.e., dive equipment maintenance and checkout, full-face masks, bailouts, or other diving procedures)
- Safety training for specific jobs, diving modes, and specific equipment used routinely (i.e., lift bags, acoustics, inspections, data collection, power [hydraulic or air] tools, underwater work procedures, etc.)
- Diving emergency procedures, diving medicine, and emergency evacuation of divers
- Review and familiarization with Reclamation Diving Standards and *Diving Safe Practices Manual*
- Dive planning and air decompression procedures
- CPR and first aid
- Employee accident reporting requirements

4.3 Maintaining Eligibility as Reclamation Diver

4.3.1 Dive Proficiency

Each diver must make twelve (12) dives annually in the modes of diving for which he or she is qualified with at least one dive every six months. At least one (1) dive shall be done under the supervision of the Regional Dive Team Leader or their representative every twelve (12) months.

4.3.2 Training

Each diver must complete required diver training every three years. Divers unable to accomplish this requirement due to illness or other unavoidable circumstance shall be suspended from Reclamation diving activities. A suspended diver may be reinstated by the Regional Dive Team Leader upon demonstrating acceptable diving skills and a working knowledge of diving first aid, rescue diving techniques, and oxygen first aid administration.

4.3.3 Physical Fitness and Endurance

Each diver must demonstrate a minimum level of physical fitness and endurance (PFE) every 12 months. This PFE test consists of a 500-meter swim, 10-minute tread water – with hands out of the water the last 2 minutes, and a 100-meter inverted diver tow in full gear.

4.3.4 Degree of Suitability

Each diver must demonstrate suitable participation in diving activities. Demonstration includes, but is not limited to, the following factors: watermanship (comfort in the water); contributions to the goals of the underwater inspection team as stated in Section 2.1, Purpose; willingness to comply with these regulations and standards; willingness to work in a team-oriented environment; exercising sound judgment; and acting in a safe manner at all times.

4.3.5 Good Judgment

Any diver who does not possess and demonstrate the necessary professional and safe judgment during diving-related activities may be denied continued participation as a dive team member. Team members are expected to conduct themselves in an ethical manner with respect to fellow team members, other personnel on site, and the general public.

4.3.6 Suspension

When a diver fails to meet these proficiency requirements, the diver shall be suspended from Reclamation diving activities. Suspended divers may be reinstated by the Regional Dive Team Leader, provided the diver can demonstrate acceptable diving skills as stated in section 4.3.2 to the Dive Team Leader or their representative.

5 Medical Surveillance of Divers

Diving activities are physically challenging and Reclamation encourages divers to engage in routine exercise as part of an ongoing personal fitness program. There is no upper age limitation if the individual can meet the medical standards and has adequate reserves of pulmonary and cardiovascular fitness.

All employees who are assigned as divers or who may be exposed to hyperbaric conditions shall have successfully completed a physical examination by a licensed physician, preferably trained in diving or hyperbaric medicine, prior to any diving or exposures. Reclamation employees will not be permitted to make dives unless a licensed physician has examined them and determined that they are medically fit to tolerate the pressure exposures.

OSHA and the *Department of the Interior Office of Occupational Health Medical Program Handbook* provides medical conditions and/or physical impairments that may be incompatible with safe and efficient job performance, and as result be disqualifying. If a person, as determined by a licensed physician, does not meet the diving medical standards and still desires to participate in Reclamation diving, then he or she must appeal to the RDAC after a second medical opinion has been obtained. Based on the recommendations by the DOI Chief Medical Officer, the RDAC will render a decision on the fitness of an individual to dive under the Reclamation program. Medical records will be protected in accordance with the Privacy Act.

5.1 Dive Medical Policy

The Regional Dive Team Leader is responsible for ensuring that all dive team members have an initial examination and re-examinations as required by this section and the U.S. Department of the Interior, *Office of Occupational Health Medical Program Handbook*, Chapter 7, Medical Standards.

This section establishes the minimum requirements for medical fitness that are considered necessary for the safe and efficient performance of the full range of essential functions of divers.

The Regional Dive Team Leader must ensure that each diver assigned has a current physical exam and has been determined medically qualified to dive. Divers shall inform Dive Team Leaders or Dive Supervisors of significant findings or health problems that might affect the ability to dive safely. Before the diver can dive, the Regional Dive Team Leader must receive a dive clearance letter from the examining physician as to the diver's medical fitness to dive.

5.2 Dive Medical Surveillance

5.2.1 Frequency of Diving Physical Exams

Divers will have complete physical examinations performed by a licensed physician experienced in diving medicine at the following intervals:

- Initially, before any Reclamation diving or hyperbaric exposures.
- At one year intervals (annually) thereafter.
- After an injury, surgery, or illness requiring more than 24 hours of hospitalization.
- After diving injuries, recompression treatments, or any episode of unconsciousness related to diving activities. The exam shall be appropriate with respect to the nature and extent of the injury or illness as determined by the examining physician. Information must include the diving modes and the level of physical activity that is expected and other relevant information from previous medical exams.
- Exit exam within one month after leaving the team.

5.2.2 Pre-Exam Information Requirements

A letter containing the following information will be provided to the examining physician prior to the exam.

- A copy of this section on medical surveillance
- A summary of the nature and extent of the diving conditions to which the diver will be exposed
- Information on the diving modes and the level of physical activity expected
- Other relevant information from previous medical exams

5.2.3 Minimum Exam Content

The medical evaluation criteria found in the U.S. Department of the Interior, *Office of Occupational Health Medical Program Handbook*, Chapter 7, Medical Standards should be used as a guide by the examining physician. See:
https://www.doi.gov/sites/doi.gov/files/migrated/bureaus/doi_medical_handbook_2018_-draft.pdf

Diving physical examinations, initial exams, re-exams, and exit exams will consist of the following:

- General medical and occupational history

- Noise exposure history
- General appearance and vital signs
- General physical examination with focus on:
    - Skin
    - Head, Eyes, Ears (including TM movement), Nose, Mouth, and Throat
    - Thyroid
    - Endocrine and Metabolic System
    - Cardiovascular System, including sensation, reflexes, and proprioception
    - Respirator System
    - Central Nervous System
    - Peripheral Nervous System, including sensation, reflexes, and proprioception
    - Back and Musculoskeletal System, including strength, ROM, flexibility, stability
    - Genitourinary System, including inguinal ring
    - Gastrointestinal System, including umbilicus and abdominal wall
- Diving-related medical history (i.e., decompression sickness, vertigo, lung squeeze)
- Diagnostic Test/Procedures (Table 5-1).
- Any additional tests the physician feels are necessary based on examination results

Table 5-1: Physical Exam Content

Test	Initial examination	Annual re-examination	Exit exam
Vision Acuity (Far & Near)	Yes	Yes	Yes
Peripheral Vision			
Color Vision Acuity	Yes	No	No
Spirometry –Pulmonary Function	Yes	Yes	Yes
Chest X-Ray (PA and LAT)	Yes	See Note (a)	Yes
Urinalysis (RandM)	Yes	Yes	Yes
Complete Blood Count (w/ Hematocrit or Hemoglobin)	Yes	Yes	Yes

Test	Initial examination	Annual re-examination	Exit exam
Chemistry Panel (fasting glucose, electrolytes, renal function, liver function, and cardiac risk factor assessment)	Yes	Yes	Yes
EKG rest or equivalent	Yes	See Note (b)	Yes
Audiogram	Yes	Yes	Yes
PPD (tuberculosis skin test)	Yes	No	No

(a) Every 3 years unless medical conditions dictate otherwise.
(b) Annually. If an exercise EKG is conducted, it replaces any requirement for a resting EKG. Exercise stress test requires department medical office clearance.

5.2.4 Medical Contraindications to Diving and Hyperbaric Exposures

The disorders listed below may restrict or limit diving or occupational exposures to hyperbaric conditions, depending on the severity of the condition, presence of residual effects, response to therapy, number of occurrences, diving mode, depth of exposure, and degree and duration of isolation.

- History of seizure disorders
- Malignancies (active) unless treated and without recurrence for 5 years
- Chronic inability to equalize sinus and/or middle ear pressure
- Cystic or cavitary disease of the lungs, significant spontaneous recurrent pneumothorax, or obstructive or restrictive lung disease
- Conditions which require continuous medications for control (i.e., antihistamines, steroids, barbiturates, mood altering drugs, insulin, etc.)
- Meniere's disease
- Hemoglobinopathies
- Pregnancy
- Vestibular end organ destruction
- Cardiac abnormalities (i.e., pathological heart block, valvular disease, intraventricular conditions other than isolated right bundle branch block, angina pectoris, arrhythmia, coronary artery disease, etc.)
-

- Juxta–articular osteonecrosis
- Decompression sickness with any residual neurological symptoms after treatment

5.3 Documentation of Physical Examinations

Reclamation shall require that the examining physician provide a written report to the employee and Reclamation's Regional Human Resource Office.

The examining physician's report to the employee is usually a copy of the examination forms and attached tests. In all cases the results must include:

- Detected medical conditions that would interfere with the employee's health on the job
- Detected medical conditions that would interfere with the employee's fitness for diving
- Results of the complete medical examination
- Conditions the employee might have that require further examination or treatment, regardless of whether they are occupationally related

The examining physician's report to Reclamation's Regional Human Resource Office will include:

- A written final opinion on the individual's fitness for diving, including any interpretation of results related to occupational exposures. Reclamation will provide the employee with a copy of the physician's written final opinion.
- Recommendation of any limitations (related to the employee's job duties) on the employee

5.4 Medical Removal or Suspension from Diving

It will be determined by the RDAC, based on the physician's written report, whether the diver is medically fit or unfit for diving.

5.5 Medical Recordkeeping Requirements

Medical records must be kept in accordance with regulatory requirements at 29 CFR 1910.1020 and *Reclamation Records Information Management Handbook*.

Medical information is considered confidential and all persons who gain medical information on an individual during a hyperbaric treatment will protect the confidentially of such information under the provisions of the Privacy Act.

The Regional Dive Team Leader will keep a copy of the medical clearance forms.

The Human Resources Office will maintain the medical record for each diver in the medical folder. The medical record should contain copies of all physical examinations, copies of all lab results, examining physicians report, hyperbaric treatments, accident reports, diving incidents, and any work-related disability incidents which might affect the diver's ability to perform diving duties.

Each record must contain a signed "Authorization to Release Medical Records" to ensure the privacy of each diver is protected. The diver must be informed of all disclosures.

6 Dive Planning, Basic Guidelines, and Safety

The success of any diving operation is a direct result of careful and complete planning. A diving services request form provides the Dive Supervisor with the basic information needed to begin planning a safe dive. The scope of the planning effort is determined by the objectives. Considerations listed in this section provide guidelines and requirements for ensuring the safety of divers while planning successful diving operations.

Reclamation diving is limited to SCUBA (self contained underwater breathing apparatus) and surface supply air diving. All other modes require prior approval by the Reclamation Diving Safety Advisory Board and documentation or certification of training in their use. Current commercial diving standards and regulations define differences between lightweight and heavyweight surface supply air diving. 'Heavyweight' refers to divers using open circuit or free flow helmets with variable-volume dry suits. 'Lightweight' equipment is defined as full face, demand regulator masks, or helmets. Currently, Reclamation only uses lightweight surface supply air diving with demand regulator helmets or masks.

Depth limitations, specific manning, and equipment requirements for each mode are outlined in greater detail in Sections 7 and 8. Training and certification requirements are outlined in Section 4. Any diving operations that are outside the scope of the DSPM, but within OSHA regulations, will require approval by Reclamation's RDSAB.

At the dive site, any changes to the dive plan may be made by the Regional Dive Team Leader or Dive Supervisor if the changes are within the scope of this manual (i.e., night diving, needing a bailout, etc.) and meet the intent of the original approved dive plan. Changes that are outside the scope of the DSPM (i.e., need for decompression, etc.) must be approved by the RDSAB before proceeding (see Section 9, Special Diving Guidelines).

6.1 Dive Hazard Analysis

A dive hazard analysis (DHA) of both surface and underwater conditions shall be prepared by the Dive Supervisor and approved by the Regional Dive Team Leader, RDAC Regional Safety and Occupational Health Manager, and one other RDAC member, see Appendix A. In the absence of the Dive Team Leader or the RDAC Regional Safety and Occupational Health Manager, a journeyman diver on the RDAC may sign in their place, but not for both. The DHA shall be reviewed by all divers and non-divers involved prior to beginning the dive operation. At a minimum, the DHA should include the following:

- Emergency information and phone numbers
- Planned depths and no-decompression limits

- Mode of diving
- Altitude and altitude depth corrections
- Environmental conditions, currents, visibility, temperature, and other natural and man-made hazards
- Activities in the area of operations that may interfere with the dive or that pose a safety hazard to dive team members (i.e., vessel traffic, noise, pollution, etc.)
- Analysis of underwater job tasks with solutions to eliminate, guard against, or prevent hazards
- Analysis of required hazardous energy control (lockout/tagout and confined spaces) at the facility

6.1.1 Job Hazard Analysis

When diving around structures where local facility support personnel are operating cranes, man-skips, motorized equipment, vessels, etc. or when non-divers are involved in the diving activity, a standard job hazard analysis (JHA) shall be completed by the responsible facility representative and discussed prior to any diving activities. This requirement is in addition to the dive hazard analysis.

6.2 Dive Planning

Dive planning will vary according to the tasks and conditions of the diving operation. A dive plan will be included as part of the dive hazard analysis. The dive plan must be completed and approved by the Regional Dive Team Leader, Regional Safety and Occupational Health Manager, and at least one other RDAC member before beginning diving operations. The RDSAB must approve dive plans outside the scope of this manual (see Section 9, Special Diving Guidelines, for additional guidance).

The following elements are required to be included in all dive plans [29 CFR 1910.421]:

- Operational objectives
- Dive site description
- Diving mode selection
- Surface and underwater conditions and hazard analysis
- Air supply requirements
- Thermal protection (see Section 6.2.6 for special cold-water instructions)
- Diving equipment and systems and required support equipment

- Dive team assignments and responsibilities
- No-Decompression limits
- Emergency procedures
- Evacuation procedures and recompression treatment procedures

6.2.1 Operational Objectives

A clear statement of the goals, desired results, and the diving tasks needed to achieve the objective(s) must be included in every dive plan. The Regional Dive Team Leader or Dive Supervisor will provide details of what is needed. The dive planner must ensure these needs and operational goals can be met in consideration of the chosen diving mode and the limitations of on-site systems.

6.2.2 Dive Site Description

List the following: physical location, depth of water, temperature (surface ambient and water at working depth), access, and any other vital information (currents, tides, traffic, etc.).

6.2.3 Diving Mode Selection

The selection of diving mode depends on the depth of the planned dives, the labor intensity of planned work, use of underwater tools, bottom conditions, and other environmental factors. All penetration dives greater than 50 feet from the ingress/egress point or in conditions where the diver could easily become disoriented shall be performed on surface supplied air. Lack of training will not be a justification. A chamber is required on-scene for dives deeper than 100 fsw (foot sea water) and for any dive requiring decompression. For dives at altitude greater than 1,000 feet, the corrected depth will be used. Section 9.1.5 addresses diving at altitude. The following three diving techniques are normally used in Reclamation diving operations:

- **Mode I: SCUBA - Untethered**: Open circuit SCUBA with two (or three) buddy divers, free swimming in visual/contact communication with each other. SCUBA is limited to 100 fsw. Dives shall stay within the Unlimited/No Decompression table limits. Minimum crew size is four, with three being divers. (Refer to Section 7.3.1) [29 CFR 1910.424]

- **Mode II: SCUBA - Tethered:** Open circuit SCUBA diver alone in the water, line tended from the surface. Tethered SCUBA is limited to 30 fsw. Divers working in currents exceeding 1 knot or entering physically confining spaces must be line tended from point of entry. Drift diving in ocean currents or river currents does not require tethering (see Section 9.3). Minimum crew size is three, with two being divers. (Refer to Section 7.3.1) [29 CFR 1910.424]

- **Mode III: Surface Supplied Air (Lightweight)**: Surface supplied divers are tethered with an umbilical that must be tended continuously while the diver is in the water. Reclamation surface supplied dives are limited to 130 fsw. Minimum manning is 4 divers. Depth beyond 100 fsw requires pre-approval by the RDSAB, a written

variance to the *Reclamation Safety and Health Standards*, and an on-site re-compression chamber with a certified chamber operator.

6.2.4 Safety Stop

When diving to depths of 30 feet or more, a degassing safety stop is recommended. The safety stop will be at a depth of 15 feet for a minimum of 3 minutes.

6.2.5 Air (Gas) Supply Requirements

The Regional Dive Team Leader or Dive Supervisor, as part of the planning process, shall calculate the amount of air needed for a planned dive profile. Calculations should include:

- The size and capacities of diver-worn cylinders, surface banks, flasks and compressor outputs
- Duration of diver-worn cylinders
- Unusable air in the cylinders and flasks
- Anticipated consumption of divers based on equipment used and work levels
- Emergency air requirements and bailout size selection
- All planned air sources
- Reserve air requirements

6.2.6 Planned Thermal Protection

Water temperature is a primary factor in determining dive duration. Most divers require thermal protection in water below 70 ºF. If wet or dry suits are not used, it is recommended that working divers wear coveralls for protection. Dry suits are recommended for long exposures, in water temperatures below 50 ºF, or in contaminated waters. Dive plans should include:

- Water temperature versus duration of dives
- Type of thermal protection
- Plan for handling exposure problems in harsh conditions

6.2.7 Diving Equipment and Systems and Required Support Equipment

List all diving equipment for the entire operation. The equipment list should include the following:

- Sufficient equipment and spares to support the planned operation

- Vessel or platform where diving is being performed including power, fuel, and gas requirements, lay down area needs, safety boats, etc.

- Logistics plan for re-supply and support

6.2.8 Dive Team Assignments and Responsibilities

Dive Team assignments and responsibilities may vary through the diving operation. Assignments and responsibilities will be rotated through the available divers to reduce fatigue and hyperbaric exposure. Prior to each dive, the Dive Supervisor shall assign:

- A journeyman diver to record dive times, dive notes, and monitor surface activities

- Individual divers or dive buddies with specific task(s) to be accomplished during the dive

- One diver for each buddy pair as the lead diver

- One diver as standby (safety) diver

6.2.9 Decompression

Diving should be conducted in the Unlimited/No-Decompression diving range. Decompression diving must be requested as part of the Dive Plan and must be approved by the RDSAB and written variance to the *Reclamation Safety and Health Standards*. Carefully follow all repetitive diving procedures. See Decompression Policy 6-4.5, 10-1 and Appendix D for decompression procedures. At a minimum, list the following:

- Planned diving and repetitive diving tables

- Planned bottom depth work times

6.2.10 Emergency Procedures

Emergency procedures are the actions or procedures needed to regain control of a situation and prevent or minimize injury to the diver or support personnel.

6.2.10.1 Evacuation Procedures and Recompression Treatment Procedures

Emergency aid, evacuation, and contacts must be listed on the dive hazard analysis for each dive operation. The information will be reviewed in pre-dive briefings and must include, but is not limited to, the following:

- Operation-specific emergency procedures (i.e., location and vessel specific procedures, equipment failure, fire, or other possible emergencies, etc.)

- Emergency response and evacuation contacts and telephone numbers for diving and diving-related accidents: site-specific emergency response network contacts for diving and non-diving accidents, evacuation transport options, diving- and non-diving-related hospitals and clinics

- Physicians available 24 hours a day for consultation (i.e., divers alert network)
- Location of closest recompression chamber

6.2.10.2 Diving First Aid Kits and Emergency Oxygen Delivery System

First aid supplies that are appropriate for the diving operation must be available at the dive location. Minimum requirements for first aid and medical supplies for all diving operations are:

- An *American Red Cross Standard First Aid Handbook* (or equivalent)
- A diving first aid kit composed of at least the items listed in Appendix I
- Emergency oxygen delivery system with sufficient gas to stabilize the patient while in transport to a medical facility
- A spine board

6.2.10.3 General Emergency Procedures

Depending on the nature of the diving accident, stabilize the patient, administer 100 percent oxygen, contact local emergency medical system for transport to medical facility, and contact diving alert network (DAN) for assistance from a diving physician, as appropriate, (emergency phone numbers are listed in the dive hazard analysis). Explain the circumstances of the dive incident to the evacuation teams, medics, and physicians. Do not assume that they understand why 100 percent oxygen is required for the diving accident victim or that recompression treatment may be necessary. Accompany the evacuation team to the hospital. For specific emergency procedures use Scuba (diving Mode I and II) and Surface Supplied Air (diving Mode III) see Sections 7.4 and 8.5, respectively.

6.3 Pre-Mobilization and Dive Guidelines

At a minimum, the following procedures [29 CFR 1910.421] will be used in pre-dive preparation at the dive location. The Dive Supervisor or person in charge may require additional operation-specific requirements.

6.3.1 Diver Briefing

Dive team members shall be briefed on the tasks to be undertaken, safety procedures for the diving mode, any unusual hazards or environmental conditions likely to be encountered, and any modifications to standard operating procedures. Before each dive, the Dive Supervisor will brief each diver and ensure the diver has an understanding of the tasks to be completed underwater. During the pre-dive briefing, the Dive Supervisor will inquire as to each diver's current state of physical fitness and will indicate the procedure for reporting physical problems resulting from the dive.

6.3.2 Equipment Inspection

The Dive Supervisor will ensure that all breathing air supply systems and diver support systems are inspected prior to each dive. He will ensure that all normal and reserve breathing air supplies are adequate. Furthermore, both the diver and the Dive Supervisor will ensure that the diver is wearing the minimum equipment required and that pre-dive inspections have been made on all diver-worn life support equipment, especially the following:

- SCUBA cylinders, including valves or manifolds
- Buoyancy compensator devices (BCDs), including secondary inflation
- Regulators, submersible pressure gauges and depth gauges
- Face masks
- SCUBA tending lines (when applicable)
- Surface supply diving helmets
- Surface supply umbilicals
- Dry suits, particularly those with variable inflation attachments and dumps
- Weight belts or harness
- Any auxiliary equipment required (i.e., fins, boots, knife, watches, etc.)

6.3.3 Warning Flags and Marking Dive Locations

An international flag "A" (alpha or replica if diving from other than a vessel in areas capable of supporting marine traffic) shall be displayed at the dive location in a manner that allows all around visibility. It shall be illuminated during night diving operations. Additionally, the work vessel (safety boat) shall be illuminated as specified in USCG Rules of the Road or in-inland situations as per state or local regulations. When diving at night, turn on deck lights – make yourself visible (see Section 6.6, Night Diving). The red diver's flag with a diagonal white stripe may also be displayed.

6.4 General Diving Requirements and Guidelines

At a minimum, the following procedures will be used during diving operations (29 CFR 1910.422). Depending on the nature of the task, the Dive Supervisor may dictate additional requirements.

6.4.1 Water Entry and Exit

Diver shall be able to safely enter and exit the water. The Dive Supervisor must evaluate the situation and ensure an adequate means is available for egress/ingress. When required for

safe entry and exit, ladders capable of supporting the diver shall be provided. The ladder shall extend below the water surface at least 3 feet [29 CFR 1910.422(b) (1)].

A descent line should be used in situations where divers need a guideline from the surface to an underwater work site.

6.4.2 Confined Space or Ladder Entry

Divers entering a confined space, such as a pump chamber, gate chamber, or basin that requires ingress/egress via a ladder (over 3 feet vertical distance) or man-skip shall wear a fall restraint/retrieval harness. A retrieval tripod/winch or other mechanical means of hoisting an incapacitated diver to ground surface shall be on site.

6.4.3 Communications

An operational two-way voice communication system must be used between each surface supplied air diver and Dive Supervisor on the diving station. Tenders and divers will know and use line pull signals.

An effective communication system should be used on SCUBA dives. This can include two-way voice communication devices, thru-water communication devices, hand signals, or slates for writing. Line pull signals will be used for communications with surface tended SCUBA divers. See Appendices E and E1 for a list of approved hand and line-pull signals.

An operational two-way communication system shall be available at the dive location to obtain emergency assistance. Two-way communication systems include radio and/or cellular telephone equipment.

An effective scuba diver recall signaling device, such as banging on a scuba tank or underwater air horn must be used.

6.4.4 Dive Log

The Dive Supervisor is responsible for maintaining a dive log for each dive. A depth time profile of the dive shall be maintained for each diver during the dive and must include decompression. See Appendix F for SCUBA Repetitive Dive Worksheet and Appendix G for Surface Supplied Air Diving Mode Log. An equivalent form or database may be used; however, completed logs will remain on file as a permanent record at each Region [29 CFR 1910.423(e), 29 CFR 197.410 (a) (4)]. If a SCUBA diver keeps, his/her own time during a dive, the dive log must be completed as soon as possible after surfacing. Each Region may tailor their own log; however, the dive profile/log must include the following information:

- Name of the diver, Dive Supervisor and other positions of dive team members
- Date, time and location of the dive
- Diving mode
- Nature of the work performed, and underwater tools used

- Underwater and surface conditions (visibility, water temperature, current, etc.)
- Log record of the dive events, including maximum depth, total bottom time, and decompression profile, etc.
- Residual nitrogen obligations at the beginning and end of the dive, including altitude adjustments upon arrival at dive site.
- Mode of determining residual nitrogen (RNT) , dive tables or dive computer
- Altitude depth correction
- General nature of the work performed
- Any emergency incidents during the dive
- PSI of bailout cylinder before the dive

6.4.5 Air Decompression Policy

It is the policy of Reclamation not to plan or perform decompression diving. **No exceptional exposure diving will be planned**. If an emergency situation occurs where the no-decompression limit is exceeded due to entrapment, entanglement or timing device failure, in-water decompression is permitted to avoid injury to the diver. The U.S. Navy Standard Decompression Tables shall be used to calculate decompression depths and times. The tables from the *U.S. Navy Diving Manual* (Revision 7/01 December 2016) are included as Appendix D to this manual.

Normal diving procedures shall be conducted in Unlimited /No-Decompression. See Appendix B: Unlimited/No Decompression Dive Tables and C: Emergency Gas Supply Calculations. Repetitive diving procedures will be followed carefully; each diver shall always know his or her repetitive group and last time of reached surface, so surface intervals can be quickly determined for daily dive planning.

The Regional Dive Team Leader and the Dive Supervisor shall ensure that all divers are trained on the use of standard and repetitive diving procedures (see also Sections 7.1.3, Repetitive Diving, and 7.1.4, Dive Computers).

6.5 Post-Dive Requirements and Guidelines

At a minimum, the following procedures will be used post-dive. The Regional Dive Team Leader or Dive Supervisor may specify additional operation-specific requirements.

6.5.1 Physical Condition Check

At the end of each dive, the Dive Supervisor will assess the physical condition of each diver. Diver "OK" means the diver has no symptoms of any decompression sickness (DCS) or arterial gas embolism (AGE) and is feeling well after the dive. Divers will not respond "OK"

if they are not feeling well. Dive Supervisors will not only get an "OK" from the diver but shall also observe each diver for any signs of DCS, AGE, trauma, or environmental exposure.

6.5.2 Flying after Diving Rules

Ascent to altitude after diving increases the risk of decompression sickness. Reclamation follows the U.S. Navy policy in Appendix H2, regarding flying after diving. The waiting time required between the last dive and flying depends on the repetitive group of the diver after diving. Appendix H2 lists the surface interval allowed between the last dive and flying. Commercial airliners are assumed to be pressurized in flight to 8,000 feet.

6.6 Night Diving

Night diving is defined as diving during the periods from one hour after sunset to one hour before sunrise. Divers must have lights for visual illumination underwater and the diver's helmets or heads need to be marked with some type of warning light so the divers can easily be seen on the surface. Typical head marking lights can be chemical lights or colored strobe lights. The deck working areas must be appropriately illuminated. Deck workers shall wear life jackets with lights while working at night. Safety stops should be illuminated on the descent line (this is easily done with chemical lights). See Appendix E for night diving signals.

6.7 Low Visibility Diving

Some of Reclamation's diving is performed in low/no visibility environments. Diving in these conditions requires special provisions. Divers must be equipped with two working dive lights (one primary and one back-up). The lights will be checked to make sure they are working before leaving the surface. A down line will be established to the structure to be examined so divers have a reference to and from the structure to be inspected. Divers will remain in physical contact with one another throughout the dive. If contact is lost, divers will have one minute to try to find each other. If contact is not re-established, the divers will ascend to the surface. Divers can then regroup and ,if they have sufficient air and time remaining on their dive tables, they can descend together and resume the dive inspection.

6.8 Standby (Safety) Diver Requirements

A standby diver is a fully qualified diver, trained and certified as a rescue diver, ready to enter the water and render assistance any time during a dive. Standby divers must be briefed along with the primary divers on the job and tasks, so they are fully aware of the dive situation and conditions. It is a good idea, if possible, to position the standby diver near the communications box so the standby is fully aware of the dive progress. Standby divers shall not be assigned as the tender for the primary diver. His or her sole responsibility is as emergency standby diver. A standby (safety) diver is required at all times.

6.9 Diving Deeper than 100 fsw

When diving deeper than 100 fsw the following additional equipment is required:

- Must be pre-approved by the RDSAB (see Section 2.3.1)
- Must obtain a written waiver to the *Reclamation Safety and Health Standards*
- Must be performed with surface supplied air
- An emergency recompression chamber (PVHO) must be on site. A certified PVHO operator other than the diver must be available to operate the chamber [46 CFR 197.410 (a) (8)].
- A bailout reserve breathing supply with sufficient air for the diver to return to the surface in a controlled manner must be carried by the diver.

6.10 Termination of a Dive

Working dives shall be terminated under the following conditions:

- Diver requests termination
- Diver fails to respond correctly to communications or signals from another diver or tender
- Communications are lost between the dive station and diver
- Communications are lost between the Dive Supervisor or other critical controlling operators (i.e., vessel operator when liveboating, crane operators, etc.)
- Air supply system failure or interruption (SSA). Diver goes on bailout supply or topside shifts to reserve or emergency supply, etc.
- Diver loses his buddy in SCUBA operations. After one minute, both divers should immediately surface. Unless the diver has through-water communications, he or she should inform the Dive Supervisor, then follow the lost diver emergency procedure.
- Failure of a dive computer or submersible depth gauge in the water
- Scuba tank cylinder pressure below 500 psi

6.11 Diving Safety Guidelines

No set of standard procedures can anticipate all operating situations that may be encountered, and consequently, no diver or employee supporting diving operations may assume safe operation by merely following these guidelines.

Safety rules do not exist as a substitute for common sense, sound judgment, and a continuing concern and vigilance for maximum safety.

6.11.1 Safety Precautions Applicable to all Diving

- Care must be taken to secure or neutralize any equipment or system at the work site that present a potential hazard to the diver.

- The depth of water, condition of the diver, water temperature, and type of work shall determine the length of the dive. The amount of work shall not be a factor.

- Boats or craft of any kind shall not come alongside a vessel from which diving operations are being conducted while a diver is in the water without receiving permission from the Dive Supervisor.

- Hazardous energy clearances, lockout, warning tags, and equipment position or status shall not be modified while divers are in the water.

- Whenever diving operations are conducted from a boat, precautions shall be taken to ensure that the diver's umbilical does not become fouled in the propellers.

- Before lifting heavy objects or weights from the bottom, the diver should leave the water or ensure he/she and his/her umbilical is clear of the load.

- Appropriate signals and flags such as International Code Alpha, and day shapes shall be displayed in a prominently visible location during daylight diving operations. Night operations should ensure that proper anchor lights, RAM light, etc. are displayed.

- Mode for signaling diver recall, such as diver-to-surface communications, line pull, or underwater air horn shall be in place.

- Every precaution must be taken to prevent the diver from becoming fouled on the bottom.

- Divers must not cut any lines until their purpose is known or until directed by the Dive Supervisor.

- No diver, tender, or dive support personnel who shows signs of intoxication, its after-effects, or appears to be under the influence of drugs or medications will be allowed on the station during diving operations.

- All work activities in close proximity to the dive site shall be informed before diving operations begin and after diving operations are completed.

- Whenever a diving operation requires a diver to go into a pipe, structure or other restricted underwater area, a standby diver shall be available at the point of entry to tend the diver who has entered the confined area.

- Divers must be properly trained on the safe operation of tools and equipment to be used in the water.

- All power tools passed to the diver or recovered from the diver shall be turned off.

- Any diver who has a cold, sinus infection, inability to clear ears, or any other physical or mental problem that may interfere with his ability to perform the assigned task in the water in a safe and healthful manner will inform the Dive Supervisor, and will not be allowed to dive until he can dive in a safe and healthful manner.

6.11.2 Oxygen Safety

Oxygen by its very nature can be a hazardous gas if handled improperly because it lowers the ignition temperature of flammable substances and greatly accelerates combustion. Hydrocarbons can ignite spontaneously in the presence of high oxygen percentages; additionally, oxygen fires also create intense heat. The following rules apply when working with oxygen.

- Always use an oxygen-clean regulator to get oxygen from a cylinder.

- Never lubricate or allow oil or grease to get on oxygen connections, blowpipes, or other oxygen equipment. Do not use oil-filled gauges in an oxygen system.

- Oxygen systems with pressure greater than 125 psig (pounds per square in gauge) should have slow opening shutoff valves. All valves will be the appropriate Compressed Gas Association (CGA) recommended valve.

- Lubricants, gaskets, plastics, cleaning solvents, sealants, threading compounds, diaphragm materials, insulation, and other items used on oxygen systems which are potential fuels must be O_2 compatible.

- Oxygen systems must be assembled free of organic elements and loose particles. Valves, gauges, piping and other elements used in oxygen systems must have been cleaned for oxygen service.

- Oxygen for breathing in diving operations/first aid should be Type II, Grade A or B.

- Never use oxygen for compressed air or as a source of pressure.

- Oxygen cylinders should never be completely emptied, but should be maintained with a minimum of 25 psig in the cylinder to prevent contamination.

6.11.3 Pneumatic and Hydraulic Power Tool Safety

Each tool and item of support equipment has its own detailed set of safety instructions, which should be consulted prior to any operation. Hydraulic tools designed for diver use normally have extra seals to prevent salt-water contamination of the hydraulic system. If oil leaks occur or water contamination is suspected, using the tools should be stopped and repairs effected. Hydraulic tools designed for diver use normally do not have any cooling heat exchangers, because the hoses being immersed in water cools the oil. Prolonged surface use of diver tools should be avoided. Care should be taken to adjust the oil flow to support the individual tool requirements. If a hydraulic tool results in an environmental contamination spill, it must be reported as specified in current regulations.

The following general safety precautions are applicable to all hydraulic and/or pneumatic tools that divers use:

- Pneumatic and hydraulic tools that are used underwater should be specially designed for diving use.
- A separate air source should be used to supply pneumatic tools. Diver's air must not be used.
- Whenever pneumatic or hydraulic tools are used on the surface, eye protection must be worn.
- Pneumatic tools, when not in use, should be disconnected from the air source. Secure air prior to disconnecting.
- Gloves should be used by the diver when using pneumatic or hydraulic tools underwater.
- Never use equipment that is not in good working condition.
- Arrange to have all required gear and tools readily available.
- Electrical tools require a ground fault interrupter (GFI) in the circuit between the power source and the tool. Use of electrical tools underwater requires pre-approval from the Reclamation Diving Safety Advisory Board.
- Never have loose items on the diver that could be entangled in the tool.
- The diver must always tend his umbilical when working with grinding tools to ensure that an umbilical is not severed.
- Hold the tool firmly with two hands while running; never overreach.
- Inspect tools topside before sending the tool down to the diver. Ensure grinding wheels, drill bits, etc. are in good condition and function properly.

- Never override the on/off trigger. Only the diver in the water at the work site shall operate the on/off trigger switch.
- The diver should make sure he is clear and all other divers are clear before energizing any tool.
- Never exceed the maximum operating pressure and flow rating of a tool.
- Always ensure that the tool rotation is proper. Do not reverse the oil flow to reverse the direction of the tool.
- Never clean or inspect a tool with the hydraulic power source connected.
- Always ensure hydraulic chain saws have water supply flow to the tool. Chain saws need a continuous flow to remove the slurry, even underwater.
- Hydraulic chain saws require visibility or safety straps to prevent kick back injury.
- Power tools shall be off when sent to a diver and when brought to the surface. Make sure any moving blade has stopped moving before setting down the tool. Topside should shut off the oil flow before moving the tool up from or down to the diver.

6.11.4 Tending Safety

When tending an umbilical, hose, etc., tend about 1-3 feet from the side rail, if possible, and hand over hand the umbilical over the side. Never let it slip freely through your hands. A backup tender should be used on a heavy umbilical.

If an umbilical, hose, or line starts to run free, do not try to stop it by jumping on it, stepping on it, or grabbing it by hand. Pick it up at the coil or figure 8 stack and use a line to tie it down to a cleat or foundation.

The NEVER list of tending safety:

- Never step into the bight
- Never let an umbilical slip freely through your hands
- Never tend over the rail
- Never tend loosely; always feel the diver
- Never step or jump on a running umbilical, hose, or line.

6.11.5 Jetting Safety

A jetting nozzle will be fitted with a balanced jet that should be taken over the diver's shoulder in such a manner as to prevent blowing off the diver's mask or causing injury. Divers and tenders must be extra alert when working in reduced visibility situations.

6.11.6 Lift Bag Safety

There are many potential safety hazards when divers are using lift bags. If a lift bag should get away from the diver or break loose from whatever it is attached to, the lift bag could snag the diver or the diver's umbilical, and bring the diver to the surface, creating a blowup situation. The following safety procedures must be observed when using lift bags:

- Lower lift bags deflated. Attach the bag securely to the object being lifted.
- If at all possible, use a safety line from the bottom to the lift.
- Divers should control the lift bag at all times, ensuring they are clear and not fouled in either the object being lifted or the lift bag. If control is lost, the diver should get clear and maintain a normal ascent.
- Always deflate bags when finished. Send them to the surface with a crane or tugger, or tied off to the down line. Never cut bags loose and allow them to rise free to the surface.
- Always calculate the amount of lift required and use the proper size lift bag. Oversized bags will continue to expand as they rise through the water column and accelerate rapidly toward the surface
- If the object to be lifted is very large, attach the lift bags as low as possible and in a manner that will keep the object stable and floating on the surface.
- On soft or muddy bottoms, suction must be overcome between the mud and the object. If the object is light, pull up firmly after each burst to break the suction. On heavy items, the lift bags are located near the surface (10 feet) and rigging is extended to the object requiring lift. Once the object is off the bottom, the object can be moved to the surface by repeating this procedure with additional lift bags.

6.11.7 Compressed Gas Cylinder or Flask Safety

Hazards associated with cylinders of high pressure gasses can be avoided by careful handling of the cylinders at all times.

- Never use cylinders as rollers or supports even if they are empty.
- Use valve protection caps when lifting or moving cylinders.
- Never use a hammer to open cylinder valves.
- Never drop or allow any cylinder to fall, especially oxygen cylinders. Handle cylinders carefully—do not bang, clang, or batter.
- Never tamper with safety fuses or blowout plugs.

- Always open cylinder valves slowly to allow the pressure to build up evenly and prevent the hammering of tubing, piping, hoses, or regulators.

- Always keep cylinders far enough away from hot areas and work so that sparks, slag, or flames will not reach them. Aluminum cylinders subjected to more than 350 ºF must be condemned.

- Always store cylinders securely, both full and empty, to prevent them from being knocked over, causing damage to personnel and equipment.

- Always check for leaks. Soap test (Snoop®) new connections.

- Always shut the valves when the work is finished, even for a short time.

- Always replace the valve safety protection cap when the regulator is removed or the cylinder is not connected. Always move the cylinders with the safety protection cap in place.

- Always secure cylinders in proper racks or tie cylinders down. Never leave cylinders free standing.

- Always store cylinders in a ventilated area.

- Always check that cylinder hydrostatic and annual visual test date has not lapsed.

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7 Open Circuit SCUBA Diving – Modes I and II

This section covers diving operations using open circuit Self Contained Underwater Breathing Apparatus (SCUBA) while breathing air. SCUBA is a lightweight and rapidly deployed mode of diving that can be used to conduct a wide variety of tasks. Mode l open circuit is defined as a diving buddy pair on SCUBA. Mode II open circuit diving is defined as a single tethered diver on SCUBA.

Divers and Dive Supervisors must be properly trained, safety conscious, and alert at all times when conducting SCUBA operations. Prior to leaving the surface, divers must be thoroughly briefed concerning maximum depth, times permitted on the bottom to remain within the no-decompression limits, and what decompression obligations would be required if the planned bottom time is exceeded.

Modes I and II air SCUBA diving policies outlined here represent safe commercial practices that comply with the minimum standards listed in OSHA 29 CFR 1910, Subpart T. These modes of diving include tethered or buddy air SCUBA divers with appropriate support personnel. Due to special programmatic needs or operational conditions, more specific or stringent procedures may be required. Implementing more specific procedures will be at the discretion of the Dive Supervisor or the Regional Dive Team Leader.

All personnel using SCUBA equipment for Reclamation diving operations must possess a working knowledge of the equipment, equipment limitations, diving procedures, and any other tools and techniques that may apply to SCUBA diving operations [29 CFR 1910.410 (a)]. Dive Supervisors must ensure that all divers assigned on a given job are currently qualified to dive in that mode and have been properly trained on any special equipment used and tasks to be performed [29 CFR 1910.410(b)]. The Regional Dive Team Leader will ensure that dive plans include dive team assignments and comply with this policy.

7.1 Open Circuit SCUBA Limits

Open circuit air SCUBA diving shall not be conducted under the following conditions:

- At depths greater than 100 fsw
- Against currents exceeding one knot unless the diver is line tended
- In enclosed or physically confined spaces unless the diver is line tended (see Section 9.2, Physically Confined Space Diving)
- Penetration/Confined Space dives over 50 feet from the point of entry shall not be permitted on SCUBA

7.1.1 Current Diving

The maximum allowable current that a SCUBA diver can swim against is 1 knot or 1.69 feet/second velocity. Dives against currents above 1 knot shall be performed with a tethered scuba diver or a tethered surface supplied diver. Drift diving in a river, canal, or ocean tidal current in excess of 1 knot is permitted if a chase boat is accompanying the divers.

7.1.2 SCUBA Decompression

Reclamation does not normally conduct decompression SCUBA dives. Diving outside the unlimited /no-decompression limits must be approved by Reclamation's RDSAB. If some unusual situation occurs where it is necessary to conduct decompression diving, then the following rules apply.

- A written variance to the *Reclamation Safety and Health Standards* will be obtained.
- The diver shall be trained in decompression diving.
- A decompression chamber will be ready for use at the dive location.
- Divers must remain awake and in the vicinity of the chamber for 1 hour after the dive.
- Standby diver must be available on the surface while divers are in the water.
- A safety pickup boat must be available.

Reclamation uses the U.S. Navy (USN)-based Dive Decompression Tables contained in Appendix D. These tables are based on data taken from the *U.S. Navy Diving Manual,* Revision 7, dated 01 December 2016. It is the intent of Reclamation to use the most current version of these tables. Newer versions will be used as they become available. Refer to Sections 6.4.5, Air Decompression Policy, and 9.1, Decompression Guidelines, for detailed discussions on decompression tables.

The use of other tables or methods must be pre-approved by the RDSAB.

7.1.3 Repetitive Diving

Repetitive diving is a routine procedure in SCUBA and surface supplied air diving. The tables will be followed to determine a diver's repetitive group after 10 minutes on the surface and less than 12 hours. The diver and the Dive Supervisor must know a diver's repetitive group at all times. When planning repetitive dives, every effort should be made to dive deep first then make subsequently shallower dives. Care should be taken to ensure that only USN-based tables are used – some tables published by other agencies are not USN-based tables and have different times listed. Appendix B: Unlimited/No Decompression Dive Tables and Repetitive Group Table will be used to compute the new group after a specific surface interval. Using the new group and depth of the repetitive dive the residual nitrogen time can be determined.

7.1.4 Dive Computers

Use of dive computers while performing dives is acceptable; however, it is still important to plan all dives using the USN-based tables (rev 7) and have them on hand to consult. The following are general guidelines for dive computer use.

- Divers must have a working knowledge of the proper operation of the specific dive computer being used.
- Dive computers may not be shared or exchanged between divers at any time.
- Divers must have an 18-hour surface interval before activating a dive computer.
- Once the computer is in use, it will not be switched off until it indicates complete off gassing has occurred or 18 hours, whichever comes first.
- On a buddy pair the diver with the shorter allowable bottom time dictates when the pair will leave the bottom.
- If the dive computer fails, the dive must be terminated.
- Never use the computer and dive tables together—use one or the other.
- Rate of ascent is still 30 feet per minute (fpm).

7.2 General SCUBA Guidelines

The following rules and procedures apply to all air SCUBA operations.

- All equipment will be checked for readiness and proper operation prior to each dive by the diver.
- Equipment that is not operating properly will not be used.
- Dive Supervisors are responsible for calculating the primary air supply to ensure there is sufficient air to complete the planned dive, including reserve air for returning to the surface.
- SCUBA divers must carry/wear an emergency gas supply (EGS). This requirement can be met by either an independent cylinder with a separate regulator or a manual reserve on the main cylinder (J valve). It is recommended that the EGS provide at least 4 minutes of breathing air at working depth. Refer to Appendix C. The diver must verify EGS pressure prior to the dive.
- When diving in open water, such as an intake structure in a reservoir, a safety pickup boat should be used in Mode I, unless the Dive Supervisor has a justification for not using a boat.

7.2.1 Buddy Diving

It is Reclamation's policy to conduct normal SCUBA diving using the buddy system. The buddy system calls for two divers to be in the water together and able to effectively communicate with each other throughout the dive. Usually this is best achieved by remaining in visual sight of each other or connected together with a buddy line. On SCUBA dives where only one diver is in the water, the diver should be tended from the surface, as a Mode II diver.

A buddy pair shall:

- Be familiar with the equipment and alternative source of breathing air for the buddy diver. Complete buddy check prior to entering the water.
- Maintain effective communications.
- Discuss and agree upon a reuniting location to return to should they become separated while diving.
- Any diver unable to locate a buddy within one minute shall return to the surface and notify the person in charge (Dive Supervisor).

7.2.2 SCUBA Standby (Safety) Diver

A standby diver, in immediate readiness to enter the water, will be available during all SCUBA operations, while the divers are actually in the water.

7.2.3 Safety Pickup Boat

A pickup boat is required for open water dives, where access to the dive site from the shoreline or a maintained road is limited or diving on structures that are more than 200 feet from shore. Drift diving in a river, canal, or in a tidal current requires a chase boat.

7.3 SCUBA Diving Procedures

Dive Supervisors will ensure that divers have performed pre-dive inspections on all equipment. The divers will be briefed as to maximum depth and bottom time for the planned dive. Divers will ensure the open circuit SCUBA cylinders contain sufficient air for the planned dive, and the pressure is checked just prior to the dive. The cylinder shall be filled from a known source of safe breathing air (see Section 10.3.3, Air Purity Standards). After entering the water, the divers will do a final check of all equipment before descending.

7.3.1 SCUBA Minimum Manning Requirements

OSHA and other regulatory agencies have various interpretations on dive team minimum manning. The Regional Dive Team Leader should carefully evaluate the proposed dive plan, including the conditions, potential emergency response plans, regulations, experience and abilities of the proposed dive team and any other conditions that may materially affect the safety of personnel when determining the required manning, particularly when using

minimum manning. No dive may be conducted with less than the manning described in the following section.

7.3.1.1 Mode I: SCUBA - Untethered

This mode requires a minimum of 4 personnel: a diver, a buddy diver, a standby safety diver, and a topside person in charge (Dive Supervisor). The person in charge must be available to render assistance and emergency response. The topside person in charge should be experienced in diving-related emergency response procedures.

7.3.1.2 Mode II: SCUBA - Tethered

This mode requires a minimum of 3 personnel: a diver, a standby diver, and a topside person in charge. The person in charge must be available to render assistance and emergency response. The topside person in charge (Journeyman Diver) should be experienced in diving-related emergency response procedures. The use of a three-diver SCUBA team is limited to a single tethered diver in the water and depths not to exceed 30 fsw.

7.3.2 Communications

The diver and buddy diver shall remain in continuous communication during the dive. Standard hand signals will be used (see Appendix E); special signals can be established prior to the dive. Details of communication plans will be addressed individually for each dive operation. Divers in the tethered Mode II will use standard line pull signals to communicate. The use of through-water communications does not allow deviation from minimum SCUBA manning requirements.

There will be a diver recall procedure in place for SCUBA divers in a free-swimming mode. Use acoustic recall systems, through-water communications, or some method of placing a predetermined recall noise or signal into the water. Divers who are line tended can be recalled by line signals (see Appendix E1).

7.3.3 SCUBA Equipment Requirements

Each diver using open-circuit air SCUBA must have the following equipment:

- High pressure SCUBA cylinder(s) outfitted with approved valves or manifolds. Cylinders will be connected with backpack and harness capable of quick release.
- A regulator assembly comprised of a first stage, second stage, and alternate air source, such as an octopus or buoyancy compensator device (BCD) with built-in regulator, such as an Air II. Only those models specifically approved by the RDAC shall be used.
- A high pressure (HP) submersible pressure gauge
- Diving wristwatch, timer with second indication, or dive computer
- Depth gage or dive computer that automatically corrects for altitudes up to 10,000 feet elevation

- A full-face mask with through-water communication. Full-face mask used shall have an oral nasal or mouthpiece to minimize dead space volume.
- Buoyancy compensator device (BCD), inflatable personal flotation device
- Weight belt or harness, capable of quick release by the diver in the water. The use of BCDs with an integrated weight system is allowed.
- Bailout cylinder (Emergency Gas Supply)
- A knife or other cutting tool (sharp and able to cut wet line). Knives should have a protective sheath or be folding. Knives should be attached directly to the SCUBA diver in a manner that no matter what equipment is jettisoned, the knife is still on the diver.
- Swim fins
- Thermal protection: wet suit, dry suit, or coveralls with hood and gloves
- Lights (2) – primary and backup
- Compass
- Optional equipment
- Through-water communications or underwater signaling device
- Dive tables, slates, and pencils or pens that write underwater

7.4 Scuba Emergency Procedures (EPs)

Emergencies by definition are unexpected and require prompt corrective action. Each Dive Team routinely performing SCUBA dives will have a standard set of Scuba Emergency Procedures. The EPs will include the procedure and the operator who must perform the action, and options and considerations concerning the emergency. They will include but should not be limited to:

Scuba EP-1	Lost Diver
Scuba EP-2	Fouling or Entrapment
Scuba EP-3	Loss of Air/Out of Air
Scuba EP-4	In-water trauma or injury
Scuba EP-5	Unconscious Diver
Scuba EP-6	In-water equipment failure
Appendix J	Scuba Emergency Procedures, Situation and Recommended Action

8 Surface Supply Air Diving (Lightweight) Mode III

Surface supplied air diving involves all forms of diving in which the breathing mixture is supplied from the surface to the diver through a flexible hose called an umbilical. Surface supply diving can be further categorized as surface supply free flow and surface supply demand. Only surface supply demand mode is approved for use during Reclamation surface supply air dives.

Mode III diving policies outlined here represent safe dive practices that comply with the minimum standards of 29 CFR 1910, Subpart T. This mode of diving includes a surface supplied, tethered diver, and support personnel.

Air for surface supplied diving operations is supplied either from an air compressor(s) or from high pressure (H.P.) air cylinders. All air supplies must meet the purity requirements as set forth in Section 10, Diving Equipment Standards and Maintenance, of this manual.

8.1 Limits for Surface Supply Air Diving

Surface supplied diving shall not be conducted for dives deeper than 100 fsw [29 CFR 1910.425] or for dives greater than the U.S. Navy no-compressions limits.

For dives deeper than 100 fsw or outside the no-decompression limits, a recompression chamber and certified operator must be ready for use at the dive location.

Reclamation will conduct dives only when the tasking of each dive team member is commensurate with documented experience and training. The Regional Dive Team Leader and Dive Supervisor are responsible for ensuring that dive team member assignments comply with this policy.

Diving outside the unlimited/no-decompression limits must be pre-approved by Reclamation's RDSAB. A written variance to the *Reclamation Safety and Health Standards* will also be required. Decompression diving will not be allowed unless the diver is trained in decompression diving and a chamber is available for use at the dive location.

Reclamation shall use the unlimited/no-decompression dive tables contained in Appendix D. These tables are taken from the *U.S. Navy Diving Manual*, Revision 7.

It is the intent of Reclamation to use the most current version of these tables. Newer versions will be used as they become available.

8.2 Operations using Surface Supply Air Mode III

Surface supplied diving should be done from a stable vessel or platform that is anchored or secured to a structure.

8.2.1 Mode III – Minimum Manning

Dives between 0 to 100 fsw and within the no-decompression limits require a minimum manning of 4:

- 1 Dive Supervisor
- 1 diver
- 1 standby (safety) diver
- 1 tender

Additional personnel are needed under the following conditions:

- When diving is conducted in physically confining or enclosed spaces, an additional diver shall be stationed at the underwater point of entry.
- Penetration dives, whether horizontal or vertical. Each diver in the water must have a tender.
- Any crane/ tugger operations associated with the dive.
- Use of additional surface-tended equipment by the diver. This includes, but is not limited to, jetting, pneumatic or hydraulic tools, etc.
- Additional divers may be necessary as determined by the Dive Supervisor or person in charge to provide for proper shift relief, particularly in remote locations where assistance from non-diving crew personnel is not immediately available. The use of qualified non-diver helpers may be needed in these operations to run compressors, charge flasks, operate cranes, etc. More divers may be required to support a proper rotation and ensure divers obtain rest between dives.

8.2.2 Communications

Continuous, two-way voice communications between the diver(s) and the surface will be maintained throughout the diving operation. If communications are lost, terminate the dive and use line pull signals for diver's ascent to surface (see Appendix E1). Communications must be established for emergency assistance, using radio or phone.

When a diver fails to respond correctly to communications or signals from another dive team member, the dive shall be terminated. If communications are lost and cannot be

quickly re-established between the diver and the topside supervisor or another diver at the dive location, then the dive shall be terminated.

8.2.3 Recompression Capability Requirements

An approved recompression chamber and certified operator must be ready for use at the dive location when dives are:

- Deeper than 100 fsw
- Outside the unlimited / no-decompression limits
- Planning surface decompression

8.2.4 Equipment Requirements

Minimum support and diver-worn equipment needed for a surface supply dive are listed below.

- Supply of primary breathing air that can be supplied by a low pressure air compressor (LPAC) or from fixed flasks or cylinders
- Emergency or reserve breathing air with at least 4 minutes of breathing air at working depth
- Diver communications system
- Pneumofathometer system (diver depth monitoring system)
- Umbilical capable of providing air, communications, pneumofathometer, and safety strength member
- Air distribution box or rack (i.e., central air [gas] distribution center)

Minimum Diver-Worn Equipment

- Helmet or mask equipped with a non-return valve and an exhaust valve. Must have a minimum ventilation rate of 4.5 ACFM (actual cubic feet per minute) at any depth and/or capable of maintaining CO_2 levels below 0.02 ATA (atmospheres absolute) when the diver is producing CO_2 at the rate of 1.6 liters per minute [29 CFR 1910.430]. Fitted with a two-way audio communications system and maintained in accordance with manufacturer's specifications.
- Safety Harness designed to be attached around the diver's body with leg straps and of sufficient strength to permit the lifting of the diver and his equipment from the water. There will be a mechanical quick release between the harness and the umbilical. The harness shall not be used as a weight belt; however, it can be integrated with the bailout cylinder.

- Bailout supply (i.e., emergency gas supply – EGS). Diver-worn emergency supply gas cylinder must provide sufficient air (gas) to allow the diver to return to the surface and at least 4 minutes breathing gas at the planned working depth. Must be configured such that the diver can activate bailout without assistance.

- Thermal protection suit. The thermal protection suit shall be suitable for the water temperature and duration of exposure. The suit will be sized to the diver properly to prevent injury.

- Weight belt or harness with sufficient weight to maintain the diver at working depth. The weight belt or harness shall not be used to attach the umbilical to the diver. It will be equipped with an appropriate release buckle and attached to the diver in a manner to prevent accidental disengagement.

- Knife. Carried in a sheath or folding, must be sharp and capable of cutting wet line.

- Boots. As appropriate for the type of dive.

- Fins are optional.

- Lights. Primary and backup.

Table 8-1. List of air system requirements for commonly used equipment

Type of Equipment	Minimum Over Bottom Pressure	Working ACFM	Average ACFM	Maximum ACFM
Kirby Morgan Dive Helmets and Bandmask	for depths less than 60' (D x 0.445) + 135 = OB psi for depths deeper than 60' (D x 0.445) + 170 = OB psi Inlet pressures between 115 and 225 OB permitted.	0.9	1.2	4.5
AGA	(D x 0.445) + 135 = OB psi	0.7	1.0	3.2
EXO-26	(D x 0.445) + 135 = OB psi	0.8	1.2	3.2

*__Notes: Refer to technical manual for any helmet or mask not listed.__
__ACFM (actual cubic feet per minute)__

8.2.5 Breathing Gas Supply

Each diving operation shall have a primary breathing air (gas) supply sufficient to support divers for the duration of the planned dive. The Dive Supervisor must carefully calculate to ensure both over bottom pressure and flow requirements are met (See Table 8-1).

8.3 Surface Supply Diving Systems

All air piping systems, air compressors, volume tanks, and distribution consoles shall be constructed, cleaned, and maintained as life support equipment. Refer to Section 10, Diving Equipment Standards and Maintenance, for other details on required preventive maintenance service requirements.

8.3.1 Air Flasks and HP Storage Cylinders

High pressure cylinders must be manufactured to a recognized code or standard and approved by DOT. Valves will be standard as specified by the Compressed Gas Association. Valves must be equipped with an over pressure relief device. Each flask must be labeled as to its contents and color coded. They should be stored in a well-ventilated area, protected from overheating, and secured.

8.3.2 Volume Tanks or Air Receivers

Volume tanks shall be designed, fabricated, inspected, and tested in accordance with ASME Boiler and Pressure Vessel Code, Unfired Pressure Vessels, or equivalent. They will be equipped with pressure gauges, a check valve on the inlet side, a drain valve at the lowest point, and a relief valve set at 110 percent of maximum working pressure.

8.3.3 Air (Gas) Distribution Piping

Piping, tubing, valves, regulators, filters, etc. must be manufactured to a recognized ASNI code or standard to ensure the piping and tubing is rated to the maximum working pressure and permits flow rates. Valves will be slow opening when design pressure exceeds 500 psi. Piping systems must be equipped with over-pressure relief devices. Each system must be labeled by its contents.

8.3.4 Gauges

Gauges utilized in diving systems and equipment should be of rugged construction and suitable for the purpose. Gauges for depth and life support systems must be calibrated or tested every twelve months.

8.3.5 Hoses

Flexible hoses used to interconnect various components of diving equipment must have a minimum burst pressure equal to 2.5 times the maximum allowable pressure and sized to permit required flow rates for diver consumption. They shall be of rugged construction, kink-resistant, and corrosion-resistant.

Connectors shall be rated to a pressure in excess of the hose on which they are installed.

8.3.6 Compressors

Compressors used for diver air should be designed specifically for delivering divers breathing air. Personnel protection will be installed as per OSHA requirements for rotating machinery. Air intakes shall be arranged to be clear of engine exhausts or other airborne contaminants. Diesel or gasoline exhaust must be kept clear of air intakes. National Electrical Code requirements for control, wiring, and drive units must be met.

A low pressure air compressor (LPAC) used to supply diving air must be equipped with a volume tank. The volume tank shall have a check valve on the inlet side, a pressure indication gauge, a relief valve, and a drain valve. It is recommended, but not required, to have a filter on the outlet side of the compressor and a particle filter on the inlet side.

A high pressure air compressor (HPAC) used to charge diving air and high pressure cylinders should have filter packages installed on the outlet side. Oils used in compressors shall be of an approved non-hydrocarbon type.

All compressors shall have air tested every six months, or after each repair or alteration to the system. A current air sample test shall be kept with the compressor. [29 CFR 1910.430 (b) (4)] (See Section 10.3.3, Air Purity Standards.)

8.3.7 Umbilical

The umbilical shall be marked in 10-foot increments to 100 feet, beginning on the diver's end. There shall be 50-foot increments marked after the first 100 feet.

Umbilical shall be made of kink-resistant materials and have a nominal breaking strength of at least 1,000 pounds. A strength member with a breaking strength of at least 2,650 pounds shall be included as an integral part of each umbilical. The umbilical line shall be purged of foreign material with breathable air prior to connection to the helmet or mask.

8.4 Emergency Gas Supply (EGS) Requirements

A diver will wear or carry an emergency gas supply for all lightweight surface supply dives. The diver-worn or carried emergency gas supply shall have a minimum calculated 4-minute supply of air at the anticipated working depth. Refer to Appendix C for calculating EGS requirements. Emergency gas supply must be equipped with a SCUBA HP regulator capable of being adjusted to an outlet pressure of at least 135 psi over bottom pressure or as recommended by the helmet manufacturer. The EGS regulators should have a relief valve installed (set to 165 psi or using the manufacturer's requirements). The valve to activate the EGS shall be positioned for easy access by the diver. EGS hoses should be connected to the helmet or mask with connections that permit ease of donning or doffing the helmet or mask.

8.5 Surface Supply - Emergency Procedures

Each diver and Dive Supervisor shall know his or her responsibilities and necessary action in each emergency situation. Divers and Dive Supervisors will train on and thoroughly understand each emergency situation.

Each dive team conducting surface supply air diving in Mode III must have an understanding of at least the emergency procedures listed below, in addition to any other job specific EPs needed. See Appendix K, Emergency Procedures on Surface Supplied Air.

SS EP-1	Fouled or Entrapped Diver
SS EP-2	Loss of Air
SS EP-3	Severance of Divers Umbilical
SS EP-4	Loss of Communications
SS EP-5	In-Water Trauma or Injury
SS EP-6	Unconscious Diver
SS EP-7	Fire in Surface Equipment, On or Near Dive Station

When performing surface supplied diving from a vessel, the vessel shall be secured to a surface structure or anchored with a minimum of two anchors, each of which is of appropriate size to individually hold the vessel in position against expected tidal currents or unexpected winds or wind-generated currents. When possible, the first diver down should positively attach a down line to the structure. The line should be of sufficient size to hold the vessel in position if the anchors were to unexpectedly give way.

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9 Special Diving Guidelines

The special diving conditions listed in this section are considered non-standard (or non-routine) dives. They are not to be considered abnormal but are unusual and require extra consideration and additional planning. Many may require additional training to ensure the divers perform the jobs in a safe manner. The list below is a guideline for types of special diving, which should be approved by the RDSAB.

Items on a submitted dive plan, which require prior approval by Reclamation's RDSAB:

- Decompression diving or diving deeper than 100 fsw, and/or surface decompression
- Multilevel diving
- Dives involving changes to U.S. Navy tables (i.e., in-water oxygen breathing, decompression stops, etc.)
- Penetration diving (greater than 50 feet penetration) or 30 fsw on SCUBA
- Solo untethered SCUBA diving
- Diving in waters with radioactive contamination
- Diving in waters with chemical contamination
- Diving in waters with biological contamination
- Penetration dives (greater than 300 feet penetration) on surface supplied air
- Operations using hydro blasters

9.1 Decompression Guidelines

Decompression diving requires specific approval and training. It is the policy of Reclamation not to perform decompression diving. If approval and training is obtained for a specific diver(s), it is the policy of Reclamation to use U.S. Navy-based standard decompression tables, Appendix D. No modifications will be permitted to the tables (i.e., oxygen breathing in the water, shorting of stop times, arbitrary adding of stops, etc.). The use of any other decompression tables or modifications to the U.S. Navy tables shall require written Reclamation RDSAB approval**.** Any region asking to modify or use other decompression tables must have well-researched and reference-supported documentation and a justification for the request.

9.1.1 Standard Air Decompression

When decompression is needed, the preferred method is a recompression chamber. In-water decompression should only be used when approved by the RDSAB and all divers involved have completed the proper training. For in-water air decompression procedures refer to the *U.S. Navy Diving Manual* chapter 9 volume 2.

The Regional Dive Team Leaders and the Dive Supervisors shall ensure that all divers are trained on the use of standard and repetitive diving procedures. The prevention of decompression sickness is one of the primary responsibilities of the Dive Supervisor. However, each diver must contribute by maintaining themselves in good physical condition, reporting medical problems to the Dive Supervisor, getting proper rest, keeping hydrated during operations (drink lots of water or non-carbonated drinks), carefully monitoring individual repetitive groups, informing the Dive Supervisor of any illness or problems they may be experiencing, and following rules established for driving to altitude or flying after diving.

9.1.2 Unlimited/No-Decompression Table

Revision 7 to the *U.S. Navy Diving Manual* changed this table to indicate that dives to depths less than 20 fsw are unlimited. This table is used to determine the limit of no-decompression dives and provide the repetitive dive groups. Reclamation dives should be conducted within the limits of this table (see Appendix D).

9.1.3 Repetitive Diving

Repetitive dives are those dives made after 10 minutes and less than 12 hours after a diver reaches surface (RS). If the surface interval is less than 10 minutes then the time shall be added to the bottom time of the previous dive to determine the equivalent single dive time. The diver and the Dive Supervisor must know a diver's repetitive group at all times. When planning repetitive dives, every effort should be made to dive deep first, then make subsequently shallower repetitive dives. Appendix B: Unlimited/No Decompression Dive Tables and Repetitive Group Table will be used to compute the diver's new repetitive group after a specific surface interval. Using the new repetitive group and the depth of the repetitive dive, the residual nitrogen time can be determined. Repetitive dives using exceptional exposure tables are prohibited.

Residual Nitrogen Time (RNT) exception rule is still in effect. If the dive is made to the same or greater depth than the previous dive, the RNT-specified time may be longer than the bottom time of the previous dive. A diver cannot contain more residual nitrogen than he or she was originally exposed to. If this situation occurs, simply add the bottom time of the previous dive to that of the repetitive dive to obtain an equivalent single-dive time.

9.1.4 Exceptional Exposure Diving

Exceptional Exposure decompression times are listed on the standard decompression table. No exceptional exposure diving will be planned and will only be used in emergency situations (i.e., entrapment, etc.). No repetitive dives can be made after decompressing from an exceptional exposure dive.

9.1.5 Altitude Diving

Because of the reduced atmospheric pressure at altitude, the no-decompression limits must be adjusted for dives above 1000 feet elevation. To determine the sea level equivalent depth, a *cross correction* must be applied. To apply the cross correction technique, the actual dive depth and altitude must be known. See Appendix H to determine the sea level equivalent depth at a known actual depth and altitude. A diver ascending to altitude will have a repetitive dive group to start with, unless the diver has been at altitude for more than twelve hours prior to the dive. See Appendix H1 for repetitive group upon arrival at altitude. If a diver is ascending (driving or flying) to a greater altitude after diving, a time delay may be necessary. To determine the required surface interval before ascent to a higher altitude, see Appendix H2. Whenever possible, a down line should be used for descend/ascend. Ascend rate shall not exceed 30 feet per minute. All dives to a depth (altitude corrected depth) in excess of 30 feet shall include a 3-minute safety stop at a depth of 15 feet. Always dive conservatively when at altitude.

SCUBA mechanical gauges, which are sealed at sea level, must be corrected. A correction factor of 1 foot for every 1000 ft of altitude will be used for sealed mechanical gauges. If the depth gauge can be re-zeroed at altitude, then no further correction is needed. Some dive computers' depth gauges are equipped to automatically adjust to altitude and need no manual correction.

For dives at altitude the Dive Supervisor and diver will be familiar with the altitude correction procedure and cross-check the correction being made. The dive hazard analysis shall clearly state the altitude and correction.

9.2 Physically Confined Space Diving

Confined space diving requires (at a minimum) special considerations for reserve air supply and minimum dive team requirements. Special diver rescue procedures and communication plans should be included in the plan. Examples of confined spaces in diving operations are pipelines, tanks, gate chambers, pump chambers, or other underwater structures.

A physically confined space is any space that would restrict the diver's ability to rotate himself/herself head to toe, 180 degrees in any plane and still have no direct access to the surface, or any space that requires a ladder entry. When diving into physically confining spaces, the following limitations apply.

- On a penetration dive, an additional diver must be stationed underwater at the point of entry to tend and come to the aid of the diver making the penetration.
- The primary and safety diver must wear or carry an emergency gas supply.
- No free-swimming SCUBA Mode I penetrations should be allowed.
- SCUBA divers in Mode II shall wear a fall protection/retrieval harness under their BCs.

- A standby diver will be dressed, ready, and have no decompression obligations that would prevent a rescue.

- A retrieval tripod and hoist shall be on site for dives requiring a ladder entry.

9.3 Drift Diving

When drift diving on SCUBA in river, canal, or ocean tidal currents where the divers shall be moving with the current, a tether shall not be required. All drift diving shall be performed with buddy pairs of divers. Each diver shall have a signaling device, such as a mirror, whistle, or horn, and shall stay in visual contact with a buddy. Drift diving in poor visibility water or between one hour before sunset and one hour before sunrise is prohibited. A chase boat shall accompany the diving pair on the surface and will keep in visual contact of the diver's bubbles.

9.4 Contaminated Water Diving

When diving in contaminated water, risks can be reduced by careful planning and taking proper precautions. These precautions should include surface supply diving, which should be the first choice for mode of diving. The best protection is full coverage—fiberglass helmet, vulcanized dry suit mated directly to the helmet, direct hard wire communications, and diving equipment meticulously serviced at a high level of readiness. If SCUBA is used, a full-face mask is preferred with through-water communications. All divers engaged in these types of operations must have training on the risks, selection of equipment, proper procedures, decontamination procedures, emergency aid measures, and added responsibilities inherent in this type of diving. The information provided in this section should only be used as general diving guidelines.

Divers working at uncontrolled hazardous waste sites as defined by 29 CFR 1910.120 must complete training as required by *Reclamation Safety and Health Standards* (RSHS), Section 21, Hazardous Waste Site Operations. Projects conducted under these conditions will require dive plan review and approval by the RDSAB. In addition, an approved plan will be required. Additional medical surveillance may also be required.

9.4.1 Diving in Waters Contaminated with Radioactive Materials

Diving in waters suspected or known to be contaminated with radioactive materials or in areas that require dosimeter or Thermoluminescent Dosimeter (TLD) monitoring, requires specific approval from the RDSAB. Diving in or around sources of nuclear radiation should be left strictly to commercial diving organizations with the knowledge, experience, and equipment to deal with radiation hazards. Diving personnel use three methods to decrease the danger of radiation. First, limit the time spent around the radioactive source. Second, maintain distance from the radiation. Finally, use protective clothing or other devices as shielding from the harmful effects of radiation. Equipment for nuclear diving is more specialized than the equipment normally used for other contaminated water diving operations.

9.4.2 Diving in Waters with Chemical Contamination

International UN numbers identify the most common chemicals that are used and transported. It is important to know what the various chemicals are, how they interact with each other, and the potential consequences for the diver. If you are not 100 percent certain that every component in your diving system is compatible with the environment you intend to enter, you must not dive! When considering protective clothing, always know exactly what the performance of the equipment will be in a particular chemical environment before entering that environment.

Standard hazard classes include explosives, gases, flammable liquids, flammable solids, oxidizing substances, poisons or infecting agents, radioactive substances, corrosives, and miscellaneous dangerous substances. Water (or dilution) is not necessarily sufficient protection against the chemicals. Certain chemicals such as nitroglycerin, hydrogen sulfide, etc. are toxic to divers by ingestion, inhalation, and skin absorption—even a dry suit is not sufficient protection from high levels of hydrogen sulfide and can affect a diver in the water. Many agents are carcinogens (cancer causing). Poisons can be irritants, respiratory paralyzers, asphyxiants, function disrupters, or neural blockers.

Planning diving operations in waters with chemical contamination where the chemicals are known, such as hazardous materials spills, should include:

- Exact type and quantity of chemical
- Toxic effect on a diver
- Lethal dosage determination
- Lethal concentration
- Threshold limit value
- Exposure limits – maximum entry stay times in a given concentration
- Decontamination procedures
- Protection of topside personnel

The Environmental Protection Agency (EPA) identifies four levels of protection for topside workers in hazardous environments:

- Level A – full-encapsulated suit with self-contained breathing apparatus (SCBA).
- Level B – hooded chemical splash suit with SCBA.
- Level C – hooded suit for skin protection with air purification respirator.
- Level D – splash suit without a respirator.

Employees working topside must have appropriate protection for the levels of contamination.

9.4.3 Diving in Condition of Biological Contamination

Pathogens (disease causing organisms) can be present even in clear and clean-looking waters.

When diving in waters in which biological contamination is a known or suspected factor, surface supplied air, a fully encapsulating suit, and a helmet should be used. Prior to diving in known biological contaminated water, the appropriate testing for biological pathogens should be performed several days prior to the dive.

The most common problems associated with sewage contaminated waters are diarrhea from E. coli, salmonella, or hepatitis. Divers who dive in sewage contamination should have the basic series of immunizations for Hepatitis A and B. All personnel involved in diving operations where biological contamination is a known factor should be aware that diseases may not develop for days or even weeks after the exposure. Continual follow-up monitoring should be part of closure on these types of operations. Most of the factors for planning considerations in Section 9.4.2, Diving in Waters with Chemical Contamination, should also be evaluated for planning dives in areas of biological contamination.

9.5 Diving in Other Jurisdictions

Regional Dive Team Leaders and Dive Supervisors are responsible for ensuring that all dives comply with local diving regulations.

9.5.1 Offshore Diving in USCG Jurisdiction

Commercial diving operations taking place from U.S. Coast Guard inspected vessels or from vessels and facilities under U.S. Coast Guard jurisdiction must comply with the regulations at 46 CFR 197, Subpart B.

The commercial diving regulations of 46 CFR differ from those of 29 CFR regarding procedures, equipment, recordkeeping, and reporting. It is the responsibility of the Regional Dive Team Leader and Dive Supervisor to ensure compliance with the regulations.

9.5.2 Pool, Dock, and Lake Diving

Diving in pools, off docks, and in lakes within a state's boundaries requires compliance with the state or local safety requirements. If none exist, the federal OSHA regulations of 29 CFR 1910, Subpart T apply.

9.6 Non-Reclamation Divers

Any agency, military, or contractor personnel currently meeting the requirements of 29 CFR 1910, Subpart T, may be allowed to dive with Reclamation teams after proper certification, documentation, and a signed reciprocity agreement has been approved by the RDAC.

10 Diving Equipment Standards and Maintenance

Reclamation policy on diving equipment is to use quality and state-of-the-art equipment to ensure the safety and well-being of the divers. Equipment used in diving operations, particularly those items which are classified as life-support equipment, must be properly maintained and kept in good working order. This section provides information on maintenance standards to ensure diving systems and equipment are in proper working order prior to being used in Reclamation diving operations.

Each team engaged in diving will have a system to track and document preventive maintenance and servicing of diving life-support equipment, including all modifications, repairs, tests, and calibrations. Preventive Maintenance Service (PMS) shall be recorded using a database, tagging system, or logging system and shall include the date and nature of work performed, and the name and signed initials of the person performing the work. Each item of diving life support equipment must have a unique identity (number or designation), so the performance and results of the PMS can be documented.

In most cases the manufacturer of diving equipment provides recommended maintenance service in an operations and maintenance manual. However, if such a manual does not exist, regulatory agencies (OSHA, USCG, etc.) list minimum maintenance requirements for diving equipment used for Reclamation diving.

This section lists the minimum standards and maintenance cycles required for diving equipment. This is sufficient for most locations that perform only a few dives a year. However, those teams engaging in routine diving on a regular basis shall have an aggressive program to perform PMS. For such teams, the Regional Dive Team Leader (or designated appointee) will carefully review the manufacturer's service requirements, and develop the recommended maintenance requirements (PMS Schedule).

It is not Reclamation's policy to approve the selection of specific items of diving equipment. Diving equipment will be procured from a source (manufacture or vendor) that specializes in making equipment used in diving. The Regional Dive Team Leader, local RDAC, Dive Supervisor, and safety professional must ensure the equipment meets the needs of the planned dive and meets the performance minimums listed in current regulations.

Documentation for maintenance of Reclamation-owned dive equipment shall be retained at the Reclamation facility where the equipment is normally stored.

Rented dive equipment or dive equipment owned by other entities shall be subject to the same maintenance schedules as those presented here if used on a Reclamation operation.

The maintenance will be performed by a qualified technician who is able to perform the service and applicable testing required. This can be a Reclamation employee with the appropriate experience and equipment for testing, or it can be an outside vendor. The Regional Dive Team Leader will oversee the maintenance schedule and ensure that personnel performing the maintenance are qualified.

Examples of equipment maintenance log sheets are provided as Appendices L, L1, and L2. The log sheet (or an acceptable substitute) will be used to document the maintenance performed on diving equipment.

10.1 SCUBA Equipment

10.1.1 SCUBA Regulators

Approval – Only those makes and models specifically approved by the RDAC shall be used.

SCUBA regulators will be overhauled and rebuilt following recommendation from the manufacturer, which in most cases will be annually. The inspection/repair facility will provide a signed Regulator Service Log similar to the example in Appendix L2. The regulators should be inspected and functionally tested prior to each mobilization, checking at least the following:

- Inhalation and exhalation pressure
- Condition of hoses, second stage diaphragm, and mouthpiece
- Proper regulator breathing performance

SCUBA regulators used for emergency gas supply will be equipped with a relief valve if the regulator LP hose is connected to a closed valve. The relief should be set at 165 psi (+/- 10) and must be serviced annually.

DIN connections should be serviced annually or as recommended by the manufacturer.

Cleaning is the most important preventive maintenance that can be done on any SCUBA regulator. Rinse the regulator with fresh water immediately (or as soon as practical) after each dive with the dust cap in place. The following routine service should be done on most regulators:

- Annual disassembly and inspection—clean all components, replace o-rings as required, and reassemble. Functionally test as described above. A qualified service technician should do this service.
- Inspect all hoses carefully and replace as needed. Pay particular attention to areas covered with hose protectors.

10.1.2 SCUBA Cylinders, Valves and Manifolds

Cylinders, valves, and manifolds must be designed, constructed, maintained, and stored in accordance with the applicable provisions of 29 CFR 1910.101 and 1910.169. Cylinders shall be stored in a ventilated area and protected from excessive heat. If inspection of aluminum cylinders reveals indications of heat damage or cylinders have been subjected to more than 350 ºF, the cylinder must be removed from service and destroyed. Keep cylinders secured at all times to prevent damage. The following maintenance is required on all cylinders:

- Rinse cylinders and valves after each saltwater dive (pay close attention to the areas around bands and boots).
- Hydrostatic test every 5 years by a certified facility and have the cylinder stamped with the date of the last hydro.
- Must have an internal visual inspection at intervals not to exceed 12 months. A Visual Inspection Program (VIP) sticker shall be attached indicating when the cylinder is due for inspection. Cylinders with corrosion or rust should be rolled.
- Aluminum cylinders shall be visually checked for cracks in the threaded-neck area annually.
- Tank valves and manifolds must be inspected and functionally tested annually. Valves must have an over-pressurization relief (blowout safety). Cylinder valves and manifolds should be overhauled every 5 years when the cylinder is hydro tested or more often as indicated by inspection, failure, or function test. J valves should be function tested annually.
- Whenever a valve is installed on a cylinder, ensure the burst disk is rated for that cylinder pressure.

10.1.3 Submersible Pressure Gauges and Consoles

Each depth gauge shall be tested or calibrated against a master reference gauge every 12 months and whenever there is a discrepancy greater than two percent of full scale between any two equivalent gauges.

A cylinder pressure gauge capable of being monitored by the diver during the dive shall be worn by each SCUBA diver and will be tested annually.

10.1.4 Weight Belts and Harnesses

Divers shall be equipped with a weight belt or harness capable of quick release. These belts and harnesses shall be inspected prior to each operation and must be in good condition.

Harnesses used to connect SCUBA cylinders to backpacks (or the diver) must be inspected to ensure they are structurally sound and capable of quick release.

The use of integrated weights on BCDs is allowed. Prior to each dive, inspect the weight pockets and connections to ensure proper operation.

10.1.5 BCs/Inflatable Flotation Devices

BCDs (Buoyancy Compensator Devices) must be capable of maintaining the diver at the surface in a face-up position. All inflatable flotation devices (BCDs) must have a manually activated inflation source independent of the breathing supply, an oral inflation device, and an exhaust valve. Chlorine solutions in pools quickly break down rubbers and seals used in BCDs. BCDs should be rinsed clean with fresh water after each saltwater dive. BCDs should be stored partially inflated. The following are the minimum service requirements for BCDs:

- Functionally inspect at intervals not to exceed 6 months.
- Service annually—check for leaks and patch as needed, service over-pressurization valve, and inspect straps.
- Service power inflators and oral inflators annually.

10.1.6 Dry Suits

Dry suits must be constructed of materials suitable to the environment in which they are being used. To this end a dry suit should protect the diver from hazards, whether it be temperature or other factors such as abrasion, chemical, biological, etc. All dry suits must have an adjustable exhaust valve to prevent over-inflation and uncontrolled ascent. Helmets or masks or other buoyancy-changing equipment connected directly to the dry suit shall be equipped with an exhaust valve. Maintenance checks should include the following items:

- Suits should be inspected before each job, ensuring the seals are in good condition, there are no leaks, and all valves operate correctly.
- To ensure proper operation, valves should be inspected and cleaned annually or as needed, following manufacturer's instructions.
- Suits should be dried completely before being stored. Suits must be protected from sunlight (UV) and stored away from temperature extremes.

10.1.7 Full-Face Masks

There are two types of SCUBA full-face masks—those with a 2nd stage built in and those that permit use of a standard SCUBA regulator 2nd stage. SCUBA full-face masks that do not have an oral nasal shall have the capability to be fitted with a mouthpiece. SCUBA full-face masks that do not have a built in regulator shall have positive attachment of the SCUBA 2nd stage regulator. Maintenance checks should include the following:

- Use manufacturer's specifications and documented performance testing.
- Oral nasals and other soft goods should be inspected annually and replaced as needed.
- Service installed second stage regulators annually.

- If used, communication equipment must be inspected semiannually and connectors cleaned.

10.1.8 SCUBA Dive Computers

Dive computers will be inspected and tested every 12 months. This will be accomplished by pressurization in a wet (water filled) pressure chamber. Depth readings from the dive computer will be measured against a calibrated master gauge. Accepted Accuracy is +/- 2 percent of full scale 0-200 fsw. Recording of the timing should verify accuracy.

Follow manufacturer's instructions and PMS schedule for all other maintenance requirements.

10.1.9 Accessories

Accessories are items such as fins, wetsuits, backpacks, masks, knives, etc. These items are each diver's personal responsibility to inspect and maintain. As with most equipment, cleaning and storage are the most important preventive maintenance practice. Accessories should be stored dry and protected from sunlight (UV). Inspections should be done before mobilization and at the beginning of each dive.

- Masks should be inspected for deterioration and proper attachment of lens, straps, or buckles. If equipped with a purge valve, ensure it functions properly. Never dive with a cracked lens.

- Diving suits should be inspected for material deterioration, seal deterioration, holes, and proper zipper operation. Lubricate zippers with bee's wax or silicone, but never use petroleum jelly. Wash wet suits in warm fresh water after each operation. Diving suits should be thoroughly dried before stowing. Repair seams or tears as needed.

- Knives should be sharp and lubricated as necessary to prevent or minimize corrosion.

- Inspect fin straps before each mobilization. Replace if damaged or worn. Remove straps for prolonged storage.

- Lights should be inspected prior to each mobilization. Check batteries, seals and o-rings. Replace as needed or when damaged.

10.2 Surface Supplied Equipment

10.2.1 Helmets and Masks

A non-return valve and an exhaust valve must be installed on each helmet or mask used. Non-return valves must be installed at the attachment point between the helmet or mask and the supply hose and shall function readily and positively.

Maintenance checks should include the following:

- Perform PMS in accordance with manufacturer's specifications and documented performance testing.
- Non-return valves shall be tested daily during set up and serviced annually.
- Communication equipment must be inspected semiannually and connectors cleaned.
- Second stage regulators should be serviced annually.
- Oral nasals and other soft goods should be inspected annually and replaced as needed.

10.2.2 Hoses and Umbilicals

Breathing gas (air) hoses must have a working pressure at least equal to the working pressure of the total breathing gas system and a rated bursting pressure at least equal to 4 times the maximum working pressure. Hoses must be of suitable design that they will not collapse when subjected to external pressures in excess of internal pressure. Hose ends must not be left open when not in use but shall be taped, capped, or plugged when not in use. Perform the following maintenance:

- Visually inspect annually for cuts, bubbles, kinks, etc.
- Pressure test to 2.5 times working pressure held for 10 minutes.
- Visually inspect and pressure test after each repair or alteration.

Air (gas) supply hose connectors shall be made of corrosion-resistant materials and resistant to accidental disengagement. Connectors must have working pressure at least equal to the working pressure of the attached hose. Required checks include annual inspection of hose connections.

Umbilicals consist of an air (gas) hose, communications cable, pneumofathometer hose, and a strength member. Hoses must be made of kink- and corrosion-resistant materials, and have a working pressure greater than the pressure equivalent to the maximum depth of the dive (relative to the supply source) plus 150 psi. In some umbilicals, the strength member is part of the communications cable.

Every effort will be made to ensure the air hose is one continuous length. If a repair is made, then no more than one splice-barb connection will be permitted in an umbilical air supply hose. In some specialized setups (i.e., pool diving) where the bottom is controlled, only an air and communications cable is needed. The following maintenance checks will be performed:

- Annual inspection of the hoses, cables and marries. Verify hose markings—10 foot increments to 100 feet beginning at the diver's end and in 50 foot increments thereafter.

- Annual inspection of the positive attachment to the umbilical to the diver's safety harness with a mechanical quick release (i.e., spinnaker shackle). Attachment must be in a manner to prevent placing a strain on the diver's helmet or mask.

- Pressure test every 2 years (or more often if needed) to 1.5 times designed working pressure with a 200 lb. axial load applied to the fittings while the test pressure is applied for 10 minutes. There should be no loss of pressure when corrected for temperature or creeping of end fittings.

- Breathing hoses must be cleaned after any contamination or repairs.

10.2.3 Pneumofathometer Gauges

Accurate gauges must be used to monitor diver depth. Gauges must be located for ease of monitoring on all surface supplied dives. Pneumofathometer depth gauge must be tested or calibrated against a master reference gauge every 6 months or when there is a discrepancy greater than two percent of full scale between any two equivalent gauges [29 CFR 1910.430.g.2].

10.2.4 Buoyancy Control

Helmets or masks connected directly to the dry suit or other buoyancy-changing equipment shall be equipped with an exhaust valve. A dry suit or other buoyancy-changing equipment not directly connected to the helmet or mask shall be equipped with an exhaust valve. See Section 10.1.6, Dry Suits for maintenance.

10.2.5 Weights and Harnesses

Divers shall be equipped with a weight belt or assembly capable of appropriate release. Each diver shall wear a safety harness with a positive buckling device, leg straps, an attachment point for the umbilical to prevent strain on the mask or helmet, and a lifting point to distribute the pull force of the line over the diver's body. Visually inspect all weight belts and harnesses before mobilization and before each dive.

10.2.6 Compressed Gas Cylinders / Flasks

Compressed gas cylinders and flasks must be designed, constructed, and maintained in accordance with the applicable provisions of 29 CFR 1910.101 and 1910.169 through 1910.171, and must be stored in a ventilated area, protected from excessive heat, and secured from falling. Cylinders used for bailouts will meet the provisions listed in Section 10.1.2, SCUBA Cylinders, Valves and Manifolds. Shut-off valves must be protected by a cap, except when in use or manifolded.

The following maintenance checks must be performed:

- Hydrostatic test every 5 years. Overhaul or replace valves when hydrostatically tested.
- Visually inspect the cylinder annually for damage and proper valve operation.

10.2.7 Timekeeping

A timekeeping device shall be kept at each dive location. It should be suitable and easily read. Stopwatches or timers will not be used when an error of ¼ of one minute in four hours exists. Test stopwatches annually against a known standard. Mark or tag with a sticker noting the date of the last test.

10.3 Diving Support Systems

Records must be maintained on PMS, repairs, and modifications to gas systems and compressors. Air compressor intakes shall be located away from areas containing exhaust or other contaminants. Piping should meet American National Standards Institute (ANSI) code B31.1. Flexible hoses used must comply with rules listed in Section 10.2.2, Hoses and Umbilicals.

10.3.1 Diving Systems

Diving systems must be assembled specifically for the planned job. Each system should be manufactured to a recognized code or standard and have an operation and maintenance manual. In general, diving air systems maintenance must include the following:

- Inspected and pressure tested annually to maximum working pressure and held for 10 minutes.
- Pressure-relief valves cracking pressure tested annually.
- Pressure gauges tested annually.
- Depth gauges (i.e., pneumofathometer) tested semiannually.
- Installed filters must meet or exceed the flow rate and pressure ratings of the compressor or piping system in which they are installed. Change or clean filters following manufacturer's instructions or annually.
- Systems that deliver oxygen percentages above 40 percent will be kept oxygen clean. Breathing air will be cleaned to a breathing air standard. Clean whenever contamination is suspected and after repairs or modifications to the system.

10.3.2 Air Compressors

Compressors used for diver air are designed specifically for that purpose, and must be the proper type, have sufficient pressure and flow rate, and be suitable for the service. Instrumentation should be installed to monitor safe operation.

Mechanical guards will be installed as per OSHA requirements for rotating machinery [29 CFR 1910.219]. Air intakes shall be arranged to be clear of engine exhaust or other airborne contaminants. Diesel or gasoline exhaust must be kept clear of air intakes. National Electrical Code requirements for control, wiring, and drive units must be met.

Only compressors specifically designed and cleaned shall be used to pump oxygen or mixtures containing oxygen above 40 percent. Oxygen systems must have slow opening valves.

Low-pressure air compressors (LPAC) used to supply diving air must be equipped with a volume tank. It is recommended to have a filter on the outlet side of the compressor and a particle filter on the inlet side. LPACs used to supply air to the diver shall be equipped with a volume tank, a check valve on the inlet side, a pressure gauge, a relief valve, and a drain valve.

High-pressure air compressors (HPAC) used to charge diving air should have filters packages installed on the outlet side. Oils used in compressors should be of an approved non-hydrocarbon type.

Each compressor shall be maintained following recommended manufacturer's preventative maintenance schedule (PMS). Compressors shall have a unique identity incorporating manufacture, model, and serial number. Records must be kept on all maintenance service actions on both the compressor and the primemover (diesel, electric, or gas engines). The records should include at least the following:

- Oil changes annually
- Belt changes every 3 to 5 years
- Gauge testing annually
- Relief-valve testing annually
- Filter service and replacement annually
- Flexible hose inspections and testing annually
- Air quality testing semiannually
- Engines serviced annually, including an oil change

Filters are installed to prevent contamination and should be serviced at least annually or more frequently as recommended by the manufacture. Filters and housings must meet or exceed the flow rate and pressure ratings of the compressor or piping system in which they are installed.

10.3.3 Air Purity Standards

All compressor, transfer, or booster pumps used for diver breathing air or gas, must be tested within the last six months for air purity. Sampling will be done as listed in CGA and shall be taken at the discharge point that would normally supply the breathing gas system, the diver's hose, or cylinder fill point. The samples will be analyzed by an independent professional laboratory.

Non-oil lubricated compressors need not be tested for oil mist.

Respirable air supplied to a diver must meet the following criteria [29 CFR 1910.430(b) and RSHS Section 29.2.22.b].

- Oxygen (O_2) 20 to 22 percent by volume
- Carbon Monoxide (CO) not greater than 10 ppm
- Carbon Dioxide (CO_2) not greater than 1000 ppm
- Oil mist (liquid and solid particles) not to exceed 5 milligrams per cubic meter
- Hydrocarbons (including methane and hydrocarbons expressed as methane) not to exceed 25 ppm
- Have no noxious or pronounced odor

Compressors with a discharge above 500 psi will meet the requirement of ANSI CGA 7.1-1989 for Grade E Air or the USN standards.

Compressors with a discharge below 500 psi will meet the requirement of ANSI CGA 7.1-1989 for Grade D Air and shall contain a maximum of 25 ppm of total hydrocarbon content as methane.

Copies of the most recent air sample should be kept with the compressor.

10.3.4 Volume Tanks and Air Receivers

Volume tanks and receivers should have the following PMS checks:

- Internal visual inspection annually
- Hydrostatic testing every 5 years

10.4 PVHO Chambers and Support Systems

Each PVHO chamber manufactured after October 20, 1977, shall be built and maintained in accordance with the ASME PVHO Code or the equivalent.

Chambers manufactured prior to this date shall be maintained in conformity with the code requirements to which it was built, or equivalent. Chambers must have certification documentation on the chamber and viewports. The PVHO chamber must meet the requirements as listed in this section.

Treatment gas appropriate to the diving mode and sufficient air to conduct treatment shall be available at the dive location. All chamber treatments must be under the direction of a qualified Dive Supervisor under the guidance of a diving physician or Diving Medical Officer (DMO). All piping and electrical systems supporting the chamber are diver life support systems and must meet the diving system requirements.

10.4.1 Chamber maintenance

Chambers must be kept clean and ready for treatments. All preventive maintenance service, repairs, or modifications must be documented.

- Chamber must be pressure tested every 2 years, after being moved, or after modification to any pressure boundary.
- Depth gauges must be tested every 6 months; all other gauges must be tested annually.
- Relief valves must be subjected to cracking pressure; test annually.
- Fire extinguisher or fire suppression system must be serviced annually.
- Viewports must be replaced every 10 years or as specified in PVHO-1 directives.
- Atmosphere sampling must be conducted annually, after painting, or if any contaminates were introduced into the chamber.
- Testing of pressurization and depressurization rates must be verified annually.
- Chamber and bedding should be cleaned after each treatment.
- Regulators must be overhauled following manufacturer's recommendations (usually a 5 or 10-year cycle).
- Hyperbaric medical kits should be inventoried and restocked after each treatment and semiannually when the chamber is in treatment standby.
- Scrubbers must be refurbished and cleaned every 5 years, or more frequently as specified by the manufacturer.

- Electrical safety (GFI, emergency batteries, etc.), lighting, and backup systems must be checked annually.

- Communications system should be serviced annually and tested before each mobilization.

10.4.2 BIBS (Built-In-Breathing System) Maintenance

BIBS are considered an oxygen delivery system. All components must be cleaned for oxygen service and never lubricated with hydrocarbon greases or oils. Following is a minimum of BIBS PMS that should be performed:

- Cleaned after each use with soap (non ionic) and water and dried thoroughly

- Cleaned, inspected, and function checked quarterly if chamber is in treatment standby

- Overhauled every five years, replacing soft goods which have deteriorated

10.4.3 Chamber Atmosphere Analysis Equipment

Analysis equipment used for monitoring chamber atmosphere should be maintained following manufacturer's recommended service.

- Oxygen analyzers with monitoring cells must be serviced annually and kept capped when not in use.

- Batteries should be checked or replaced (or recharged) annually or as necessary prior to each operation.

- Analyzers should be checked and calibrated prior to each operation.

10.5 Handling Systems

Handling systems (man skips) used to deploy or lift divers must be designed specifically for personnel transport. Manlift design, installation, testing and operation must conform to requirements of ANSI A90.1 and *Reclamation Safety and Health Standards* (RSHS).

10.6 Diving Safety Boats

Diving safety boats are considered diver life critical equipment. Construction and operation of all watercraft will be in accordance to the requirements of RSHS section 28, as well as applicable U.S. Coast Guard (USCG) and other jurisdictional entities. Divers operating boats must be certified or licensed in accordance with Departmental regulation 485 DM 22 to operate the vessel and follow the rules of the road and safe handling procedures. Each vessel

must be outfitted with all required safety equipment and maintained in a high state of readiness.

Boats used in night operations must have the required navigation lights.

Employees operating vessels are subject to all the regulatory requirements of OSHA and USCG vessel operators. The vessel operator is in command of the vessel and will be held responsible and accountable for the safe operation and navigation of the vessel. Vessel operators must ensure that boats are operated in safe sea conditions and in a manner consistent with established safe boat handling.

Maintenance should include at least the following:

- Annual service of engine.
- Inspection of hull before each mobilization. If the boat is an inflatable, it should be pressurized and checked for leaks.
- Inspect daily and prior to use. Ensure fluid levels are OK, and that all safety equipment and life jackets are in the boat.

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11 Diving Accident Reporting

Diving accidents and incidents are defined as an injury or diving illness occurring during or as a result from the dive or hyperbaric exposure. A diving near miss is any adverse consequence that could have caused an injury to personnel and/or damage to equipment, facilities, or the environment.

Accidents and incidents in diving operations can range from minor injuries and mishaps to life-threatening injuries or decompression illness, even loss of life. All accidents, incidents and near misses shall be reported to the Dive Supervisor, dive team lead, and Reclamation Safety and Health Office.

All diving accidents and incidents will be reported to the RDAC, Regional Dive Team Leader, RDASB, and the Reclamation Safety and Health Office. The Reclamation Safety and Health Office will brief the DASHO; they will determine if a serious accident investigation should be conducted, and appoint a serious accident investigation team if necessary.

All diving accidents must be reported immediately to Regional Dive Team Leader and Safety Manager and include the following initial information:

- Nature of the incident
- Extent of injury, including symptoms and time of onset
- Treatment and results
- Possible cause
- Actions taken to prevent or minimize the injury or illness

11.1 Investigation Responsibilities

A key element of any successful accident prevention program is the timely reporting and investigation of all accidents, incidents, and near misses. All personnel involved in the dive operation, the diver or topside personnel, the Dive Supervisor, and the Regional Dive Team Leader must freely discuss the incident to determine the root causes and develop corrective actions.

11.1.1 Diver or Topside Personnel

Diver or topside personnel must report accidents, incidents, and near misses to the Dive Supervisor. Diver or topside personnel must immediately report to the Dive Supervisor any and all symptoms that may be a pressure-related injury or illness symptom.

11.1.2 Dive Supervisor

The Dive Supervisor has the following responsibilities to investigate and report incidents:

- Complete and submit accident and incident reports in accordance with Reclamation Safety Directive SAF 01-02. The Department's Safety Management Information System (SMIS) shall be used to document all accidents/incidents/near misses. OSHA, USCG, etc., notification and reporting should be completed in coordination with the Reclamation Safety and Health Office.

- Immediately investigate each employee-reported accident or incident (See Appendix O).

- Notify their respective Regional Dive Team Leader and safety and health official of a near miss, or work-related accident or incident that involves personal injury, property damage exceeding $500, or the public (i.e., non-Reclamation) for which the respective safety and health official will determine the extent of investigation.

- Submit to their respective safety and health official, the timely documentation of elements necessary for completion of the SMIS incident report for job-related injuries or illness requiring medical treatment or first aid provided by a medical professional.

- For boating accidents, use "Boating Accident Report" (USCG form 3865) or USCG-accepted State form in addition to the SMIS report.

11.1.3 Regional Dive Team Leader

The Regional Dive Team Leader must immediately notify the Regional Director and Regional Safety and Health Manager in the region where an accident or incident occurred which resulted in death, hospitalization, or public injury or illness (non-Reclamation).

The Dive Team Leader must ensure that the OSHA Area Office closest to the incident site (or if unavailable, the national office at 1-800-321-OSHA) is notified of a worker fatality within 8 hours, and any amputation, loss of an eye, or hospitalization of a worker within 24 hours.

11.2 Accident Reporting in Compliance with USCG Requirements

Reclamation diving operations taking place from U.S. Coast Guard inspected vessels or from vessels and facilities under U.S. Coast Guard jurisdiction must comply with the reporting requirements of 46 CFR 197.484-486(c).

The reporting requirements of 46 CFR 197 require that the person in charge file written reports with U.S. Coast Guard officials. The person in charge on an inspected vessel is normally the vessel master. Close coordination will be required between Reclamation representatives and the vessel crew to ensure that reporting meets the requirements of all parties. When diving in this jurisdiction, a tailored dive plan is required that addresses details of these issues.

Glossary of Diving Terminology and Definitions

Abort – Common term for termination of a dive in an emergency situation or to prevent an emergency situation.

Absolute Pressure – Pressure measurement that includes the weight of the atmosphere; usual measurements would be psig, ATA, or mmHg.

Acoustics – Devices that place sound in the water; used for sonar, transponders, pingers, and interrogators. Sounds at certain frequencies can injure divers.

Adjunctive Therapy – Medical measures other than recompression used to treat decompression sickness or gas embolism symptoms. Includes, but is not limited to, injection of drugs, administration of oxygen, etc.

Advanced Cardiac Life Support (ACLS) – Medical procedures performed to resolve life threatening conditions such as cardiac arrest, respiratory arrest, etc. Normally done by physicians, trained emergency medical technicians, or qualified dive medics.

Alternobaric Vertigo (ABV) – A form of transient vertigo common to diving that occurs during ascents or descents.

Altitude Correction – Due to the lower atmospheric pressure at altitude, a correction is required to adjust the actual diving depth to the sea level equivalent depth.

$$\text{Equivalent Depth (fsw)} = \text{Altitude Depth (fsw)} \times \frac{\textit{Pressure at Sea Level (mb)}}{\textit{Pressure at Altitude (mb)}}$$

Altitude Diving – Dives performed at locations 1000 ft. or more above sea level. All decompression tables are designed for use at sea level. Altitude diving involves different or modified tables and additional special procedures.

Alveoli – The area in the lungs where oxygen and carbon dioxide exchange occur between the pulmonary and circulatory system.

ANSI – American National Standards Institute

Approved Diver Training Facility – Accredited commercial diving or military diving school that trains divers to perform work underwater.

Arterial Gas Embolism (AGE) – The most serious of the disorders resulting from over inflation syndrome where air (gas) is forced into the circulation system from over expansion of the

lungs. Usually related to a sudden ascent, blowup, or panic ascent to the surface. Serious symptoms result from air bubbles in the brain or heart.

ASME Code or Equivalent – ASME (American Society of Mechanical Engineers) "Boiler and Pressure Vessel Code," Section VIII, or an equivalent code that the employer can demonstrate to be equally effective.

ATA (Atmospheres Absolute) – Most common pressure conversion measurement used by divers.

1 ATA = 33 fsw = 14.7 psi.
See also Absolute Pressure and ATM

ATM (Atmosphere) – An ATM is one atmosphere, a single unit of atmosphere.

Bailout – A diver-carried supply of air (or mixed gas, as appropriate) sufficient under standard operating conditions to allow the diver to reach the surface, reach another source of breathing gas, or to be reached by a standby diver (to allow buddy breathing).

Barotraumas – Trauma or injury caused by pressure or barometric pressure. Normally caused when pressures are not kept in balance or equilibrium. Also refers to *squeezes* or hydrostatic injury.

BC (Buoyancy Compensator) – Variable inflation device used by SCUBA divers to control buoyancy.

Bends – Common diver term for decompression sickness. (See Decompression Sickness)

BIBS (Built-In-Breathing System) – Masks used in chambers that go on a diver's face (making a seal) to allow the diver to breath oxygen or Nitrox for treatment or decompression purposes.

Blowup – Usually a catastrophic event in diving that refers to a diver losing buoyancy control and making a rapid ascent to the surface, missing all decompression stops. In worst-case situations, the diver suffers from immediate symptoms of gas embolism and has a high probability of a fatality. Condition is more common in closed variable volume suits used in heavyweight diving; however, a blowup can occur with dry suits or when using a BC if proper procedures are not followed or if divers panic.

Bottom Time or Total Bottom Time (TBT) – The total elapsed time measured in minutes from the time the diver leaves the surface to the time that the diver begins ascent. Total bottom time includes the actual time spent on the bottom and the descent time, which should normally be at maximum of 75 FPM.

Breath-Hold Diving – A diving mode in which the diver uses no self-contained or surface-supplied air or oxygen supply. Free diving from the surface on a single breath.

Burst Pressure – The pressure at which a pressure containment device fails structurally. This is usually a factor on hoses, piping, tubing, volume tanks, PVHOs, etc.

Caloric Vertigo – A vertigo caused by cold water entering at least one outer ear canal.

cfm – Cubic feet per minute

CGA (Compressed Gas Association) – Established standards for valves and connections used for gas distribution.

Chamber – A pressure vessel for human occupancy such as a surface decompression chamber, closed bell, or deep diving systems used to decompress divers and to treat decompression sickness. Also referred to as recompression chamber, deck decompression chamber (DDC), or chamber.

Chokes (Pulmonary Decompression Sickness) - A very serious form of decompression sickness which occurs when bubbles are formed in the alveoli or great vessels of the lungs. Predominant symptoms involve choking, coughing, and respiratory arrest. Immediate recompression is indicated.

CNS (Central Nervous System) – The body system that includes the brain and spinal cord and that is most seriously affected by decompression sickness or arterial gas embolism.

CO_2 (Carbon Dioxide) – A colorless gas that is a byproduct of respiration. High CO_2 levels in diver breathing air can cause toxic conditions and lead to symptoms of respiratory distress. Dives conducted in high levels of CO_2 have an increased possibility of divers developing decompression sickness.

CO (Carbon Monoxide) – Colorless, odorless, and tasteless gas; a byproduct of incomplete combustion from an internal combustion engine or industrial pollution. CO gas, even in very low levels, prevents the red blood cells from transporting oxygen. Diver's air must be tested to ensure levels of CO are kept very low.

Commercial Diver – A diver for hire who performs work tasks underwater or any diving operation that involves construction, demolition, repair, maintenance, search, underwater inspections, placing and removing heavy objects, or other similar tasks.

Compressor – A device for compressing air or gas to low or high pressure. A continuous supply of diver's breathing air. See also HPAC and LPAC.

Confined Space Diving – A physically confining space is any space that would restrict the diver's ability to rotate himself or herself head to toe, 180 degrees in any plane, or when the diver has no direct access to the surface or bell for recovery of the diver from the water. Confined space diving requires (at a minimum) special considerations for reserve air supply and minimum dive team requirements. Special diver rescue procedures and communication plans should be included in the plan. Examples of confined spaces in diving operations are pipelines, tanks, gate chambers, pump chambers, or other underwater structures.

CPR (Cardiac Pulmonary Resuscitation) – First Aid for cardiac arrest or heart attack with no pulse.

Cyanosis – Blue or pale looking skin, lips, or nail beds

Cylinder – A pressure vessel for the storage of air or gases.

DAN – Divers Alert Network

DASHO – Designated Agency Safety and Health Official

DDC (Deck Decompression Chamber) – A common name for a chamber specifically set up and ready for surface decompression.

Decompression Illness (DCI) – An all-encompassing term that refers to all pressure-related illnesses that occur to divers. See also Decompression Sickness and Arterial Gas Embolism.

Decompression Sickness (DCS) – A condition with a variety of symptoms that may result from gas and bubbles in the tissues of divers after pressure reduction. Also referred to as Bends, Caisson Disease, and Compressed Air Illness.

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 to prevent decompression sickness.

Depth – On a dive the 'depth' is the maximum depth attained. This maximum depth is used to select the decompression table.

DIN adapter or Manifold – A connection to a SCUBA cylinder that threads in place, or a European standard SCUBA connection that is being adapted into the US for SCUBA connections in excess of 3000 psi.

Dive Hazard Analysis – A dive hazard analysis (DHA) of both surface and underwater conditions shall be prepared by the Dive Supervisor and approved by the Regional Dive Team Leader, RDAC Regional Safety Officer, and one other RDAC member.

Dive Location – A place or vessel from which a diving operation is conducted. Latitude and longitude can be used to define the dive location.

Diver – An employee working in the water (or chambers) who uses underwater breathing apparatus (including snorkels) that supplies breathing air or gas to provide life support to the diver at depth.

Diver Breathing Air – Air that has been tested and delivered to a diver from a system that is certified for delivery of diver air.

Diver-Carried Reserve Breathing Gas – A diver-carried 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 a standby diver (to allow buddy breathing). Also referred to as bailout supply or come-home bottle.

Dive Site – The physical location of a diver during a dive. A dive site may be on the surface or underwater.

Dive Station – The location where diving operations are directly controlled. The dive station also includes auxiliary or peripheral equipment needed to conduct the dive.

Dive Team – Divers and support employees who are exposed to or who control the exposure of others to hyperbaric conditions, including the person-in-charge, the Dive Supervisor, and dive tenders.

Diving Mode – A type of diving requiring specific equipment, procedures, and techniques (SCUBA, surface-supplied air, or mixed gas). Mode I = Open Circuit SCUBA, Mode II = SCUBA-Tethered, and Mode III = Surface Supplied Air.

DMO (Diving Medical Officer) – A physician trained in diving and hyperbaric medicine on call for treatment of divers with decompression-related illness or injuries.

DOT – Department of Transportation.

Drowning – Results when a person stops breathing as a result of being submerged underwater. See Near Drowning.

Dry Suit – A suit worn by a diver for thermal protection that allows no water to come in contact with the skin. The thin layer of air and underwear keep the diver warmer than a wet suit.

Dyspnea – A condition where a person is short of breath.

Ear Squeeze – The most common diver injury that results when a diver cannot clear properly when descending or ascending. This is a form of barotrauma that results in damage to the middle ear. In the worst case, the eardrum is ruptured.

Edema – A medical term that refers to swelling.

Embolism – Condition resulting from overinflation syndrome. Arterial gas embolism results when air (or gas) ruptures the alveoli in the lungs and is infused into the circulatory system. Bubbles of gas block arteries, causing CNS (stroke-like) symptoms such as paralysis, blindness, staggers, loss of hearing, ringing of ears, unconsciousness, etc. Embolisms resulting from diving require immediate recompression.

Emphysema – A condition resulting from air trapped in the body, causing overexpansion of tissues and distension of the walls. When the lungs are involved, pressure can be exerted on the heart and great vessels.

EMS – Emergency medical services

EP or Emergency Procedure – Procedures taken by divers or Dive Supervisors to resolve emergency incidents to minimize injury or prevent injury.

Exceptional Exposure Diving – Dives conducted beyond the limits of standard air decompression, in that the in-water exposure times and the partial pressure of oxygen are beyond acceptable limits of exposure.

External Otitis – External ear infections.

Facemask – Diver term for the device worn on the face to keep water out of the eyes.

First Stage Regulator – A submersible regulator that reduces the high-pressure air or gas (>500 psi) to a working low pressure, usually 110 – 175 psi over bottom.

Flasks – A high-pressure cylinder for the storage of gas.

Float – A device that floats on the surface; a device used to mark a location.

Flying after Diving – Term referring to the diver's condition for 12 to 24 hours after a dive because flying after the dive might cause development of decompression sickness.

Fouling – Term for restricting the movement of an umbilical, line, or hose from the surface; caught up on something that prevents movement of the diver in some way.

Free Ascent – A condition where divers have unrestricted ascent to the surface. Divers do not have free ascent when under vessels, in confined spaces, etc.

Free Diving – Breathhold dives made from the surface without any UBA (underwater breathing apparatus).

fsw or FSW – Feet of seawater (or equivalent static pressure head); the most common method of determining the pressure a diver is exposed to — 33 fsw = 1 atmosphere. Actual depth, not an altitude-corrected depth.

Gas Analysis – Instruments used to analyze diving breathing air or gas.

Gas Embolism – Serious diving conditions that result from overinflation syndrome. Arterial gas embolism results when air (or gas) ruptures the alveoli in the lungs and is infused into the circulatory system. Bubbles of gas block arteries causing CNS (stroke-like) symptoms, such as paralysis, blindness, staggers, loss of hearing, ringing of ears, unconsciousness, etc. Embolisms resulting from diving require immediate recompression.

Gas Free Engineering – Methods for verifying air-filled confined spaces are clear and the atmosphere is breathable.

Hand Signals – Signals given between a diver and the surface to communicate. Hand signals can be given on a hose, line, or umbilical to a tended diver or between divers on the bottom.

Hose – Flexible device for transporting gases or fluids. See also Umbilical.

Hot Water Suit – Suit worn by divers for maximum thermal protection. Hot water is supplied from a heater on the surface and pumped to the diver via an additional hose in the umbilical. The suit has a manifold that allows the diver to control his hot water.

HPAC (High Pressure Air Compressor) – A diving air compressor with a rated output pressure of greater than 500 psi; used to charge SCUBA and HP flasks.

Hydration – Keeping sufficient water in the body. Divers who become dehydrated are more prone to decompression sickness.

Hyperbaric Conditions – Pressure conditions in excess of normal atmospheric pressure at the dive site.

Hypercapnia – Carbon dioxide toxicity.

Hyperthermia – Hyper refers to an elevated state of temperature; heat injury to a diver or topside worker.

Hypothermia – Hypo refers to a lowered state of temperature; cold injury to a diver or topside worker.

Hypoxia – Condition that occurs when the body is starved for oxygen. The person usually loses consciousness very quickly.

Inside Tender – Inside chamber operator who is also the medical attendant in a recompression treatment.

IV – Intravenous fluids are the primary method of hydration. IVs are an advanced medical measure that puts fluids directly into a person to prevent shock and reduce effects of decompression sickness. IVs can be administered in a chamber by a qualified dive medic.

J Valve – A special tank valve that is equipped with a back pressure spring that holds 300-500 psi in a SCUBA cylinder, which permits a reserve to be contained for emergency ascent situations.

K Valve – A standard SCUBA cylinder valve that allows the yoke fitting on the first stage regulator to be attached.

LB (Left Bottom) – Standard abbreviation for a term that ends bottom time and begins decompression time.

Lift Bags – Inflatable bags used by diver to lift objects off the bottom or provide buoyancy control.

Lightweight Diver – Surface supply diving mode where the diver breathes from a demand mask or helmet and does not have a variable volume dry suit integrated with the helmet.

Line Pull Signals – Signals used primarily between a tender and a surface supply diver in the water. One, two, three, or four pulls has a definite meaning. Tenders and divers are required to know standard line pull signals.

Liveboating – The practice of supporting a surface-tended diver from a vessel that is underway.

Lost Diver – Situation that occurs when a free-swimming diver is separated from his buddy or whenever a tended diver is severed from his umbilical.

LPAC (Low Pressure Air Compressor) – A diving air compressor with a rated output pressure of 500 psi or less.

lpm – liters per minute

Maximum Work Pressure – The maximum pressure to which a containment device may be exposed under standard operating conditions.

mb (Millibars) – A measuring unit for expressing atmospheric pressure.

Mediastinal Emphysema – One of the conditions resulting from over-inflation syndrome that occurs when air (or gas) enters the mediastinal area of the chest. If the condition is uncomplicated (without serious symptoms), it is usually not treated by recompression.

NAUI – National Association of Underwater Instructors

Near Drowning – The condition that results from successful resuscitation of a drowning victim. Persons who have been successfully resuscitated still need medical evaluation and testing.

Neuro or Neurological Exam – An examination of a diver to determine if any neurological symptoms are present and involves evaluation of mental status, cranial nerves (vision, hearing, speech, etc.), strength, sensory ability, and reflexes.

Nitrogen Narcosis – Condition resulting from the narcotic effect of nitrogen that begins to affect divers at 99 feet and increases as the diver goes deeper. Also referred to as 'Rapture of the Deep' or being 'Narked'.

NITROX or Nitrox – Nitrogen and oxygen mixture or enriched air.

No-Decompression – The depth-time limits of the "Unlimited/No-Decompression limits and repetitive dive group designations table for no-decompression air dives" in the *U.S. Navy Diving Manual*, or equivalent limits that the employer can demonstrate to be equally effective.

Octopus Regulator – A spare second-stage regulator worn by a SCUBA diver that permits buddy breathing without interrupted breathing; allows the buddy to use the spare regulator and breathe off the same air supply as the first diver.

Omitted Decompression – Situation that occurs when a diver has surfaced and missed the required decompression in the water. Specific procedures are required to resolve decompression to prevent the onset of symptoms. Also referred to as 'asymptotic omitted decompression' because, although the diver has missed decompression, he has no symptoms of diving maladies. If the diver develops symptoms, then he must be treated for serious symptoms.

OP (Operating Procedure) – Written procedures or checklists used to align diving systems and operated equipment.

OSHA – Occupational Safety and Health Administration

Overinflation Syndrome – A Syndrome is a set of symptoms and conditions that result from a specific insult. Overinflation syndrome results from air being forced into the body tissues resulting in gas embolism, pneumothorax, mediastinal emphysema, or subcutaneous emphysema.

Oxygen Toxicity – A toxic condition that results from too much oxygen; high partial pressures greater than 1.2 effective atmospheres over a given period of time. There are two types of oxygen toxicity — CNS and Pulmonary. CNS occurs from high, short exposures that cause CNS symptoms, such as grand mal seizures, dizziness, twitching, mood changes, etc. Pulmonary oxygen toxicity results from long exposures that irritate the lungs and respiratory tissues.

PADI – Professional Association of Diving Instructors

Pain Only – Symptoms of DCS (bends) that cause pain in the joints of the arms and legs. Also considered as pain only or Type I DCS are itching, swelling, and rashes (skin or lymphatic bends).

Physically Confining Space – Any space that would restrict the diver's ability to rotate himself or herself head to toe, 180 degrees in any plane or when the diver has no direct access to the surface or bell for recovery of the diver from the water. Confined space diving requires (at a minimum) special considerations for reserve air supply and minimum dive team requirements. Special diver-rescue procedures and communication plans should be included in the plan. Examples of confined spaces in diving operations are pipelines, tanks, gate chambers, pump chambers, or other underwater structures.

PMS (Preventive Maintenance Service) – Service procedures or checklist used to document maintenance on life-support diving equipment.

Pneumofathometer – A subsystem used by the Dive Supervisor to monitor a surface supply diver's depth, consisting of a hose in the umbilical, a depth gauge on the surface, and a supply of air controlled by a valve. Air is pushed through the open hose and the gauge indicates the diver's depth.

Pneumothorax – One of the conditions that can occur from over-inflation syndrome when air is forced between the chest wall and lining of the lung; a very painful condition. The condition may or may not be recompressed. A more complicated form of the condition is tension pneumothorax, which occurs when a lung is collapsed or compressed to the extent that the heart and great vessels are shifted, causing acute cardiopulmonary distress.

Pressure-Related Injury – Any injury resulting from pressure disequilibrium within the body as the result of hyperbaric exposure, such as decompression sickness or over-inflation syndrome conditions (i.e., pneumothorax, mediastinal emphysema, gas (air) embolism, or subcutaneous emphysema).

psi – pounds per square inch

PVHO (Pressure Vessel for Human Occupancy) – A chamber certified under the ASME rules of pressure vessels construction. All chambers approved for diving should be PVHO certified.

Rate of Ascent – The rate at which a diver ascends in the water column from the bottom to the surface. Normal rate of ascent should not exceed 30 fpm.

Rate of Descent – The rate of descent from the surface to the bottom. Normal rate of descent is as fast as tolerated, not to exceed 75 fpm.

RDAC – Regional Diving Advisory Committee

RDSAB – Reclamation Diving Safety Advisory Board

Recompression Chamber – A chamber in standby for recompression treatment. Also referred to as a DDC, deck-decompression chamber, chamber, or PVHO.

Recurrence – Refers to symptoms that recur after or during a recompression treatment. Any symptom that recurs is considered more serious and requires aggressive recompression treatment.

Repetitive Dive – Defined specifically as a dive 10 minutes after surfacing and in less than 12 hours. A repetitive dive is another dive occurring before the diver can completely off gas from the first or subsequent dive.

Repetitive Group Designation – A letter A-O and Z that indicates the residual nitrogen remaining for a repetitive dive. The group is used to calculate the surface interval credit and to obtain a new group.

Reserve Breathing Gas – A supply of breathing gas at the dive location that is independent of the primary supply system and sufficient to support divers during the planned decompression. Also referred to as standby or emergency supply.

Residuals – Residual symptoms that remain after a treatment. This may indicate partial impairment or disability condition.

ROV (Remotely Operated Vehicle) – An unmanned vehicle used to perform underwater tasks or observations. ROVs can be simple camera platforms or complex units with robotic arms to perform specific tasks.

Requal or Requalification Dive – A dive to recertify a diver or evaluate his training level.

Residual Nitrogen – Refers to a level of nitrogen remaining in the diver's tissues. Residual nitrogen time is added to the bottom time of a repetitive dive to select the table for a repetitive dive.

RS or Reached Surface – The clock time recorded when a diver's head breaks the surface.

Scientific Diving – All 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 does not include performing any tasks usually associated with commercial diving, such as placing or removing heavy objects underwater, inspecting pipelines and similar objects, construction, demolition, cutting, welding, or the use of explosives. In addition, a scientific diving program is under the control of a diving control board that has absolute and autonomous authority over the program's operations. Because the project is for the advancement of science, resulting data is non-proprietary. The tasks of

the scientific diver are that of an observer and data gatherer. The scientific diver, by the nature of his or her activities, is a scientist or scientist in training.

SCUBA Diving – Acronym for Self Contained Underwater Breathing Apparatus. A diving mode independent of surface supply in which the diver is a free swimmer using a self-contained underwater breathing apparatus, breathing from a supply of air (gas) the diver is carrying.

Second Stage Regulator – The SCUBA regulator directly attached to the diver's mouthpiece that delivers the air as the diver breathes.

Self Contained Underwater Breathing Apparatus (SCUBA) – A diving mode independent of surface supply in which the diver is a free swimmer using a self-contained underwater breathing apparatus, breathing from a supply of air (gas) the diver is carrying.

Serious Symptoms of DCS (Bends) – Symptoms that involve the central nervous system or spinal cord, which include numbness, paralysis, loss of sensation or muscle strength, vision impairments, auditory symptoms (staggers), severe respiratory involvement (chokes), etc.

Shallow Water Blackout – Condition that occurs in shallow water from breath-hold diving. The diver passes out and suffers drowning or near drowning.

SMIS – Safety Management Information System

Spare Air – A small cylinder carried by a SCUBA diver as an emergency breathing supply.

Standby Diver – A diver at the dive location who is capable of rendering immediate assistance to the diver in the water.

Sur D (Sur D O2, Sur D Air, or Surface Decompression) – A standard procedure used when the diver completes only minimal or no in-water decompression and is brought to the surface and placed in a chamber to complete decompression. Sur D O2 refers to breathing oxygen in the chamber versus air, as when using Sur D air.

Surface Supplied Air Diving (SSA) – A diving mode in which the diver in the water is supplied from the dive location with compressed air for breathing.

TBT (Total Bottom Time) – Calculated as time from LS (left surface) to LB (left bottom).

TDT (Total Decompression Time) – Calculated as time from LB (left bottom) to RS (reached surface).

TTD (Total Time of Dive) – Calculated as time from LS (left surface) to RS (reached surface).

$$TBT + TDT = TTD$$

Treatment Table – A depth-time and breathing-gas profile designated to treat decompression illness (DCI).

UBA (Underwater Breathing Apparatus) – A mask or helmet used to supply breathing gas and communications to a diver.

Umbilical – The composite hose bundle between a dive location and a diver or bell, or between a diver and a bell that supplies the 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.

Vertigo – Condition that involves the balance center of the inner ear. The diver has a spinning sensation that causes disorientation, nausea, and vomiting. A symptom of AGE (arterial gas embolism), inner ear DCS (decompression sickness or *staggers*), inner ear oval or round window ruptures, ABV (alternobaric vertigo), or cold water in the ears.

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

Wet Suit – A suit worn by a diver for thermal protection that holds a thin layer of water against the skin.

Yoke Adapter or Manifold – Standard SCUBA cylinder connection used to attach a first stage regulator to the cylinder.

Appendices

A Dive Hazard Analysis (Form)

B Unlimited/No Decompression Dive Tables and Repetitive Group Table, US Navy (Table)

C Emergency Gas Supply (EGS) Calculations

D Decompression Tables, US Navy (Table)

E Hand Signals for Underwater Communication, US Navy (Figure)

- E1 Line Pull Signals, US Navy (Table)

F Scuba Repetitive Dive Worksheet (Form)

G Dive Log for Surface Supplied Air Diving Mode (Form)

H Altitude Correction, US Navy Sea Level Equivalent Depth (fsw) (Table)

- H1 Penalty Group Upon Arrival at Altitude, US Navy (Table)
- H2 Required Surface Interval Before Ascent to Altitude after Diving, US Navy (Table)

I First Aid Kit (Diving) Recommended Items (Table)

J Emergency Procedures on SCUBA (Table)

K Emergency Procedures on Surface Supplied Air (SSA) (Table)

L Equipment Maintenance/Repair Record (Example)

- L1 Equipment Maintenance/Repair Record (Scuba Cylinder Inspection) (Example)
- L2 Equipment Maintenance/Repair Record (Regulator Repair/Service) (Example)

M Scuba Diving Checklist (Example)

N Surface Supplied Air Checklist (Example)

O Diving Accident Reporting (Form)

P Diving Services Request Form (Example)

Q Chambers/PVHO

R OSHA Safe Practices Manual — 1910.401

Appendix A: Dive Hazard Analysis (Form)

DIVE HAZARD ANALYSIS

Feature:_____ Date:_____(Haz. Analysis)

Dive Location:_____ Date:_____(Examination)

Dive Purpose:_____

Dive Area: Lake___ River__ Ocean___ Dam___ Canal__

Other Previous Diving in Area:

ITEM	NOTE	OKAY	REMARKS
Access			
Exit			
Depth Actual			
Altitude			
Depth Corrected			
Non Decom Limit			
Temperature			
Maximum BT			
Bottom Condition			
Entanglement			
Weather			
Currents			
Vertical Ascent			
Visibility Water			
Lights Required			
Video Recommended			
Camera Recommended			
Surface Support			
Special Equipment			
Team Coordination			
Dive Plan			
Emergency Equipment			
Hospital			
Physician			
Recom. Chamber			
Ambulance			
Radio/Telephone			
Diver's Experience			

Appendix A Continued

Conditions:	
Satisfactory:	
Unsatisfactory:	
Regional Dive Team Leader	Date
RDAC Regional Safety Officer	Date
RDAC Member	Date
Dive Master	Date
Personnel:	
Hazardous Energy Control:	
Dive Plan:	

Appendix B: Unlimited/No Decompression Dive Tables and Repetitive Group Table (Tables)

Source: U.S. Navy Diving Tables, Rev 7

Table 9-7. No-Decompression Limits and Repetitive Group Designators for No-Decompression Air Dives.

Depth (fsw)	No-Stop Limit	Repetitive Group Designation															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
10	Unlimited	57	101	158	245	426	*										
15	Unlimited	36	60	88	121	163	217	297	449	*							
20	Unlimited	26	43	61	82	106	133	165	205	256	330	461	*				
25	1102	20	33	47	62	78	97	117	140	166	198	236	285	354	469	992	1102
30	371	17	27	38	50	62	76	91	107	125	145	167	193	223	260	307	371
35	232	14	23	32	42	52	63	74	87	100	115	131	148	168	190	215	232
40	163	12	20	27	36	44	53	63	73	84	95	108	121	135	151	163	
45	125	11	17	24	31	39	46	55	63	72	82	92	102	114	125		
50	92	9	15	21	28	34	41	48	56	63	71	80	89	92			
55	74	8	14	19	25	31	37	43	50	56	63	71	74				
60	63	7	12	17	22	28	33	39	45	51	57	63					
70	48	6	10	14	19	23	28	32	37	42	47	48					
80	39	5	9	12	16	20	24	28	32	36	39						
90	33	4	7	11	14	17	21	24	28	31	33						
100	25	4	6	9	12	15	18	21	25								
110	20	3	6	8	11	14	16	19	20								
120	15	3	5	7	10	12	15										
130	12	2	4	6	9	11	12										
140	10	2	4	6	8	10											
150	8		3	5	7	8											
160	7		3	5	6	7											
170	6			4	6												
180	6			4	5	6											
190	5			3	5												

* Highest repetitive group that can be achieved at this depth regardless of bottom time.

Appendix B continued

Table 9-8. *Residual Nitrogen Time Table for Repetitive Air Dives.*

Locate the diver's repetitive group designation from his previous dive along the diagonal line above the table. Read horizontally to the interval in which the diver's surface interval lies.

Next, read vertically downward to the new repetitive group designation. Continue downward in this same column to the row that represents the depth of the repetitive dive. The time given at the intersection is residual nitrogen time, in minutes, to be applied to the repetitive dive.

* Dives following surface intervals longer than this are not repetitive dives. Use actual bottom times in the Air Decompression Tables to compute decompression for such dives.

Repetitive Group at Beginning of Surface Interval

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
A	:10 2:20 *															
B	:10 1:16	1:17 3:36 *														
C	:10 :55	:56 2:11	2:12 4:31 *													
D	:10 :52	:53 1:47	1:48 3:03	3:04 5:23 *												
E	:10 :52	:53 1:44	1:45 2:39	2:40 3:55	3:56 6:15 *											
F	:10 :52	:53 1:44	1:45 2:37	2:38 3:31	3:32 4:48	4:49 7:08 *										
G	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:23	4:24 5:40	5:41 8:00 *									
H	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:16	5:17 6:32	6:33 8:52 *								
I	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:08	6:09 7:24	7:25 9:44 *							
J	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 7:00	7:01 8:16	8:17 10:36 *						
K	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:52	7:53 9:09	9:10 11:29 *					
L	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:44	8:45 10:01	10:02 12:21 *				
M	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:37	9:38 10:53	10:54 13:13 *			
N	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:59	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:29	10:30 11:45	11:46 14:05 *		
O	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:27	10:28 11:21	11:22 12:37	12:38 14:58 *	
Z	:10 :52	:53 1:44	1:45 2:37	2:38 3:29	3:30 4:21	4:22 5:13	5:14 6:06	6:07 6:58	6:59 7:50	7:51 8:42	8:43 9:34	9:35 10:27	10:28 11:19	11:20 12:13	12:14 13:30	13:31 15:50 *

Repetitive Group at the End of the Surface Interval

Dive Depth	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
10	**	**	**	**	**	**	**	**	**	**	**	427	246	159	101	58
15	**	**	**	**	**	**	**	**	450	298	218	164	122	89	61	37
20	**	**	**	**	**	462	331	257	206	166	134	106	83	62	44	27
25	†	†	470	354	286	237	198	167	141	118	98	79	63	48	34	21
30	372	308	261	224	194	168	146	126	108	92	77	63	51	39	28	18
35	245	216	191	169	149	132	116	101	88	75	64	53	43	33	24	15
40	188	169	152	136	122	109	97	85	74	64	55	45	37	29	21	13
45	154	140	127	115	104	93	83	73	64	56	48	40	32	25	18	12
50	131	120	109	99	90	81	73	65	57	49	42	35	29	23	17	11
55	114	105	96	88	80	72	65	58	51	44	38	32	26	20	15	10
60	101	93	86	79	72	65	58	52	46	40	35	29	24	19	14	9
70	83	77	71	65	59	54	49	44	39	34	29	25	20	16	12	8
80	70	65	60	55	51	46	42	38	33	29	25	22	18	14	10	7
90	61	57	52	48	44	41	37	33	29	26	22	19	16	12	9	6
100	54	50	47	43	40	36	33	30	26	23	20	17	14	11	8	5
110	48	45	42	39	36	33	30	27	24	21	18	16	13	10	8	5
120	44	41	38	35	32	30	27	24	22	19	17	14	12	9	7	5
130	40	37	35	32	30	27	25	22	20	18	15	13	11	9	6	4
140	37	34	32	30	27	25	23	21	19	16	14	12	10	8	6	4
150	34	32	30	28	26	23	21	19	17	15	13	11	9	8	6	4
160	32	30	28	26	24	22	20	18	16	14	13	11	9	7	5	4
170	30	28	26	24	22	21	19	17	15	14	12	10	8	7	5	3
180	28	26	25	23	21	19	18	16	14	13	11	10	8	6	5	3
190	26	25	23	22	20	18	17	15	14	12	11	9	8	6	5	3

Residual Nitrogen Times (Minutes)

** Residual Nitrogen Time cannot be determined using this table (see paragraph 9-9.1 subparagraph 8 for instructions).

† Read vertically downward to the 30 fsw repetitive dive depth. Use the corresponding residual nitrogen times to compute the equivalent single dive time. Decompress using the 30 fsw air decompression table.

Appendix C: Emergency Gas Supply (EGS) Calculations

EGS calculations for 19 foot cubic cylinder									
Depth (fsw)	Depth psi	ATA	Rate ft^3/min	Cylinder psi	Cylinder Volume	Delievery Pressure depth in PSI + 150 psi reg pressure	Usable Gas pressure	Useable Gas ft^3/cylinder	Duration Minutes at Depth
150	66.75	5.55	1.5	3000	19	216.75	2783.25	17.63	2.12
125	55.63	4.79	1.5	3000	19	205.63	2794.38	17.7	2.46
100	44.5	4.03	1.5	3000	19	194.5	2805.5	17.77	2.94
75	33.38	3.27	1.5	3000	19	183.38	2816.63	17.84	3.64
50	22.25	2.52	1.5	3000	19	172.25	2827.75	17.91	4.74
25	11.13	1.76	1.5	3000	19	161.13	2838.88	17.89	6.78

EGS calculations for 30 foot cubic cylinder									
Depth (fsw)	Depth psi	ATA	Rate ft^3/min	Cylinder psi	Cylinder Volume	Delievery Pressure depth in PSI + 150 psi reg pressure	Usable Gas pressure	Useable Gas ft^3/cylinder	Duration Minutes at Depth
150	66.75	5.55	1.5	3000	30	216.75	2783.25	27.83	3.35
125	55.63	4.79	1.5	3000	30	205.63	2794.38	27.94	3.89
100	44.5	4.03	1.5	3000	30	194.5	2805.5	28.06	4.64
75	33.38	3.27	1.5	3000	30	183.38	2816.63	28.17	5.74
50	22.25	2.52	1.5	3000	30	172.25	2827.75	28.28	7.50
25	11.13	1.76	1.5	3000	30	161.13	2838.88	28.39	10.77

EGS calculations for 50 foot cubic cylinder									
Depth (fsw)	Depth psi	ATA	Rate ft^3/min	Cylinder psi	Cylinder Volume	Delievery Pressure depth in PSI + 150 psi reg pressure	Usable Gas pressure	Useable Gas ft^3/cylinder	Duration Minutes at Depth
150	66.75	5.55	1.5	3000	50	216.75	2783.25	46.93	5.58
125	55.63	4.79	1.5	3000	50	205.63	2794.38	46.57	6.48
100	44.5	4.03	1.5	3000	50	194.5	2805.5	46.76	7.73
75	33.38	3.27	1.5	3000	50	183.38	2816.63	46.94	9.56
50	22.25	2.52	1.5	3000	50	172.25	2827.75	47.13	12.49
25	11.13	1.76	1.5	3000	50	161.13	2838.88	47.13	17.95

EGS calculations for 80 foot cubic cylinder									
Depth (fsw)	Depth psi	ATA	Rate ft^3/min	Cylinder psi	Cylinder Volume	Delievery Pressure depth in PSI + 150 psi reg pressure	Usable Gas pressure	Useable Gas ft^3/cylinder	Duration Minutes at Depth
150	66.75	5.55	1.5	3000	80	216.75	2783.25	74.22	8.92
125	55.63	4.79	1.5	3000	80	205.63	2794.38	74.52	10.38
100	44.5	4.03	1.5	3000	80	194.5	2805.5	74.81	12.38
75	33.38	3.27	1.5	3000	80	183.38	2816.63	75.11	15.30
50	22.25	2.52	1.5	3000	80	172.25	2827.75	75.41	19.99
25	11.13	1.76	1.5	3000	80	161.13	2838.88	75.70	28.72

Appendix D: Decompression Tables (Table)

Source: U.S. Navy Diving Manual, Rev. 7

Table 9-9. *Air Decompression Table.*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
30 FSW														
371	1:00	AIR									0	1:00	0	Z
		AIR/O_2									**0**	1:00		
380	0:20	AIR									5	6:00	0.5	Z
		AIR/O_2									**1**	2:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ----------														
420	0:20	AIR									22	23:00	0.5	Z
		AIR/O_2									**5**	6:00		
480	0:20	AIR									42	43:00	0.5	
		AIR/O_2									**9**	10:00		
540	0:20	AIR									71	72:00	1	
		AIR/O_2									**14**	15:00		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or SurDO_2 Required ----------														
600	0:20	AIR									92	93:00	1	
		AIR/O_2									**19**	20:00		
660	0:20	AIR									120	121:00	1	
		AIR/O_2									**22**	23:00		
720	0:20	AIR									158	159:00	1	
		AIR/O_2									**27**	28:00		
35 FSW														
232	1:10	AIR									0	1:10	0	Z
		AIR/O_2									**0**	1:10		
240	0:30	AIR									4	5:10	0.5	Z
		AIR/O_2									**2**	3:10		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ----------														
270	0:30	AIR									28	29:10	0.5	Z
		AIR/O_2									**7**	8:10		
300	0:30	AIR									53	54:10	0.5	Z
		AIR/O_2									**13**	14:10		
330	0:30	AIR									71	72:10	1	Z
		AIR/O_2									**18**	19:10		
360	0:30	AIR									88	89:10	1	
		AIR/O_2									**22**	23:10		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or SurDO_2 Required ----------														
420	0:30	AIR									134	135:10	1.5	
		AIR/O_2									**29**	30:10		
480	0:30	AIR									173	174:10	1.5	
		AIR/O_2									**38**	44:10		
540	0:30	AIR									228	229:10	2	
		AIR/O_2									**45**	51:10		
600	0:30	AIR									277	278:10	2	
		AIR/O_2									**53**	59:10		
660	0:30	AIR									314	315:10	2.5	
		AIR/O_2									**63**	69:10		
720	0:30	AIR									342	343:10	3	
		AIR/O_2									**71**	82:10		

Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
40 FSW														
163	1:20	AIR									0	1:20	0	O
		AIR/O_2									**0**	1:20		
170	0:40	AIR									6	7:20	0.5	O
		AIR/O_2									**2**	3:20		
180	0:40	AIR									14	15:20	0.5	Z
		AIR/O_2									**5**	6:20		
In-Water Air/O_2 Decompression or SurdO_2 Recommended														
190	0:40	AIR									21	22:20	0.5	Z
		AIR/O_2									**7**	8:20		
200	0:40	AIR									27	28:20	0.5	Z
		AIR/O_2									**9**	10:20		
210	0:40	AIR									39	40:20	0.5	Z
		AIR/O_2									**11**	12:20		
220	0:40	AIR									52	53:20	0.5	Z
		AIR/O_2									**12**	13:20		
230	0:40	AIR									64	65:20	1	Z
		AIR/O_2									**16**	17:20		
240	0:40	AIR									75	76:20	1	Z
		AIR/O_2									**19**	20:20		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or SurdO_2 Required ----------														
270	0:40	AIR									101	102:20	1	Z
		AIR/O_2									**26**	27:20		
300	0:40	AIR									128	129:20	1.5	
		AIR/O_2									**33**	34:20		
330	0:40	AIR									160	161:20	1.5	
		AIR/O_2									**38**	44:20		
360	0:40	AIR									184	185:20	2	
		AIR/O_2									**44**	50:20		
420	0:40	AIR									248	249:20	2.5	
		AIR/O_2									**56**	62:20		
480	0:40	AIR									321	322:20	2.5	
		AIR/O_2									**68**	79:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ---------- SurdO_2 Required----------														
540	0:40	AIR									372	373:20	3	
		AIR/O_2									**80**	91:20		
600	0:40	AIR									410	411:20	3.5	
		AIR/O_2									**93**	104:20		
660	0:40	AIR									439	440:20	4	
		AIR/O_2									**103**	119:20		
Exceptional Exposure: SurdO_2 ----------														
720	0:40	AIR									461	462:20	4.5	
		AIR/O_2									**112**	128:20		

Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
45 FSW														
125	1:30	AIR									0	1:30	0	N
		AIR/O_2									**0**	1:30		
130	0:50	AIR									2	3:30	0.5	O
		AIR/O_2									**1**	2:30		
140	0:50	AIR									14	15:30	0.5	O
		AIR/O_2									**5**	6:30		
In-Water Air/O_2 Decompression or $SurDO_2$ Recommended ----------														
150	0:50	AIR									25	26:30	0.5	Z
		AIR/O_2									**8**	9:30		
160	0:50	AIR									34	35:30	0.5	Z
		AIR/O_2									**11**	12:30		
170	0:50	AIR									41	42:30	1	Z
		AIR/O_2									**14**	15:30		
180	0:50	AIR									59	60:30	1	Z
		AIR/O_2									**17**	18:30		
190	0:50	AIR									75	76:30	1	Z
		AIR/O_2									**19**	20:30		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or $SurDO_2$ Required ----------														
200	0:50	AIR									89	90:30	1	Z
		AIR/O_2									**23**	24:30		
210	0:50	AIR									101	102:30	1	Z
		AIR/O_2									**27**	28:30		
220	0:50	AIR									112	113:30	1.5	Z
		AIR/O_2									**30**	31:30		
230	0:50	AIR									121	122:30	1.5	Z
		AIR/O_2									**33**	34:30		
240	0:50	AIR									130	131:30	1.5	Z
		AIR/O_2									**37**	43:30		
270	0:50	AIR									173	174:30	2	
		AIR/O_2									**45**	51:30		
300	0:50	AIR									206	207:30	2	
		AIR/O_2									**51**	57:30		
330	0:50	AIR									243	244:30	2.5	
		AIR/O_2									**61**	67:30		
360	0:50	AIR									288	289:30	3	
		AIR/O_2									**69**	80:30		
Exceptional Exposure: In-Water $Air/0_2$ Decompression ---------- $SurDO_2$ Required----------														
420	0:50	AIR									373	374:30	3.5	
		AIR/O_2									**84**	95:30		
480	0:50	AIR									431	432:30	4	
		AIR/O_2									**101**	117:30		
Exceptional Exposure: $SurDO_2$ ----------														
540	0:50	AIR									473	474:30	4.5	
		AIR/O_2									**117**	133:30		

Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
50 FSW														
92	1:40	AIR									0	1:40	0	M
		AIR/O_2									**0**	1:40		
95	1:00	AIR									2	3:40	0.5	M
		AIR/O_2									**1**	2:40		
100	1:00	AIR									4	5:40	0.5	N
		AIR/O_2									**2**	3:40		
110	1:00	AIR									8	9:40	0.5	O
		AIR/O_2									**4**	5:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ----------														
120	1:00	AIR									21	22:40	0.5	O
		AIR/O_2									**7**	8:40		
130	1:00	AIR									34	35:40	0.5	Z
		AIR/O_2									**12**	13:40		
140	1:00	AIR									45	46:40	1	Z
		AIR/O_2									**16**	17:40		
150	1:00	AIR									56	57:40	1	Z
		AIR/O_2									**19**	20:40		
160	1:00	AIR									78	79:40	1	Z
		AIR/O_2									**23**	24:40		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or SurDO_2 Required ----------														
170	1:00	AIR									96	97:40	1	Z
		AIR/O_2									**26**	27:40		
180	1:00	AIR									111	112:40	1.5	Z
		AIR/O_2									**30**	31:40		
190	1:00	AIR									125	126:40	1.5	Z
		AIR/O_2									**35**	36:40		
200	1:00	AIR									136	137:40	1.5	Z
		AIR/O_2									**39**	45:40		
210	1:00	AIR									147	148:40	2	
		AIR/O_2									**43**	49:40		
220	1:00	AIR									166	167:40	2	
		AIR/O_2									**47**	53:40		
230	1:00	AIR									183	184:40	2	
		AIR/O_2									**50**	56:40		
240	1:00	AIR									198	199:40	2	
		AIR/O_2									**53**	59:40		
270	1:00	AIR									236	237:40	2.5	
		AIR/O_2									**62**	68:40		
300	1:00	AIR									285	286:40	3	
		AIR/O_2									**74**	85:40		
Exceptional Exposure: In-Water Air/O_2 Decompression ---------- SurDO_2 Required----------														
330	1:00	AIR									345	346:40	3.5	
		AIR/O_2									**83**	94:40		
360	1:00	AIR									393	394:40	3.5	
		AIR/O_2									**92**	103:40		
Exceptional Exposure: SurDO_2 ----------														
420	1:00	AIR									464	465:40	4.5	
		AIR/O_2									**113**	129:40		

Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
55 FSW														
74	1:50	AIR									0	1:50	0	L
		AIR/O_2									**0**	1:50		
75	1:10	AIR									1	2:50	0.5	L
		AIR/O_2									**1**	2:50		
80	1:10	AIR									4	5:50	0.5	M
		AIR/O_2									**2**	3:50		
90	1:10	AIR									10	11:50	0.5	N
		AIR/O_2									**5**	6:50		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ----------														
100	1:10	AIR									17	18:50	0.5	O
		AIR/O_2									**8**	9:50		
110	1:10	AIR									34	35:50	0.5	O
		AIR/O_2									**12**	13:50		
120	1:10	AIR									48	49:50	1	Z
		AIR/O_2									**17**	18:50		
130	1:10	AIR									59	60:50	1	Z
		AIR/O_2									**22**	23:50		
140	1:10	AIR									84	85:50	1	Z
		AIR/O_2									**26**	27:50		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or SurDO_2 Required ----------														
150	1:10	AIR									105	106:50	1.5	Z
		AIR/O_2									**30**	31:50		
160	1:10	AIR									123	124:50	1.5	Z
		AIR/O_2									**34**	35:50		
170	1:10	AIR									138	139:50	1.5	Z
		AIR/O_2									**40**	46:50		
180	1:10	AIR									151	152:50	2	Z
		AIR/O_2									**45**	51:50		
190	1:10	AIR									169	170:50	2	
		AIR/O_2									**50**	56:50		
200	1:10	AIR									190	191:50	2	
		AIR/O_2									**54**	60:50		
210	1:10	AIR									208	209:50	2.5	
		AIR/O_2									**58**	64:50		
220	1:10	AIR									224	225:50	2.5	
		AIR/O_2									**62**	68:50		
230	1:10	AIR									239	240:50	2.5	
		AIR/O_2									**66**	77:50		
240	1:10	AIR									254	255:50	3	
		AIR/O_2									**69**	80:50		
Exceptional Exposure: In-Water Air/0_2 Decompression ---------- SurDO_2 Required----------														
270	1:10	AIR									313	314:50	3.5	
		AIR/O_2									**83**	94:50		
300	1:10	AIR									380	381:50	3.5	
		AIR/O_2									**94**	105:50		
330	1:10	AIR									432	433:50	4	
		AIR/O_2									**106**	122:50		
Exceptional Exposure: SurDO_2 ----------														
360	1:10	AIR									474	475:50	4.5	
		AIR/O_2									**118**	134:50		

Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
60 FSW														
63	2:00	AIR									0	2:00	0	K
		AIR/O_2									**0**	2:00		
65	1:20	AIR									2	4:00	0.5	L
		AIR/O_2									**1**	3:00		
70	1:20	AIR									7	9:00	0.5	L
		AIR/O_2									**4**	6:00		
80	1:20	AIR									14	16:00	0.5	N
		AIR/O_2									**7**	9:00		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ----------														
90	1:20	AIR									23	25:00	0.5	O
		AIR/O_2									**10**	12:00		
100	1:20	AIR									42	44:00	1	Z
		AIR/O_2									**15**	17:00		
110	1:20	AIR									57	59:00	1	Z
		AIR/O_2									**21**	23:00		
120	1:20	AIR									75	77:00	1	Z
		AIR/O_2									**26**	28:00		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or SurDO_2 Required ----------														
130	1:20	AIR									102	104:00	1.5	Z
		AIR/O_2									**31**	33:00		
140	1:20	AIR									124	126:00	1.5	Z
		AIR/O_2									**35**	37:00		
150	1:20	AIR									143	145:00	2	Z
		AIR/O_2									**41**	48:00		
160	1:20	AIR									158	160:00	2	Z
		AIR/O_2									**48**	55:00		
170	1:20	AIR									178	180:00	2	
		AIR/O_2									**53**	60:00		
180	1:20	AIR									201	203:00	2.5	
		AIR/O_2									**59**	66:00		
190	1:20	AIR									222	224:00	2.5	
		AIR/O_2									**64**	71:00		
200	1:20	AIR									240	242:00	2.5	
		AIR/O_2									**68**	80:00		
210	1:20	AIR									256	258:00	3	
		AIR/O_2									**73**	85:00		
220	1:20	AIR									278	280:00	3	
		AIR/O_2									**77**	89:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ---------- SurDO_2 Required----------														
230	1:20	AIR									300	302:00	3.5	
		AIR/O_2									**82**	94:00		
240	1:20	AIR									321	323:00	3.5	
		AIR/O_2									**88**	100:00		
270	1:20	AIR									398	400:00	4	
		AIR/O_2									**102**	119:00		
Exceptional Exposure: SurDO_2 ----------														
300	1:20	AIR									456	458:00	4.5	
		AIR/O_2									**115**	132:00		

Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
70 FSW														
48	2:20	AIR									0	2:20	0	K
		AIR/O_2									**0**	2:20		
50	1:40	AIR									2	4:20	0.5	K
		AIR/O_2									**1**	3:20		
55	1:40	AIR									9	11:20	0.5	L
		AIR/O_2									**5**	7:20		
60	1:40	AIR									14	16:20	0.5	M
		AIR/O_2									**8**	10:20		
In-Water Air/O_2 Decompression or $SurDO_2$ Recommended ----------														
70	1:40	AIR									24	26:20	0.5	N
		AIR/O_2									**13**	15:20		
80	1:40	AIR									44	46:20	1	O
		AIR/O_2									**17**	19:20		
90	1:40	AIR									64	66:20	1	Z
		AIR/O_2									**24**	26:20		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or $SurDO_2$ Required ----------														
100	1:40	AIR									88	90:20	1.5	Z
		AIR/O_2									**31**	33:20		
110	1:40	AIR									120	122:20	1.5	Z
		AIR/O_2									**38**	45:20		
120	1:40	AIR									145	147:20	2	Z
		AIR/O_2									**44**	51:20		
130	1:40	AIR									167	169:20	2	Z
		AIR/O_2									**51**	58:20		
140	1:40	AIR									189	191:20	2.5	
		AIR/O_2									**59**	66:20		
150	1:40	AIR									219	221:20	2.5	
		AIR/O_2									**66**	78:20		
160	1:20	AIR								1	244	247:00	3	
		AIR/O_2								**1**	**72**	85:00		
Exceptional Exposure: In-Water $Air/0_2$ Decompression ---------- $SurDO_2$ Required----------														
170	1:20	AIR								2	265	269:00	3	
		AIR/O_2								**1**	**78**	91:00		
180	1:20	AIR								4	289	295:00	3.5	
		AIR/O_2								**2**	**83**	97:00		
190	1:20	AIR								5	316	323:00	3.5	
		AIR/O_2								**3**	**88**	103:00		
200	1:20	AIR								9	345	356:00	4	
		AIR/O_2								**5**	**93**	115:00		
210	1:20	AIR								13	378	393:00	4	
		AIR/O_2								**7**	**98**	122:00		
Exceptional Exposure: $SurDO_2$ ----------														
240	1:20	AIR								25	454	481:00	5	
		AIR/O_2								**13**	**110**	140:00		

Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
80 FSW														
39	2:40	AIR									0	2:40	0	J
		AIR/O_2									**0**	2:40		
40	2:00	AIR									1	3:40	0.5	J
		AIR/O_2									**1**	3:40		
45	2:00	AIR									10	12:40	0.5	K
		AIR/O_2									**5**	7:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended ----------														
50	2:00	AIR									17	19:40	0.5	M
		AIR/O_2									**9**	11:40		
55	2:00	AIR									24	26:40	0.5	M
		AIR/O_2									**13**	15:40		
60	2:00	AIR									30	32:40	1	N
		AIR/O_2									**16**	18:40		
70	2:00	AIR									54	56:40	1	O
		AIR/O_2									**22**	24:40		
80	2:00	AIR									77	79:40	1.5	Z
		AIR/O_2									**30**	32:40		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or SurDO_2 Required ----------														
90	2:00	AIR									114	116:40	1.5	Z
		AIR/O_2									**39**	46:40		
100	1:40	AIR								1	147	150:20	2	Z
		AIR/O_2								**1**	**46**	54:20		
110	1:40	AIR								6	171	179:20	2	Z
		AIR/O_2								**3**	**51**	61:20		
120	1:40	AIR								10	200	212:20	2.5	
		AIR/O_2								**5**	**59**	71:20		
130	1:40	AIR								14	232	248:20	3	
		AIR/O_2								**7**	**67**	86:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ---------- SurDO_2 Required----------														
140	1:40	AIR								17	258	277:20	3.5	
		AIR/O_2								**9**	**73**	94:20		
150	1:40	AIR								19	285	306:20	3.5	
		AIR/O_2								**10**	**80**	102:20		
160	1:40	AIR								21	318	341:20	4	
		AIR/O_2								**11**	**86**	114:20		
170	1:40	AIR								27	354	383:20	4	
		AIR/O_2								**14**	**90**	121:20		
Exceptional Exposure: SurDO_2 ----------														
180	1:40	AIR								33	391	426:20	4.5	
		AIR/O_2								**17**	**96**	130:20		
210	1:40	AIR								51	473	526:20	5	
		AIR/O_2								**26**	**110**	158:20		

Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
90 FSW														
33	3:00	AIR									0	3:00	0	J
		AIR/O_2									**0**	3:00		
35	2:20	AIR									4	7:00	0.5	J
		AIR/O_2									**2**	5:00		
40	2:20	AIR									14	17:00	0.5	L
		AIR/O_2									**7**	10:00		
In-Water Air/O_2 Decompression or SurdO_2 Recommended														
45	2:20	AIR									23	26:00	0.5	M
		AIR/O_2									**12**	15:00		
50	2:20	AIR									31	34:00	1	N
		AIR/O_2									**17**	20:00		
55	2:20	AIR									39	42:00	1	O
		AIR/O_2									**21**	24:00		
60	2:20	AIR									56	59:00	1	O
		AIR/O_2									**24**	27:00		
70	2:20	AIR									83	86:00	1.5	Z
		AIR/O_2									**32**	35:00		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or SurdO_2 Required ----------														
80	2:00	AIR								5	125	132:40	2	Z
		AIR/O_2								**3**	**40**	50:40		
90	2:00	AIR								13	158	173:40	2	Z
		AIR/O_2								**7**	**46**	60:40		
100	2:00	AIR								19	185	206:40	2.5	
		AIR/O_2								**10**	**53**	70:40		
110	2:00	AIR								25	224	251:40	3	
		AIR/O_2								**13**	**61**	86:40		
Exceptional Exposure: In-Water Air/0_2 Decompression ---------- SurdO_2 Required----------														
120	1:40	AIR							2	28	256	288:20	3.5	
		AIR/O_2							2	**14**	**70**	98:40		
130	1:40	AIR							5	28	291	326:20	3.5	
		AIR/O_2							5	**14**	**79**	110:40		
140	1:40	AIR							8	28	330	368:20	4	
		AIR/O_2							8	**14**	**87**	126:40		
Exceptional Exposure: SurdO_2 ----------														
150	1:40	AIR							11	34	378	425:20	4.5	
		AIR/O_2							11	**17**	**94**	139:40		
160	1:40	AIR							13	40	418	473:20	4.5	
		AIR/O_2							13	**20**	**101**	151:40		
170	1:40	AIR							15	45	451	513:20	5	
		AIR/O_2							15	**23**	**106**	166:40		
180	1:40	AIR							16	51	479	548:20	5.5	
		AIR/O_2							16	**26**	**112**	176:40		
240	1:40	AIR							42	68	592	704:20	7.5	
		AIR/O_2							42	**34**	**159**	267:40		

Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
100 FSW														
25	3:20	AIR									0	3:20	0	H
		AIR/O_2									**0**	3:20		
30	2:40	AIR									3	6:20	0.5	J
		AIR/O_2									**2**	5:20		
35	2:40	AIR									15	18:20	0.5	L
		AIR/O_2									**8**	11:20		
In-Water Air/O_2 Decompression or SurDO$_2$ Recommended ----------														
40	2:40	AIR									26	29:20	1	M
		AIR/O_2									**14**	17:20		
45	2:40	AIR									36	39:20	1	N
		AIR/O_2									**19**	22:20		
50	2:40	AIR									47	50:20	1	O
		AIR/O_2									**24**	27:20		
55	2:40	AIR									65	68:20	1.5	Z
		AIR/O_2									**28**	31:20		
60	2:40	AIR									81	84:20	1.5	Z
		AIR/O_2									**33**	36:20		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or SurDO$_2$ Required ----------														
70	2:20	AIR								11	124	138:00	2	Z
		AIR/O_2								**6**	**39**	53:00		
80	2:20	AIR								21	160	184:00	2.5	Z
		AIR/O_2								**11**	**45**	64:00		
90	2:00	AIR							2	28	196	228:40	2.5	
		AIR/O_2							2	**14**	**53**	82:00		
Exceptional Exposure: In-Water Air/0_2 Decompression ---------- SurDO$_2$ Required----------														
100	2:00	AIR							9	28	241	280:40	3	
		AIR/O_2							9	**14**	**66**	102:00		
110	2:00	AIR							14	28	278	322:40	3.5	
		AIR/O_2							14	**14**	**76**	117:00		
120	2:00	AIR							19	28	324	373:40	4	
		AIR/O_2							19	**14**	**85**	136:00		
Exceptional Exposure: SurDO$_2$ ----------														
150	1:40	AIR						3	26	46	461	538:20	5	
		AIR/O_2						3	26	**23**	**109**	183:40		

Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
110 FSW														
20	3:40	AIR									0	3:40	0	H
		AIR/O_2									**0**	3:40		
25	3:00	AIR									5	8:40	0.5	I
		AIR/O_2									**3**	6:40		
30	3:00	AIR									14	17:40	0.5	K
		AIR/O_2									**7**	10:40		
In-Water Air/O_2 Decompression or SurDO_2 Recommended														
35	3:00	AIR									27	30:40	1	M
		AIR/O_2									**14**	17:40		
40	3:00	AIR									39	42:40	1	N
		AIR/O_2									**20**	23:40		
45	3:00	AIR									50	53:40	1	O
		AIR/O_2									**26**	29:40		
50	3:00	AIR									71	74:40	1.5	Z
		AIR/O_2									**32**	35:40		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or SurDO_2 Required ----------														
55	2:40	AIR								5	85	93:20	1.5	Z
		AIR/O_2								**3**	33	44:20		
60	2:40	AIR								13	111	127:20	2	Z
		AIR/O_2								**7**	**36**	51:20		
70	2:40	AIR								26	155	184:20	2.5	Z
		AIR/O_2								**14**	**42**	64:20		
Exceptional Exposure: In-Water Air/0_2 Decompression ---------- SurDO_2 Required----------														
80	2:20	AIR							9	28	200	240:00	2.5	
		AIR/O_2							9	**14**	**54**	90:20		
90	2:20	AIR							18	28	249	298:00	3.5	
		AIR/O_2							18	**14**	**68**	113:20		
100	2:20	AIR							25	28	295	351:00	3.5	
		AIR/O_2							25	**14**	**79**	131:20		
110	2:00	AIR						5	26	28	353	414:40	4	
		AIR/O_2						5	26	**14**	**91**	154:00		
Exceptional Exposure: SurDO_2														
120	2:00	AIR						10	26	35	413	486:40	4.5	
		AIR/O_2						10	26	**18**	**101**	173:00		
180	1:40	AIR					3	23	47	68	593	736:20	7.5	
		AIR/O_2					3	23	47	**34**	**159**	298:40		

Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop 100	90	80	70	60	50	40	30	20	Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
120 FSW														
15	4:00	AIR									0	4:00	0	F
		AIR/O_2									**0**	4:00		
20	3:20	AIR									4	8:00	0.5	H
		AIR/O_2									**2**	6:00		
25	3:20	AIR									9	13:00	0.5	J
		AIR/O_2									**5**	9:00		
In-Water Air/O_2 Decompression or $SurDO_2$ Recommended ----------														
30	3:20	AIR									24	28:00	0.5	L
		AIR/O_2									**13**	17:00		
35	3:20	AIR									38	42:00	1	N
		AIR/O_2									**20**	24:00		
40	3:00	AIR								2	49	54:40	1	O
		AIR/O_2								**1**	**26**	30:40		
45	3:00	AIR								3	71	77:40	1.5	Z
		AIR/O_2								**2**	**31**	36:40		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or $SurDO_2$ Required ----------														
50	3:00	AIR								10	85	98:40	1.5	Z
		AIR/O_2								**5**	**33**	46:40		
55	3:00	AIR								19	116	138:40	2	Z
		AIR/O_2								**10**	**35**	53:40		
60	3:00	AIR								27	142	172:40	2	Z
		AIR/O_2								**14**	**39**	61:40		
70	2:40	AIR							13	28	190	234:20	2.5	
		AIR/O_2							13	**14**	**51**	86:40		
Exceptional Exposure: In-Water $Air/0_2$ Decompression ---------- $SurDO_2$ Required----------														
80	2:40	AIR							24	28	246	301:20	3	
		AIR/O_2							24	**14**	**67**	118:40		
90	2:20	AIR						7	26	28	303	367:00	3.5	
		AIR/O_2						7	26	**14**	**80**	140:20		
100	2:20	AIR						15	25	28	372	443:00	4	
		AIR/O_2						15	25	**14**	**95**	167:20		
Exceptional Exposure: $SurDO_2$ ----------														
110	2:20	AIR						21	25	38	433	520:00	5	
		AIR/O_2						21	25	**19**	**105**	188:20		
120	2:00	AIR					3	23	25	47	480	580:40	5.5	
		AIR/O_2					3	23	25	**24**	**113**	211:00		

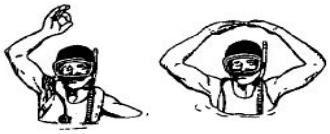
Appendix D Continued

Table 9-9. *Air Decompression Table (Continued).*
(DESCENT RATE 75 FPM—ASCENT RATE 30 FPM)

Bottom Time (min)	Time to First Stop (M:S)	Gas Mix	DECOMPRESSION STOPS (FSW) Stop times (min) include travel time, except first air and first O_2 stop									Total Ascent Time (M:S)	Chamber O_2 Periods	Repet Group
			100	90	80	70	60	50	40	30	20			
130 FSW														
12	4:20	AIR									0	4:20	0	F
		AIR/O_2									**0**	4:20		
15	3:40	AIR									3	7:20	0.5	G
		AIR/O_2									**2**	6:20		
20	3:40	AIR									8	12:20	0.5	I
		AIR/O_2									**5**	9:20		
In-Water Air/O_2 Decompression or $SurDO_2$ Recommended ----------														
25	3:40	AIR									17	21:20	0.5	K
		AIR/O_2									**9**	13:20		
30	3:20	AIR								2	32	38:00	1	M
		AIR/O_2								1	**17**	22:00		
35	3:20	AIR								5	44	53:00	1	O
		AIR/O_2								**3**	**23**	30:00		
40	3:20	AIR								6	66	76:00	1.5	Z
		AIR/O_2								**3**	**30**	37:00		
Exceptional Exposure: In-Water Air Decompression ---------- In-Water Air/O_2 Decompression or $SurDO_2$ Required ----------														
45	3:00	AIR							1	11	84	99:40	1.5	Z
		AIR/O_2							1	**6**	**33**	49:00		
50	3:00	AIR							2	20	118	143:40	2	Z
		AIR/O_2							2	**10**	**36**	57:00		
55	3:00	AIR							4	28	146	181:40	2	Z
		AIR/O_2							4	**14**	**40**	67:00		
60	3:00	AIR							12	28	170	213:40	2.5	Z
		AIR/O_2							12	**14**	**46**	81:00		
Exceptional Exposure: In-Water $Air/0_2$ Decompression ---------- $SurDO_2$ Required----------														
70	2:40	AIR						1	26	28	235	293:20	3	
		AIR/O_2						1	26	**14**	**63**	117:40		
80	2:40	AIR						12	26	28	297	366:20	3.5	
		AIR/O_2						12	26	**14**	**79**	144:40		
90	2:40	AIR						22	25	28	375	453:20	4	
		AIR/O_2						22	25	**14**	**95**	174:40		
Exceptional Exposure: $SurDO_2$ ----------														
100	2:20	AIR					6	23	26	38	444	540:00	5	
		AIR/O_2					6	23	26	**20**	**106**	204:20		
120	2:20	AIR					17	24	27	57	534	662:00	6	
		AIR/O_2					17	24	27	**29**	**130**	255:20		
180	2:00	AIR				13	21	45	57	94	658	890:40	9	
		AIR/O_2				13	21	45	57	**46**	**198**	418:00		

Appendix E: Hand Signals for Underwater Communication (Figure)

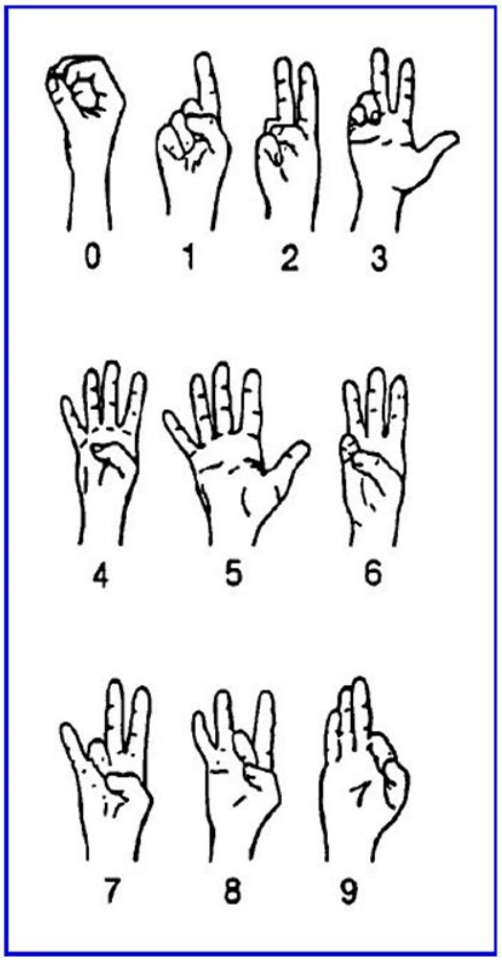
Source: U.S. Navy Diving Manual, Rev 7

	Meaning/Signal	Comment
	**STOP** Clenched fist.	
	**SOMETHING IS WRONG** Hand flat, fingers together, palm out, thumb down then hand rocking back and forth on axis of forearm.	This is the opposite of Okay. The signal does not indicate an emergency.
	**I AM OKAY or ARE YOU OKAY?** Thumb and forefinger making a circle with three remaining fingers extended (if possible).	Divers wearing mittens may not be able to extend three remaining fingers distinctly. Short range use.
	**OKAY ON THE SURFACE (CLOSE)** Right hand raised overhead giving Okay signal with fingers. **OKAY ON THE SURFACE (DISTANT)** Both hands touching overhead with both arms bent at 45° angle.	Given when diver is close to pickup boat. Given when diver is at a distance from the pickup boat.
	**DISTRESS or HELP or PICK ME UP** Hand waving overhead (diver may also thrash hand in water).	Indicates immediate aid is required.
	**WHAT TIME? or WHAT DEPTH?** Diver points to either watch or depth gauge.	When indicating time, this signal is commonly used for bottom time remaining.
	**GO DOWN or GOING DOWN** Two fingers up, two fingers and thumb against palm.	
	**GO UP or GOING UP** Four fingers pointing up, thumb against palm.	
	**I'M OUT OF AIR.** Hand slashing or chopping at throat. **I NEED TO BUDDY BREATHE** Fingers pointing to mouth or regulator.	Indicates signaler is out of air. Signaler's regulator may be in or out of mouth.

Appendix E Continued

	Meaning/Signal	Comment
	**COME HERE** Hand to chest, repeated.	
	**ME or WATCH ME** Finger to chest, repeated.	
	**OVER, UNDER, or AROUND** Fingers together and arm moving in and over, under, or around movement.	Diver signals intention to move over, under, or around an object.
	**LEVEL OFF or HOW DEEP?** Fingers and thumb spread out and hand moving back and forth in a level position.	
	**GO THAT WAY** Fist clenched with thumb pointing up, down, right, or left.	Indicates which direction to swim.
	**WHICH DIRECTION?** Fingers clenched, thumb and hand rotating right and left.	
	**EAR TROUBLE** Diver pointing to either ear.	Divers should ascend a few feet. If problem continues, both divers must surface.
	**I'M COLD** Both arms crossed over chest.	
	**TAKE IT EASY OR SLOW DOWN** Hand extended, palm down, in short up-and-down motion.	
	**YOU LEAD, I'LL FOLLOW** Index fingers extended, one hand forward of the other.	

Appendix E Continued



NIGHT DIVING SIGNALS
(Buddy at Distance)

When buddy is near, use regular hand signals in front of light.

Something is wrong.
I require assistance.
(Large, rapid up-and-down motions with arm extended.)

I am Okay.
Are you Okay?
(Large, slow circles with light.)

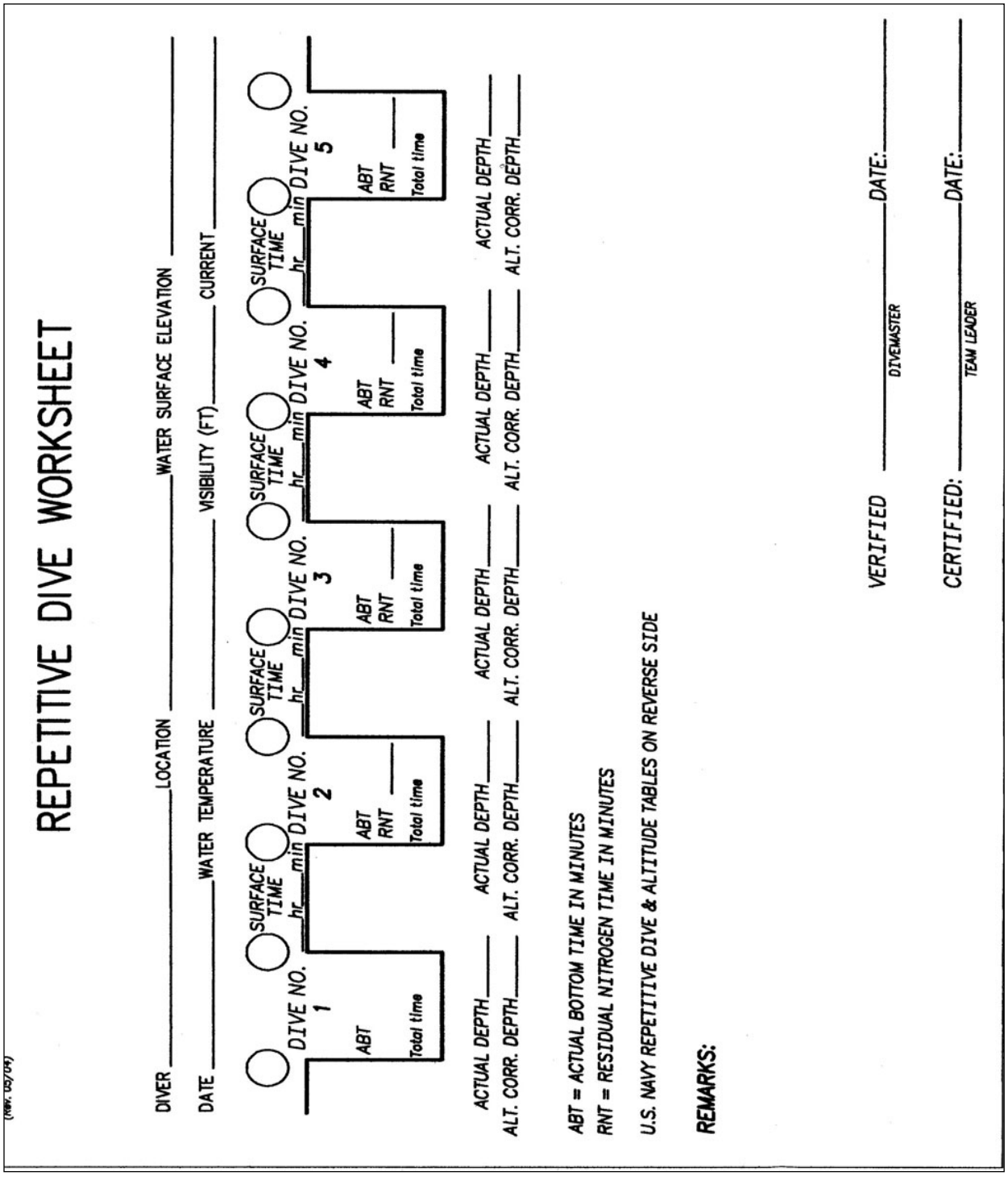
Appendix E1: Line Pull Signals (Table)

Source: U.S. Navy Diving Manual, Rev.7

From Tender to Diver		Searching Signals (Without Circling Line)	
1 Pull	"Are you all right?" When diver is descending, one pull means "Stop."	7 Pulls	"Go on (or off) searching signals."
2 Pulls	"Going Down." During ascent, two pulls mean "You have come up too far; go back down until we stop you."	1 Pull	"Stop and search where you are."
3 Pulls	"Stand by to come up."	2 Pulls	"Move directly away from the tender if given slack; move toward the tender if strain is taken on the life line."
4 Pulls	"Come up."	3 Pulls	"Face your umbilical, take a strain, move right."
2-1 Pulls	"I understand" or "Talk to me."	4 Pulls	"Face your umbilical, take a strain, move left."
3-2 Pulls	"Ventilate."		
4-3 Pulls	"Circulate."		
From Diver to Tender		**Searching Signals (With Circling Line)**	
1 Pull	"I am all right." When descending, one pull means "Stop" or "I am on the bottom."	7 Pulls	"Go on (or off) searching signals."
2 Pulls	"Lower" or "Give me slack."	1 Pull	"Stop and search where you are."
3 Pulls	"Take up my slack."	2 Pulls	"Move away from the weight."
4 Pulls	"Haul me up."	3 Pulls	"Face the weight and go right."
2-1 Pulls	"I understand" or "Talk to me."	4 Pulls	"Face the weight and go left."
3-2 Pulls	"More air."		
4-3 Pulls	"Less air."		
Special Signals From the Diver		**Emergency Signals From the Diver**	
1-2-3 Pulls	"Send me a square mark."	2-2-2 Pulls	"I am fouled and need the assistance of another diver."
5 Pulls	"Send me a line."	3-3-3 Pulls	"I am fouled but can clear myself."
2-1-2 Pulls	"Send me a slate."	4-4-4 Pulls	"Haul me up immediately."

ALL EMERGENCY SIGNALS SHALL BE ANSWERED AS GIVEN EXCEPT 4-4-4

Appendix F: Scuba Repetitive Dive Worksheet (Form)



REPETITIVE DIVE WORKSHEET

(Rev. 05/04)

DIVER _____ LOCATION _____ WATER SURFACE ELEVATION _____

DATE _____ WATER TEMPERATURE _____ VISIBILITY (FT) _____ CURRENT _____

DIVE NO. 1 — ABT _____ Total time _____

SURFACE TIME _____ hr ____ min

DIVE NO. 2 — ABT _____ RNT _____ Total time _____

SURFACE TIME _____ hr ____ min

DIVE NO. 3 — ABT _____ RNT _____ Total time _____

SURFACE TIME _____ hr ____ min

DIVE NO. 4 — ABT _____ RNT _____ Total time _____

SURFACE TIME _____ hr ____ min

DIVE NO. 5 — ABT _____ RNT _____ Total time _____

ACTUAL DEPTH _____ ACTUAL DEPTH _____ ACTUAL DEPTH _____ ACTUAL DEPTH _____ ACTUAL DEPTH _____

ALT. CORR. DEPTH _____ ALT. CORR. DEPTH _____ ALT. CORR. DEPTH _____ ALT. CORR. DEPTH _____ ALT. CORR. DEPTH _____

ABT = ACTUAL BOTTOM TIME IN MINUTES

RNT = RESIDUAL NITROGEN TIME IN MINUTES

U.S. NAVY REPETITIVE DIVE & ALTITUDE TABLES ON REVERSE SIDE

REMARKS:

VERIFIED _____ DIVEMASTER DATE: _____

CERTIFIED: _____ TEAM LEADER DATE: _____

Appendix G: Dive Log for Surface Supplied Air Diving Mode (Form)

Diver Date

Job Name Dive Master:

Site Location Altitude

Bailout Pressure: _____PSI Air Temp _____°F Water Temp. _____°F

Water Vis:	☐ Poor 0-2	☐ Fair 2-10	☐ Good 10-20	☐ V. Good 20-50	☐ Excellent 50+
Current (Knts)	☐ None	☐ Light 0.2-.5	☐ Mod 0.5-1	☐ Heavy 1-2	☐ 2+
Weather	☐ Clear	☐ Overcast	☐ Rain	☐ Snow	☐ Fog
Water State	☐ 0 Calm	☐ 1 Chop	☐ 2 Lt Waves	☐ 3 Mod 4-6	☐ 4+
Bottom	☐ Mud	☐ Sand	☐ Rock	☐ Rip Rap	☐ Concrete
Dive Dress	☐ Shorts	☐ Coveralls	☐ 1/8" Wet Suit	☐ ¼" Wet Suit	☐ Dry Suit

Dive#1 LS RB LB RS TBT TTD D

☐ USN Table _____ ☐ _____ Altitude Correction ☐ _____ Safety Stop

Console Oper. Dive Platform Repet Group

Log Keeper Standby Tender

Work Completed

Dive#2 LS RB LB RS TBT TTD D

☐ USN Table _____ ☐ _____ Altitude Correction ☐ _____ Safety Stop

Console Oper. Dive Platform Repet Group

Log Keeper Standby Tender

Work Completed

Dive#3 LS RB LB RS TBT TTD D

☐ USN Table _____ ☐ _____ Altitude Correction ☐ _____ Safety Stop

Console Oper. Dive Platform Repet Group

Log Keeper Standby Tender

Work Completed

Dive#4 LS RB LB RS TBT TTD D

☐ USN Table _____ ☐ _____ Altitude Correction ☐ _____ Safety Stop

Console Oper. Dive Platform Repet Group

Log Keeper Standby Tender

Work Completed

☐ Diver Injury or Causality or Emergency Procedures used. Incident Report Attached

☐ **Diver Okay** We hereby certify that the Diver was fully briefed prior to the dive, fully understood the task and associated hazards. The no-decompression limits for this dive were not exceeded and the diver has reported no injuries resulting from this dive.

Signature of Dive Master (Date/Times) **Signature of Diver** (Date/Time)

Appendix H: Altitude Correction, US Navy Sea Level Equivalent Depth (fsw) (Table)

Source: U.S. Navy Diving Manual, Rev 7

Table 9-4. *Sea Level Equivalent Depth (fsw).*

Actual Depth (fsw)	Altitude (feet)									
	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
10	10	15	15	15	15	15	15	15	15	15
15	15	20	20	20	20	20	20	25	25	25
20	20	25	25	25	25	25	30	30	30	30
25	25	30	30	30	35	35	35	35	35	40
30	30	35	35	35	40	40	40	45	45	45
35	35	40	40	45	45	45	50	50	50	60
40	40	45	45	50	50	50	55	55	60	60
45	45	50	55	55	55	60	60	70	70	70
50	50	55	60	60	70	70	70	70	70	80
55	55	60	70	70	70	70	80	80	80	80
60	60	70	70	70	80	80	80	90	90	90
65	65	70	80	80	80	90	90	90	100	100
70	70	80	80	90	90	90	100	100	100	110
75	75	90	90	90	100	100	100	110	110	110
80	80	90	90	100	100	100	110	110	120	120
85	85	100	100	100	110	110	120	120	120	130
90	90	100	110	110	110	120	120	130	130	140
95	95	110	110	110	120	120	130	130	140	140
100	100	110	120	120	130	130	130	140	140	150
105	105	120	120	130	130	140	140	150	150	160
110	110	120	130	130	140	140	150	150	160	160
115	115	130	130	140	140	150	150	160	170	170
120	120	130	140	140	150	150	160	170	170	180
125	125	140	140	150	160	160	170	170	180	190
130	130	140	150	160	160	170	170	180	190	190
135	135	150	160	160	170	170	180	190	190	200
140	140	160	160	170	170	180	190	190	200	210
145	145	160	170	170	180	190	190	200	210	
150	160	170	170	180	190	190	200	210		
155	170	170	180	180	190	200	210			
160	170	180	180	190	200	200				
165	180	180	190	200	200					
170	180	190	190	200						
175	190	190	200							
180	190	200	210							
185	200	200								
190	200									
Table Water Stops	**Equivalent Stop Depths (fsw)**									
10	10	9	9	9	8	8	8	7	7	7
20	19	19	18	17	17	16	15	15	14	14
30	29	28	27	26	25	24	23	22	21	21
40	39	37	36	35	33	32	31	30	29	28
50	48	47	45	43	42	40	39	37	36	34
60	58	56	54	52	50	48	46	45	43	41

Note: ——— = Exceptional Exposure Limit

Appendix H1: Penalty Group Upon Arrival at Altitude, US Navy (Table)

Source: U.S. Navy Diving Manual, Rev 7

Table 9-5. Repetitive Groups Associated with Initial Ascent to Altitude.

Altitude (feet)	Repetitive Group
1000	A
2000	A
3000	B
4000	C
5000	D
6000	E
7000	F
8000	G
9000	H
10000	I

NOTE: When traveling from a lower to a higher elevation there will be a reduction of the ambient pressure. Prior to diving at altitude the diver needs to equilibrate, which can take up to 12 hours. Since waiting 12 hours before diving is not practical in most situations, the diver will need to correct for Equilibration.

Example: The diver is staying at a location at an elevation of 2200 feet and plans to drive the next morning to an elevation of 5500 feet to dive. The change in altitude is 3300 feet. Rounding up to the next higher elevation (4000 feet on the table). Enter the table at 4000 feet and read across to the repetitive group. The diver will be in a repetitive group of D upon arrival at the dive site.

Appendix H2: Required Surface Interval Before Ascent to Altitude After Diving, US Navy (Table)

Source: U.S. Navy Diving Manual, Rev 7

Table 9-6. Required Surface Interval Before Ascent to Altitude After Diving.

Repetitive Group Designator	Increase in Altitude (feet)									
	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
A	0:00	0:00	0:00	0:00	0:00	0:00	0:00	**0:00**	0:00	0:00
B	0:00	0:00	0:00	0:00	0:00	0:00	0:00	**0:00**	0:00	1:42
C	0:00	0:00	0:00	0:00	0:00	0:00	0:00	**0:00**	1:48	6:23
D	0:00	0:00	0:00	0:00	0:00	0:00	0:00	**1:45**	5:24	9:59
E	0:00	0:00	0:00	0:00	0:00	0:00	1:37	**4:39**	8:18	12:54
F	0:00	0:00	0:00	0:00	0:00	1:32	4:04	**7:06**	10:45	15:20
G	0:00	0:00	0:00	0:00	1:19	3:38	6:10	**9:13**	12:52	17:27
H	0:00	0:00	0:00	1:06	3:10	5:29	8:02	**11:04**	14:43	19:18
I	0:00	0:00	0:56	2:45	4:50	7:09	9:41	**12:44**	16:22	20:58
J	0:00	0:41	2:25	4:15	6:19	8:39	11:11	**14:13**	17:52	22:27
K	0:30	2:03	3:47	5:37	7:41	10:00	12:33	**15:35**	19:14	23:49
L	1:45	3:18	5:02	6:52	8:56	11:15	13:48	**16:50**	20:29	25:04
M	2:54	4:28	6:12	8:01	10:06	12:25	14:57	**18:00**	21:38	26:14
N	3:59	5:32	7:16	9:06	11:10	13:29	16:02	**19:04**	22:43	27:18
O	4:59	6:33	8:17	10:06	12:11	14:30	17:02	**20:05**	23:43	28:19
Z	5:56	7:29	9:13	11:03	13:07	15:26	17:59	**21:01**	24:40	29:15
Exceptional Exposure	Wait 48 hours before ascent									

NOTE 1 When using Table 9-6, use the highest repetitive group designator obtained in the previous 24-hour period.

NOTE 2 Table 9-6 may only be used when the maximum altitude achieved is 10,000 feet or less. For ascents above 10,000 feet, consult NAVSEA 00C for guidance.

NOTE 3 The cabin pressure in commercial aircraft is maintained at a constant value regardless of the actual altitude of the flight. Though cabin pressure varies somewhat with aircraft type, the nominal value is 8,000 feet. For commercial flights, use a final altitude of 8,000 feet to compute the required surface interval before flying.

NOTE 4 No surface interval is required before taking a commercial flight if the dive site is at 8,000 feet or higher. In this case, flying results in an increase in atmospheric pressure rather than a decrease.

NOTE 5 For ascent to altitude following a non-saturation helium-oxygen dive, wait 12 hours if the dive was a no-decompression dive. Wait 24 hours if the dive was a decompression dive.

Appendix I: First Aid Kit (Diving) Recommended Items (Table)

AIRWAY MANAGEMENT ITEMS			
QTY	***UOI***	***ITEM***	***APPLICATION***
2	EA	Oxygen Cylinders (Jumbo D)*	Oxygen Administration
1	EA	Resuscitator w/ Elder Valve (or LSP type)	Diver resuscitation
1	EA	Ambu Bag w/reservoir & full face mask	Diver resuscitation
1	EA	Pocket mask (or equivalent)	Rescue Breathing

* Adequate for open circuit use from the dive site to the chamber location. Calculate the quantity per diver required is 50 cubic feet per hour of travel to the chamber.

BASIC FIRST AID ITEMS			
QTY	***UOI***	***ITEM***	***APPLICATION***
2	EA	Triangular bandages	Splint / Dressings
2	EA	Splints Moldable (non-pneumatic) 2 sizes	Splinting
12	EA	4x4 Gauze pads, Sterile	Dressing wounds
6	EA	2x2 Gauze pads, Sterile	Dressing wounds / Eye patch
4	EA	Telfa Pads – Non-Stick Gauze	Dressing wounds
2	RL	Roller Gauze (Kling or Elastic) 2” or 3”	Wound pressure bandage
2	RL	Roller Gauze (Kling or Elastic) 3” or 4”	Wound pressure bandage
1	EA	Ace bandage, 4 inches wide	Wound pressure bandage
Various	BX	Band-Aids, assorted & large size	Cuts
12	EA	Butterfly bandages	Cuts
1	BT	Betadine, iodine, (or other disinfecting solution)	Wound cleaning
4	EA	Gel burn dressings	Burn care
2	EA	ABD pads, 5” x 9”	Wound / Burn
1	EA	Tourniquet	Bleeding control
3	RL	Adhesive Tape ½”,1” & 2” -Waterproof	Wound Bandage
10	EA	Swabs, Cotton Tip 6” wooden (Q-tips)	Wound Cleaning

MEDICATION ITEMS			
QTY	***UOI***	***ITEM***	***APPLICATION***
50	TABS	Tylenol 325 mg Tabs	Mild Pain
50	TABS	Aspirin, 325 mg Tabs (not aspirin substitute)	Mild Pain, DCS, Swelling
2	EA	Ammonia Inhalants	Dizziness
1	BT	Hydrogen Peroxide .03%	Minor wound cleaning
2	TU	Triple Antibiotic Ointment	Wound Dressing Antiseptic
1	EA	Hot Pack	Scorpion fish, ray, etc. Stings/ punctures

EQUIPMENT ITEMS			
QTY	***UOI***	***ITEM***	***APPLICATION***
1	EA	Bandage Scissors	Wound Dressing
1	EA	Forceps (i.e., Kelly, etc.)	Wound Dressing
1	EA	Tweezers (or 22 ga needle)	Foreign body / Splinter removal
1	EA	Flashlight (or Otoscope)	Examination
6	PR	Examination latex gloves	Victim handling
ALTERNATE ITEMS TO CONSIDER			
QTY	***UOI***	***ITEM***	***APPLICATION***
1	EA	Ice Pack	Sprains, injury
1	EA	Stethoscope	Examination
1	EA	BP Cuff	Examination
1	BT	Sunscreen	U/V Protection
6	PR	Examination latex gloves*	Victim handling
2	EA	Oral Airways – Adult sizes #4 & #5	Diver resuscitation, airway management

*Additional

Appendix J: Emergency Procedures on SCUBA (Table)

Emergency Situation	Recommended Action
S EP-1 Lost Diver	Each buddy pair will have one diver designated as the lead diver. Prior to entering the water the buddy pair will agree upon a reunite location in case of separation. If the buddy diver becomes separated from the lead diver, the lead diver will return to the reuniting location and signal by banging on his tank with a dive knife or use other underwater signaling device. If unable to reunite with the buddy within one minute, both divers shall make a controlled ascent to the surface, and remain at the surface. The first diver to surface shall alert the dive master of the separation. The Dive Supervisor will "fix" the position of the lost diver bubbles. If after 2 minutes the lost diver has not surfaced, the standby diver will buddy up with the primary diver on the surface and attempt to follow the lost diver's bubble trail from the surface to the lost diver. If there is no bubble trail from the lost diver, the search team will immediately return to the last known location of the lost diver and begin a search. If the initial search is unsuccessful, notify authorities of possible recovery situation and continue search.
S EP-2 Fouling or Entrapment	Remain calm. Try clearing yourself of the entanglement. If unable to free yourself, signal the buddy diver you have a problem and enlist their help. The buddy diver will assess the problem, if there is no danger of them also getting entrapped, they will attempt to free the entrapped diver and assist them to the surface. If an inherent danger exist, or the buddy is unable to free the entrapped diver. He will signal the diver he is going to the surface for help. Upon surfacing, advise the Dive Master of the situation and take the appropriate action(s) to free the entrapped diver.
S EP-3 Loss of Air	Switch to the emergency gas supply (EGS) and signal the dive buddy to surface. If the alternate supply does not restore breathing air, signal the dive buddy that you are out of air and utilize their alternate air supply (Octopus). Face one another and make a controlled ascent. If no alternate air supply is available, make an emergency ascent to the surface, remembering to continually blow out, to avoid over expansion injury of the lungs during ascent.
S EP-4 In water Trauma	Dive is terminated, dive buddy is signaled of the situation and both divers ascent to the surface. The uninjured diver should assist the injured diver as needed. Once on the surface, immediately signal the Dive Supervisor and Standby diver for assistance. Once on the shore/diving platform, assess the injury and take appropriate first aid measures.
S EP-5 Unconscious Diver	The buddy diver will assist the unconscious diver to the surface as quickly as possible, within the acceptable safe ascent rate, (30 feet per minute). If the regulator is in the victim's mouth, leave it there. If it has fallen out, leave it out. Surface with the victim in an upright position, hold them near the head. Once on the surface, immediately signal the Dive Supervisor and Standby diver for assistance. Once on shore/diving platform assess the condition of the victim and take appropriate first aid measures.
S EP-6 In Water Equipment Failure	Signal buddy of situation, both divers ascent to surface in a controlled manner.

Appendix K: Emergency Procedures on Surface Supplied Air (SSA) (Table)

Emergency Situation	Recommended Action
SS EP-1 Fouled or Entrapped Diver	Provide diver a reasonable amount of time to clear himself. In the event he is unable to free himself, the standby diver will enter the water to assist. Once diver is free, if shaken or standby diver was required to go to his assistance, terminate dive.
SS EP-2 Loss of Air	The Dive Supervisor (console operator) will switch to the standby supply at the dive manifold and immediately surface the diver. Standby diver should be alerted to the situation and ready to assist the diver as required If the diver is not receiving air from the standby supply, he should be instructed to go to the bail out air supply and surface immediately in a controlled manner.
SS EP-3 Severance of Divers Umbilical	The diver shall be alerted to the situation and immediately instructed to go to the bail out air supply and surface in a controlled manner.
SS EP-4 Loss of Communications	Go to line pull signals and surface the diver. If line pull signals cannot be established, then the standby diver will enter the water and swiftly advance following the primary diver's umbilical hoses to aid the primary diver in his ascent to the surface.
SS EP-5 In-Water Trauma Or Injury	Diver to immediately inform topside of nature and extend of injury Dive is terminated and diver surfaces either by himself or with the aid of the standby diver. Proper ascent rates (30 fpm) should be followed except when the severity of the injury indicates a greater risk than possible over expansion or decompression injuries. Initiate emergency evacuation plan.
SS EP-6 Unconscious Diver	Standby diver shall immediately be deployed to assist the unconscious diver to the surface. Surface with the victim in an upright position, hold them near the head. Once on shore/diving platform assess the condition of the victim and take appropriate first aid measures. Initiate emergency evacuation plan.
SS EP-7 Fire in Surface Equipment on or near dive station	Extinguish fire and secure equipment Determine damage and effect on diver. If required, terminate dive and surface the diver.
SS EP-8 Equipment failure with diver in the water	Dive Supervisor and Diver to evaluate effect on failure on diver. Inform diver of plan of action. Alert standby diver and topside crew. Immediately terminate dive is equipment failure involves or effects life support equipment.

Appendix L: Equipment Maintenance/Repair Record (Example)

Manufacturer:_____ Model No: ____

Serial No: _____

Date	Nature of Work	Done By	Notes

Appendix L1: Equipment Maintenance/Repair Record (Scuba Cylinder Inspection) (Example)

Reclamation Lower Colorado Region Diving & Marine Operations

Visual Cylinder Inspection Evaluation Form

Cylinder Information

Cylinder Serial #:_____ Shop reference #:_____

Manufacturer:_____

Working Pressure:_____psi Cylinder Volume:_____cubic FT

Material: Aluminum Steel other:_____Type: SCUBA SCBA other:_____

Original Hydro Date:_____ Current Hydro Date:_____

Valve: K J other:_____ Backpack: Yes No Boot: Yes No

Last VCI: _____

External Inspection
Evidence of Heat: Yes No
Odor: Yes No
Evidence of Bulges: Yes No
Steel Cylinder bell tone: Yes No N/A

Description of External Surface: _____

Gouges, dings, pits + 0.015": none seen location:_____
Depth: _____

Line Corrosion: none seen other:_____

Comparison to P.S.I. Standards: Acceptable Marginal Unacceptable

Internal Inspection

Amount and composition of contents: none seen other:_____

Description of internal surface: _____

Location and depth of any pitting:_____

Comparison to P.S.I. Standards: Acceptable Marginal Unacceptable

Appendix L1 Continued

Visual Cylinder Inspection Evaluation Form
Page 2

Cylinder Threading

Description of threads:_____

Crack assessment:_____O-ring gland surface:_____

Eddy current Test: Not required Pass Failed

Comparison to P.S.I. Standards: Acceptable Marginal Unacceptable

Valve
Burst Disk Replace: Yes No
O-ring Replaced: Yes No

Dip Tube:_____Threads:_____

Service needed: none other:_____

Cylinder Condition

Acceptable Sticker Affixed:_____Date:_____

Marginal Action Taken:_____Recommendations:_____

Unacceptable Disposition:_____Condemn _____

Additional Notes:

Inspection completed by:_____Date:_____

Inspector's #:_____

Appendix L2: Equipment Maintenance/Repair Record (Regulator Repair/Service) (Example)

Regulator Service Form

Customer Name_____

Phone (Home)_____(Work)_____

Date Received_____Date Requested_____

Date Finished_____

I authorize_____to perform the necessary services needed to make this regulator safe, according to manufactures specifications, for use in SCUBA diving activities. I understand it is required by me to test this equipment upon completion of services to ensure my safety and others.

Signature_____

Regulator Type and History

Configuration

1st Stage_____Serial #_____

2nd Stage_____Serial #_____

Octopus_____Serial #_____

Gauges_____

Extras_____

Warranty Work Yes_____No_____

Circle One Inspection Overhaul

IP Test		
Condition of Filter		
	Primary first Stage	Octopus
Primary Diaphragm		
Exhaust Diaphragm		
Opening Effort		
Purges		
Mouth Pieces		
Water Test		

Comments

Parts Used:

Appendix M: Scuba Diving Checklist (Example)

Pre-Dive Checklist

EQUIPMENT NEEDED

	REQUIRED		***OPTIONAL***
	Cylinder(s) w/ valve(s)		
	Regulator		Signal lights, Chemical lights
	BCD		Recall Unit
	Full Face Mask with through-water communications		
	Knife		Slate w/ Pencil
	Fins		
	Weight Belt w/ Quick Release		
	Console w/ PSI & Depth gauge		Whistle
	Dive Computer		Snorkel
	Thermal Protection Suit Wet Dry		
	Dive Tables		
	Primary Light		
	Backup Light		
	Compass		
	Emergency Gas Supply with regulator		

DIVER CHECKS

		Inspect the Cylinder(s) for cracks, dents, gouges, or defective valves. Check O-ring.
		Verify current hydrostatic test and visual inspection, on all cylinders to be used.
		Gauge Cylinder (s) Charge if necessary. (Reserve UP) Check for leaks. Shut cylinder valve.
		Inspect regulator assembly. Attach to cylinder. Open cylinder valve. Verify operation by breathing regulator. Inspect Face mask
		Inspect BCD.
		Inspect all other equipment. Ensure all rubber in good condition. Quick release mechanism operates properly. Knife is sharp. Adequate weight.
		Checkout Thru-Water Communications, if used - headsets and surface units
		Checkout emergency gas supply
		Lay out all equipment ready for use

Appendix N: Surface Supplied Air Checklist (Example)

Reclamation Surface Supply Dive Pre-Dive Checklist

Equipment: Check items being used, list any others.

	REQUIRED EQUIPMENT		OPTIONAL
	Helmet/ mask w/Non-return		
	Umbilical Assembly		Tool Bag
	Weight Belt		Handling System
	Safety Harness with leg straps		Stage or Bell
	Emergency Gas Supply w/regulator		Slate & Marking Pen
	Thermal Protection Suit ☐Wet ☐Dry		Signal Flare
	Knife w/scabbard (or folding)		Air Banks
	Boots (fins optional)		Air Compressors
	Primary Air Source		
	Air Rack		
	Communications Box		
	Descent (down) Line		
	Secondary Air Source		
	Lights		

Diver / Tender Checks

	Inspect the Helmet/ mask for damage and proper maintenance including valves, regulators, and communications. Check spiders, hood bands, valves and clearing devices.
	Test Non-Return Valve for proper operation
	Visually Inspect the umbilical for bubbles, cracks, leaks damage or contamination. Attach umbilical to primary air supply on the air rack console. Connect pneumofathometer. Connect communications plugs. Secure strength member.
	Attach helmet or mask to umbilical, after blow down. Pressurize and check for leaks. Test operation of helmet or mask for, leaks, proper operation (breath rig), and communications. Check safety latches for proper operation and condition. Apply defogger if needed.
	Verify bailout has current hydrostatic test and visual inspection. Gauge cylinder (Charge, if necessary). Inspect regulator assembly. Verify relief installed. Attach to cylinder. Open cylinder valve. Verify operation by breathing and operate purge. Check for leaks. Shut cylinder valve. Record PSI _____
	Inspect all other equipment. Ensure all rubber in good condition. Quick release mechanism operates properly. Knife is sharp. Adequate weights. Inspect safety harness. Pneumofathometer depth gauge(s) tested within past 6 months.
	Lay out all equipment ready for use.

Appendix N Continued

Reclamation Dive Supervisor Checks

	Verify all divers are fit to dive. Current dive clearance letter.
	Ensure plans are complete for emergency assistance. Nearest chamber, physician, transport, logistics, hospital, and etc.
	Brief all divers, standby divers, tenders, system operators and others directly involved of the dive plans. Cover dive objectives, depth and time limits for the dive, job assignments, work and dive techniques, tools, and phases of the dive, route to site, anticipated conditions, special signals, safety, anticipated hazards, and emergency procedures.
	Ensure all equipment maintenance has been completed. Verify compressor air samples taken within 6 months are OK.
	Verify all dive tables, logs, and dive records available for use.
	Verify all divers have complete minimum equipment
	Notify all persons concerned or boats and facilities in the vicinity that diving is being conducted. Ensure any underwater hazards presented by a vessel or facilities are secured ("Lockout /Tagged Out") prior to and during the dive.
	Verify diving platform is stable (moored or DPS), and ready for diving.
	Verify as required, stage ready and descent line rigged. If using an open bell: verify air & BIBS supply, handling wires or lines rigged, bell operating procedures complete, crane or winches manned and ready to support operations.
	Verify required dive flags and signals are displayed.
	Verify start up operating procedures have been completed. Banks have been charged, system valves aligned, moisture separators / filters / volume tanks have been drained, compressors started and operating properly. Ensure volume of air available is sufficient for anticipated dive.
	Verify Primary Supply:_____ _____ Source PSI
	Verify Backup Supply: _____ _____ Source PSI
	Verify Rack (Supply Console) Reduced Pressure to Umbilical(s): _____ PSI
	Test pneumofathometer(s).
	Ensure rack (supply console) properly aligned and manned.
	Verify tender(s) dress diver(s) properly. Umbilical properly attached to safety harness. Knife free. Weight belt on. All hoses connected. No leaks. Wet or dry suit on properly. Boots on or fins ready.
	Verify bailout (come home) connected properly. (check one) Valve open ☐ Valve Shut ☐
	Hat the diver(s). Verify rig(s) breath OK. Communications check.
	Verify standby diver ready.
	Check watches and clocks ready.
	Diver(s) enter water. Ensure divers complete final in-water checks. (Rig breathing OK. Check for leaks and dressed properly. Fins ON. Check mask seal. Buoyancy OK.).

Appendix N Continued

Post Dive Checklist

	Diver(s) reach surface. Out of water. Hat off.
	Verify Diver(s) OK. No Decompression Symptoms
	Undress diver(s). Gauge bailout cylinders, refill as needed. Clear equipment from area. Wipe out oral nasal with disinfectant.
	Rinse all equipment with fresh water as soon as possible. Perform required post dive maintenance.
	Diver (or Tender) inspects equipment for damage.
	Complete all diving logs / records.
Remarks:	

Appendix O: Diving Accident Reporting (Form)

Diving Accident Report Form

(To be completed by the Dive Supervisor)

☐ ACCIDENT **Date of Incident** _____

☐ INCIDENT

☐ NEAR MISS **Time of Incident** _____

(Check one – definitions listed in SAF 01-02 https://www.usbr.gov/recman/saf/saf01-02.pdf)

Report diver injuries or diving-related illness and equipment failures that resulted in diver injuries, which occurred during or after the dive

Name of Involved/Injured Diver(s) (full) _____

_____

Name of Dive Supervisor _____

Name of Regional Dive Team Leader_____

Name of Regional Safety Official_____

Name of Regional Director_____

Location Where Incident Occurred:_____

Nature of Incident - Describe exactly what the diver was doing and the circumstances leading to the incident._____

_____

Extent of Injury – Symptoms and time of onset. Describe the affected body parts, extent of injury and any examinations _____

_____

Cause of Incident – In the opinion of the Dive Supervisor. (Do not state carelessness; be precise)
_____
_____
_____
_____
_____
_____

Appendix O Continued

Recompression Treatments and Results

_____

_____

_____

List Witnesses:

_____

_____

_____

_____

List Actions Taken to Prevent or Minimize Injury to the Diver

_____

_____

_____

_____

_____

Type of Incident: Check Appropriate

☐ Type 1 DCS (Bends) ☐ Type II DCS (Bends) ☐ Embolism

☐ Squeeze ☐ Omitted Decompression ☐ $C0_2$ Toxicity

☐ O_2 Toxicity ☐ CO Toxicity ☐ Trauma

☐ Other, specify_____

Decompression Check Appropriate

☐ No Decompression ☐ Water Deco ☐ Sur D O_2 ☐ Sur D Air

☐ Repeat ☐ Repeat Group_____ ☐ RNT

TBT _____ TDT _____ TTD _____

Air / Gas Supply Source: Check Appropriate

☐ HPAC #_____ ☐ LPAC #_____ ☐ SCUBA ☐ Flask / Bank

List Source(s) of Air / Gas_____

Air Sample analysis attached ☐ Yes ☐ No

Equipment Check Appropriate

Was the equipment a contributing factor? ☐ Yes ☐ No

Dive Mode: ☐SCUBA Mode I ☐ SCUBA Mode II ☐ Surface Supply Mode III

Diver Worn UBA ☐ SCUBA Type Mask_____

☐ Surface Supply Helmet / Mask _____

☐ Bailout (check if yes) Size & Regulator _____

Thermal Protection ☐ Wet Suit ☐ Dry Suit ☐ Other_____

Appendix O Continued

Accessories ☐ Gloves ☐ Booties ☐ Fins ☐ Knife
☐ Snorkel ☐ Weight Belt – list weight_____
☐ Compass ☐ Computer ☐ Comms ☐ Temp Gauge ____
☐ Safety Harness ☐ Lights ☐ Others –List_____

BC Make/Model _____ Inflated at Scene _____%
☐ LP Air ☐ Oral ☐ CO_2
Operational at Scene ☐ Yes ☐ No

Regulators Make/Model _____ ID # _____

Last Known Overhaul PMS_____Operational at Scene ☐Yes ☐No

Depth Gauge /Pneumo Make/Model _____
Last Cal_____ Operational at Scene ☐ Yes ☐ No

Diver Carried Cylinder ID # _____ Last Hydro _____
Last VIP _____ Last Valve Service_____

Pressure after Dive_____

Note: Ensure cylinder valves are shut and sealed – analysis may be necessary of the breathing media.

Air Compressor ID # _____ Last Air Sample_____
☐ HPAC ☐ LPAC Filter Type _____ Last Changed _____
Umbilicals ID#'s _____ Last Service _____
ID#'s _____ Last Service _____
Chamber ID# _____ Last Pressure Test _____

List other Life Support Equipment_____

Note: In very serious injuries or fatalities, the entire diving rig shall be tagged and locked away in the exact configuration as it was after removal from the diver. The investigation team or an independent lab will disassemble and document equipment conditions, in a witnessed verification.

List Recommendations to Prevent Future Incidents of this type

_____
_____

_____ _____
Signature - Dive Supervisor Date

Attach as necessary Copies of
☐ Reclamation Injury Report
☐ Air Samples
☐ Dive Log / Record
☐ Recompression Treatment Record

Appendix P: Diving Services Request Form (Example)

XX Region

Underwater Investigation Team

Request for Diving Services

To: XX Regional Dive Team Leader

From:

Subject: Request for Services of the XX Regional Underwater Investigation Team (Dive Team)

Note: A minimum of three divers are required and approval of a diving request is subject to availability of divers and previously scheduled dives. Maximum diving depth is 100 FSW. An ROV is available for depths greater than 100 FSW.

Facility to be inspected:_____

Check Specific Feature(s) to be inspected

Outlet Works Stilling Basin

Spillway Stilling Basin Intake

Structure

Siphon or Tunnel

Gate or Gate Structure

Other:_____

Note: Include with request the Plan and section drawings of structure and details of each feature to be inspected. Reports of previous underwater inspections or historical problems or previous damage.

Date(s) of requested diving:_____

Note: When possible, dives should be scheduled to be performed when the water clarity is historically at its optimum.

Access to site (Is a boat required?):_____

Cost Authority number:_____

Regional Contact (Name/Phone):_____

Area Office Contact (Name/Phone):_____

Area Safety manager (Name/Phone):_____

Facility Contact (Name/Phone):_____

Lockout/Clearance Holder at Facility (Name/Phone):_____

Nearest Hospital and Ambulance Service to dive site (Name, Location and Phone):_____

_____

Appendix Q: Chambers/PVHO

Reclamation does not currently utilize recompression chambers in normal dive operations. This section is intended to be used as a guideline should Reclamation authorize a special diving operation that requires the use of an on-site Pressure Vessel for Human Occupancy (PVHO).

All chambers, whether called recompression chambers, deck decompression chambers or PVHO, will be ASME PVHO-1 approved. The size of the chamber should be sufficient to accommodate a diver/patient lying down and a tender to attend the diver/patient. Dual lock chambers must have a minimum depth capability of 6 ATA (atmospheres absolute) or 165 fsw. The use of surface decompression using oxygen is encouraged whenever possible.

The use of the one-man portable hyperbaric stretchers with a 2.8 ATA or 60 fsw capability do not satisfy the need for an on-site chamber for those dives that require an on-site chamber. The one-man hyperbaric stretcher is only considered a pressure vessel for transport under pressure to a qualified recompression treatment facility in an emergency.

Q-1 On-Site Chamber Recommendations

In many commercial diving operations, a dual lock chamber should be routine equipment if a chamber is required. A chamber provides emergency recompression treatment for the diver and permits surface decompression. Chamber needs should be based on, but not limited to, the following considerations.

- Diving deeper than 100 fsw or if decompression is planned
- Whenever surface decompression is planned
- Whenever multiple day or repetitive diving is planned
- If the anticipated conditions could cause incurring decompression obligations, such as potentials for entrapment or fouling, weather or sea conditions, use of power tools or lift bags, etc.

Q-2 State of Readiness

Since a chamber is both a diving system ready to support surfaced decompression and an emergency treatment facility, it must be kept in a high state of readiness at all times. The chamber and its support equipment must be well maintained, tested, cleaned, and outfitted with all necessary accessories and medical supplies. A chamber shall never be used as a storage or berthing compartment. All systems should be aligned and tested each day as part of pre-dive checks prior to commencing diving operations. All divers must be trained on the proper operations and functions of all chamber equipment; and must be able to perform all duties and tasks necessary to support surface decompression and medical treatments.

Q-3 Chamber Safety

All persons subjected to hyperbaric pressure shall be considered 'to be diving' and must be decompressed using an approved decompression procedure or treatment protocol. Additionally, anyone pressurized in a chamber must have passed a physical examination for divers (Section 5). For chambers using oxygen and Nitrox (50/50% Nitrogen /Oxygen mixture) for breathing gas inside the chamber, the following safety precautions are of amplified importance:

- Do not use oil or grease (especially hydrocarbon types) on any oxygen, air, Nitrox, or exhaust fitting, valve, gauge, or regulator. Silicone diver greases or oxygen compatible greases—such as Halocarbon, Krytox, etc.—are only to be used on hatch seals or door hinges requiring lubrication.

- Do not allow open flames, smoking materials, or any other flammable products to be carried into the chamber.

- Never permit any products that contaminate the atmosphere or off gas into the chamber atmosphere into the chamber. Only items approved for hyperbaric use should be permitted in the chamber (Section Q-13).

- Ensure the chamber remains closed when not in use with the doors dogged or battened in place. Make sure the doors are secured so they cannot get loose in a rolling sea. The dogs (if installed) should be in good operating condition.

- Leave the chamber pressurized to a shallow depth, usually the Inner Lock at 30 fsw and Outer Lock at 15 fsw to keep the atmosphere clear and chamber clean.

- If the chamber has dogs, when pressurized to depth, the dogs must be released to prevent damage when the chamber is depressurized.

- Never permit any unauthorized modifications to the chamber hull or support systems. Only qualified divers or technicians, using approved materials and methods in compliance with ASME and PVHO standards, should do repairs.

- Do not allow any electrical device inside the chamber unless specifically designed for hyperbaric conditions. Normally 115 V AC devices are not allowed and electrical devices must be DC type. Lighting should be external to the chamber or be encased in pressure-proof cases.

- Follow all oxygen safety rules for the handling of oxygen, Nitrox, BIBS, BIBS exhaust, and components inside the chamber.

- Keep the inside of the chamber clean and free of contaminants. Consider the inside of the chamber as an oxygen-use area and a hospital bed for a patient.

Appendix Q Continued

Q-4 Chamber Hygiene

Chamber hygiene is critically important on long treatments, which can last for days. Long exposures to hyperbaric pressures make a fertile breeding ground for bacterial infections. After a treatment or long operational use the chamber's inside surfaces must be cleaned with an approved antibacterial solution and dried completely before using the chamber again. BIBS masks should be wiped out between each use using an astringent solution or a soap and water rinse. All linens and towels must be washed after a treatment or diving operation. If bacterial contamination is suspected, swabs should be taken and lab tested to identify the contaminant. The following general rules should be observed to maintain a chamber's hygienic quality of life.

- Make all reasonable attempts to maintain the humidity of the chamber below 50 percent.
- Lock out sanitary wastes as soon as possible.
- Clean up standing water (e.g., bilges, decks, etc.) as soon as possible.
- Change linens and towels daily during treatments.
- Wet or Dry suits should be locked out as soon as possible. Wet suits left in a chamber will on-gas and require decompression, as well as become a bacterial problem.
- Patients should be given daily bed baths and clean clothing during treatments.

Q-5 Gas Mixing

Mixed gases utilized for hyperbaric treatment must be procured from authorized commercial sources. Gases that are mixed must have documentation that lists the gas constituents, percentage of each constituents, analysis results prior to acceptance, and vendor supplying the mixed breathing gas. Inert gases procured must be specified to be breathing gas and oil free. Gases shall meet the following purity standards [46 CFR 197.340].

- Oxygen – GGA G-4.3 Type 1 Gaseous, Grade B (Medical) is preferred, Grade A (Aviators) is acceptable. Fed Spec BB-0-925a
- Nitrogen – CGA G-10.1 Grade B preferred; however, E, F, or G are acceptable. Fed-Spec BB-N-411
- Each Nitrox cylinder must have a tag attached listing the verification of oxygen percentage in the mixture, date analyzed and name of diver responsible for verifying the contents of the cylinder.

Q-6 Chamber Outfitting Requirements

All Reclamation divers involved in diving operations that require an onsite chamber shall be familiar with the required chamber outfitting.

Q-6.1 Outfitting List

[29 CFR 1910.430 (e) and 46 CFR 197.328]

- Chambers must be capable of pressurization to 6 ATA (165 fsw).
- Chambers must be capable of pressurization rates of 66 fpm to 60 fsw and 33 fpm for deeper depths.
- Must have an external depth gauge (pressure gauge) for each lock or pressurized compartment.
- Must have interior lighting sufficient for conducting medical examinations and visual observations.
- Must have a bunk for each patient. The bunks must be visible from outside the chamber over their entire length.
- Must have protective screens or mufflers on the exhaust outlets and supply inlets.
- Must have a Built-In-Breathing System (BIBS) capable of providing treatment or decompression gas directly to the diver or patient in the chamber. There must be one mask for each occupant in the chamber with sufficient capacity to supply breathing mixtures for each occupant at a heavy work rate.
- Must have an installed two-way voice communications system between the outside control station and each lock. A back-up sound power phone system must be installed, except when sound power is the only communications.
- Shut off valves must be installed within one foot of the hull for all piping that penetrates the pressure boundary. A relief valve must be installed to relieve at 110 percent of maximum pressure; additionally, the relief valve must have a locked-open (pinned, wired, etc.) in-line stop valve. Any piping carrying fluids into the chamber must have a check valve within one foot of the pressure hull boundary.

Appendix Q Continued

- Must have the capability of scrubbing the atmosphere or venting to maintain the atmosphere gas levels within limits. Oxygen and Carbon Dioxide analyzers should be available to permit monitoring of the chamber atmosphere during manned operations. The analyzer instruments shall have sufficient accuracy to ensure the atmosphere can be maintained to the following levels:

  Oxygen: 19 - 25% (+/- 1%)
  Carbon Dioxide: less than 1½% surface equivalent (+/-½%)

- Must have an exhaust system to vent the chamber to the outside away from the chamber. The exhaust system should have mufflers to prevent hearing injuries to the outside chamber operators. Aural protectors (with drilled holes for venting) will be provided for each occupant inside the chamber.

- Must have fireproof bedding and mattresses.

- Must have Instruments inside the IL to monitor temperature, humidity and depth (pressure).

- Must have a fire extinguisher approved for hyperbaric use or installed fire suppression system.

Q-6.2 Pressure Hull and Doors

Each Pressure Vessel for Human Occupancy (PVHO) must be built and stamped in accordance with the ASME PVHO-1 code. To be Coast Guard approved the PVHO must be constructed in accordance with section VIII, division 1 or 2 of the ASME code. The chamber must be hydrostatically tested on initial construction to 1.5 times maximum working depth. Pneumatic tests must be conducted after every repair or modification to the pressure boundaries, or each year to the maximum working pressure. Chambers should also have a pneumatic test (Exhibit Q-1) whenever the chamber is moved and set up in a new location.

Q-6.3 Viewports

Viewports are normally fabricated from acrylic plastic that meets the requirements of the PVHO-1 ASME/ANSI codes. Viewports may have natural bubbles or scratches on the surface. Service inspection should ensure viewports are free of cracks, chips, discolorations, or clouding. Viewports are normally changed every ten years. Viewports should have clear protective covers over them. ‘Leak tech’ or other liquid types of ‘Snoop®’ will not be used when checking for leaks around viewports. These liquids can cause rusting of the seating surfaces. Anytime viewports are removed for inspections or repairs the chamber will be subjected to a pneumatic test to 100 percent of the maximum working depth.

Q-6.4 Electrical Systems

Electrical installations inside a chamber (PVHO) must be designed for hyperbaric conditions to minimize the possibility of fire. There will be no open plugs or switches inside the chamber. All electrical components should be of DC type (not AC). AC equipment must have a ground fault interrupter and be in compliance with PVHO-1. Lighting should be external whenever possible. Communications systems into the chamber should be of the diver radio wire type and procured from a manufacturer of diving or hyperbaric systems.

Q-7 Outer Lock Operations

The Outer Lock (OL) is designed to permit personnel and equipment to be passed into the chamber during decompression and treatments. Some chambers are equipped with a smaller lock called a supply or medical lock that allows small items to be passed in, such as medical supplies or food. When someone is locked into the chamber, the Dive Master must carefully keep track of the time and control required decompression. It is not good to tie up the outer lock conducting long decompressions. Physicians or others being locked in must be briefed on their allowed bottom time and instructed that if they exceed that bottom time, they are committed to the entire treatment in accordance with the decompression table being used. Each chamber must have a procedure for operations of the outer lock.

WARNING

If the diver is alone in the Outer Lock and oxygen breathing must be done to complete decompression, the mask straps will not be placed over the head. The mask will be held in place by hand, so that in the event that any serious symptoms of oxygen toxicity occur, the mask will fall off and the PO2 (PPO2) instantly reduced.

Q-8 Chamber Pre-Operational Ready Checks

As with any dive, the chamber must be aligned using a pre-dive checklist. General requirements are as follows:

- Ensure a pressure test has been conducted within the past two years after the chamber was last moved or after any repairs to any part of the pressure boundary, whichever is most recent.
- Turn on electrical power to the chamber. Visually inspect all wiring and lights.
- Test communications and sound power communications.

Appendix Q Continued

- Verify primary and secondary air supply is of sufficient quantity and quality. All piping and hoses should be inspected for leaks, disrepair, or contamination.
- Align oxygen (and/or Nitrox) to the BIBS. Test breathe each BIBS mask for proper function, cleanliness and operation.
- Ensure the bedding in the chamber is clean and ready.
- Verify all inside equipment is available and ready for use and should include fire extinguisher, vented ear protection, buckets, mallet, caisson gauges, temperature gauge, humidity indicator, and medical kits.
- Verify all outside equipment is available and ready for use and should include stopwatches, treatment tables, Decompression Tables, chamber log, emergency procedures, and medical supplies.

Q-9 Chamber Operational Requirements

Q-9.1 Chamber Air Supply

All chambers must have a primary and secondary air supply. The primary air supply shall be sufficient to pressurize the IL to 165 fsw once and the OL to 165 fsw twice, and be capable of supporting ventilation during one complete treatment table. The secondary air supply must be sufficient to pressurize the IL and OL to 165 fsw and provide 4,225 cubic feet of ventilation air. If the air supply will be used to support planned diving and chamber needs, the quantity must be sufficient to meet both requirements combined.

Q-9.2 Ventilation and Scrubbers

Scrubbers are installed in modern chambers to reduce the ventilation requirements. These chamber environment control systems also aid in the regulation of humidity and temperature. Constant or frequent monitoring of the chamber atmosphere also aids in the ability to control chamber atmosphere. For chambers without scrubbers or monitoring capability, ventilation rates must be used to control CO_2 and temperature levels. The following ventilation rates will be used as a basic guide.

Ventilation of divers not on BIBS:

- 2 acfm (actual cubic feet per minute) for each occupant at rest
- 4 acfm for each occupant at work

Ventilation rates for BIBS breathing that exhausts into the chamber:

- 12.5 acfm for each occupant at rest
- 25 acfm for each occupant not at rest

A General Ventilation Rule can be used for chambers without flowmeters for a constant vent rate, monitoring equipment or scrubbers. This basic procedure uses far more air than a constant vent. The General Vent Rule is:

- Vent 1 minute out of every 5 minutes if only air is being breathed
- Vent 2 minutes out of every 5 minutes if any occupant is breathing oxygen

Q-9.3 Oxygen and Nitrox Systems

All systems that provide oxygen or breathing air or gas for divers must be cleaned to approved standards. The oxygen system in particular must be oil free and constructed of non-ferrous materials. Any system which uses oxygen in excess of 40 percent will be cleaned to oxygen clean standards. Oxygen systems will be cleaned if there are any indications of contamination and after repairs or modifications to the systems. All persons involved in oxygen cleaning must be trained and use approved procedures and materials. After cleaning any breathing gas system, the system will be completely dried; then an air (gas) purity test must be conducted to ensure all cleaning agents have been removed.

BIBS masks are designed to administer oxygen or mixed gas breathing media to a diver or patient in a hyperbaric chamber. If oxygen and Nitrox mixes are permitted to be exhaled into the chamber, the percentage of oxygen would quickly rise above the allowed 25 percent level. To prevent this, BIBS designed with an overboard dump capability should be used. Exhaled gases should be piped out of the chamber. To ensure that this feature operates correctly during chamber operation, the following pre-tests will be performed prior to diving.

- BIBS must be aligned and tested prior to the beginning of the diving day. Gauge each of the oxygen cylinders and record the pressure. The regulator must be set to 50 psi over bottom [operation at 165 feet will require the regulator to be set at 125 psi (165 x 0.445 + 50 = 123.42)].
- BIBS exhaust systems which permit Nitrox delivery at deeper than 60 fsw must be equipped with a backpressure regulator. The backpressure regulator is a tracking regulator that controls the exhaust header pressure at an acceptable 5-20 psi above the ambient pressure. The backpressure regulator should be bypassed at pressures less than 60 fsw.
- Exhaust hoses are sometimes disconnected to permit equalization and collapse of the hoses. This practice is to protect the hoses from damage. These hoses will be reconnected and the exhaust hull valve opened to start exhausting.

Appendix Q Continued

Q-10 Manning of Chambers

Minimum manning requirements of a chamber are as follows:

- Dive Supervisor
- Outside Tender (Chamber Operator)
- Inside Tender (may be a Medical Attendant)

Additional outside personnel may be used to keep logs and assist.

Q-10.1 Chamber Dive Supervisor

In addition to all other duties listed for the Dive Supervisor in previous sections, chamber control includes the following responsibilities:

- Direct the medical treatment and act as a liaison to the diving physician during the conduct of the treatment. Follow all treatment tables precisely as written unless altered or modified by a Physician trained in diving medicine.
- Direct decompression and ensure all personnel pressurized in the hyperbaric environment of the chamber are properly decompressed. Monitor all breathing times on air, oxygen or Nitrox.
- Directly supervise the outside tender, inside tender or medic, and patient. Keep logs on the entire treatment or chamber operation.
- Keep the Person-In-Charge, DMO, and management informed and updated concerning any treatments or diving accidents.

Q-10.2 Outside Tender/Chamber Operator

The Outside Tender operates the chamber controls, under the direction of the Dive Supervisor, to pressurize, maintain depth, and depressurize throughout the dive or treatment. Duties include the following.

- Ensure that primary air supply and BIBS supplies are aligned to the chamber.
- Monitor and control the depth of the chamber continuously. Keep logs on the entire treatment or chamber operation.
- Communicate with the inside tender, keeping him/her informed concerning vents, going on or off oxygen or changes in depth.

Q-10.3 Inside Tender/Dive Medic

Inside Tenders are in-charge inside the chamber. They may control compression on two-way inside controls. They communicate with the Dive Master, keeping him informed regularly on conditions inside the chamber. Duties inside the chamber include, but are not limited to, the following:

- Perform neurological examinations on patients or injured divers, giving accurate, concise reports to the Dive Supervisor and DMO.

- Directly control persons breathing oxygen or increased partial pressure of oxygen. Watch for symptoms of oxygen toxicity and be ready to take actions to reduce the partial pressure of oxygen if symptoms develop.

Q-11 Chamber Temperature Control

The internal temperature should be maintained at a constant level for the comfort of all occupants. Cooling is usually accomplished by venting. Chambers that become too hot will have to be vented to cool them. Chambers should be shaded from direct sunlight. If the chamber becomes too hot, temperature will become the limiting factor rather than the treatment or decompression requirements. People who become overheated can suffer from heat cramps, heat exhaustion, or heat stroke. Dehydration can cause additional serious medical problems to the Inside Tender as well as the Patient. A chamber temperature between 75 and 85 ºF is desirable for all treatments. Never commit to a treatment table that will expose the chamber occupants to a greater temperature time combination than listed in table Q-1 below.

Table Q-1. Chamber Temperature Limits

Internal Temperature Range	Maximum Tolerance Time	Treatment Tables Allowed
>104 °F	Zero	No Treatment
94 - 104 °F	2 hours	Table 5
85 - 94 °F	6 hours	Tables 5, 6, 6A, and 1A
< 85 °F	Unlimited	All Tables

WARNING

Never use a mercury thermometer in or around a chamber. Bimetallic, electronic, or liquid crystal thermometers must meet the construction standards for hyperbaric equipment before their use is permitted inside a chamber.

Appendix Q Continued

Q-12 Chamber Fire Precautions

Fire can be a major hazard in a chamber, but it is easily minimized or eliminated. Fire cannot occur unless three factors come together at the same time—combustible materials, oxygen, and a source of ignition. By eliminating any one of these items, it becomes almost impossible for fire to occur. The problem in the chamber is that, when air is compressed, the flash point of many materials is lowered and the combined factor of the atmosphere is being warmed up by pressurization. When oxygen breathing occurs in the chamber and the oxygen percent goes above 30 percent, fire potential is critical. Chamber oxygen percent should be kept below 25 percent and as close to 21 percent as possible.

Q-12.1 Chamber Fire Prevention

To eliminate or minimize fire risk in the chamber the following precautions should be enforced at all times:

- No open flames or burning materials are permitted in the chamber at any time. No matches, cigarettes, cigars, pipes, or lighters shall ever be permitted inside the chamber. It should be a habit never to bring anything into the chamber, even in your pockets.

- A fire extinguisher or a fire suppression system must be operational and ready at all times during chamber operations.

- All bedding must be made of approved fire retardant materials. Static conductive clothing (such as nylon, rayon, etc.) should not be worn into the chamber. Clean cotton clothing and towels are permitted. Clean is the key word. Clothing being worn into the chamber should be inspected to ensure it is free of greases, paints, or solvents.

- Limit the combustible personal effects inside the chamber (reading materials, notebooks, etc.). Trash should be locked out as soon as possible.

- The Dive Supervisor must approve any materials being locked into the chamber, assuring that materials, items or equipment being locked in are safe (nonflammable) for use in a hyperbaric environment. If in doubt, get advice from the DMO or Chairman of the RDSAB. If combustible materials must be used in the chamber, use them sparingly. Carefully control items being brought into the chamber and lock them out or store them in fireproof boxes when not in use.

Q-12.2 Chamber Fire Zone

The fire zone is the depth range where combustion is possible. As the chamber goes deeper, the physiological need for oxygen is less. As the percentage of oxygen drops in the chamber, the fire danger becomes less. As the chamber gets shallower and BIBS oxygen-breathing starts, the percent of oxygen can rise if mask leakage or exhausting of O_2 into the chamber occurs, then the possibility of fire increases expediently. Always remember the key factor in determining combustibility is the percentage of oxygen, not the partial pressure of oxygen.

Q-12.3 Chamber Painting

Chambers should be painted with multiple part epoxy paint approved for hyperbaric conditions, which do not off gas after drying. Thick coats of paint within a chamber can become a fire hazard. The paint should be limited to one primer coat and one finish coat. Only two additional finish coats should be permitted or a maximum thickness of 0.005 inches, whichever comes first. After that, the chamber should be sand blasted and repainted. The following should be common practice with regards to chamber painting.

- Corrosion should be removed by hand or by using a scraper. Rust is considered a flammable material.
- Annually, small areas (less than 2 inches) should be routinely scraped, primed and spot painted to reduce deterioration.
- After painting, the chamber should be thoroughly ventilated and dried over a period of 48 hours, to ensure complete off gassing. The chamber must then be pressurized unmanned and an air sample taken and analyzed to ensure all paint fumes and possible contaminants are removed.
- Only steel chambers are painted; aluminum chambers will be left bare. Portable Kevlar collapsible bags will not be painted. Painting of steel chambers inside should be done only under controlled conditions with proper ventilation and respirators.

Q-12.4 Diver Chamber Fire Fighting Training

All divers involved in chamber operations should be able to operate all extinguishers and firefighting systems incorporated into the chamber. Additionally, divers should practice the emergency procedures to ensure they are able to respond to fire situations. Support personnel should also be familiar with diver emergencies involving fire and be trained in support of chamber fire situations.

Appendix Q Continued

Q-13 Chamber Prohibited Materials

Toxic or contaminant materials should not be permitted into the chamber. The list of prohibited items is developed for the safety of the divers in a hyperbaric atmosphere. Good habits on controlling materials into the chamber enhance safety. Several reasons for prohibiting materials from entering a chamber include the fact that flammable or combustible substances, explosives, or atmospheric contaminants can be broken or damaged by pressure, and are potentially damaging to the chamber structure or fabric; they can also directly act to affect the diver physiologically, or they simply make a mess. The following list, although comprehensive, is by no means an exclusive, all-encompassing list. "If in doubt, keep it out!" unless authorized for entry by a higher, knowledgeable authority.

Q-13.1 List of Items Prohibited Inside a Chamber

- Acetone (a, f)
- Adhesives (f)
- Aerosol products (f, a, e)
- Aftershave solutions (a, f)
- Alcohol (a) (medical alcohol pad is authorized)
- Batteries (open cell) (a, f, p)
- Brass cleaning agents or products (a)
- Cigarette Lighters and matches (f)
- Chemical cleaners (e.g., TCH, 409, Lysol, Scouring Powder, etc.) (a)
- Chloroform (a)
- Cigarettes, cigars, and tobacco products (f)
- Explosives, firecrackers, or bullets (e, f)
- Freon (a)
- Fuels (gasoline, kerosene, diesel, etc.) (a, e, f)
- Glass or battery thermometers (a, p)
- Halogen compounds (a)
- Hydrocarbon based lubricants or products (a, f)
- Methyl Ethyl Ketone (a)
- Non-Diving watches (p, m)
- Non-fireproof bedding and nylon clothing (f)
- Non-vented items (e.g., ink pens, thermos bottles, styrofoam, etc.) (m, p)
- Personal/Portable Electrical Equipment (radios, tape decks, CDs, etc.) (f, d)
- Powders, very fine (talc, baby powder, etc.) (e, f)

- Sparking metals (f)

  Key to item prohibition: (f) fire/flammable (a) atmosphere contaminant (e) explosive (c) damage chamber (p) pressure damage (m) messy

Q-13.2 List of Items Authorized Inside a Chamber

- Components of the medical kits (vent bottles prior to entry)
- Non-Ionic soaps
- Cotton clothing and towels
- Flame retardant bedding and linen
- Food and water

Q-14 Gases, Analysis and Monitoring

Air used to pressurize or ventilate a chamber must have its quality determined by laboratory testing of the compressors or air source every six months to ensure the air supply meets required minimum specifications (see Section 10.4). Oxygen, Nitrox, or any other treatment gases must be procured from a source and meet the appropriate CGA gas purity standard and be stored in DOT-approved cylinders.

Chamber occupancy and fire safety requires that oxygen content of the chamber atmosphere be kept between 21-25 percent (*USN Diving Manual*, vol. 5, chapter 22); and carbon dioxide be kept below 1½ percent (± ½%) surface equivalent by volume. To achieve this requirement monitoring of the atmosphere within the chamber during all manned evolutions is necessary.

Electronic analyzers used to monitor normally indicate in percentage, since carbon dioxide limits are specified as a surface equivalent. It may be necessary to calculate the partial pressure of the constituent gas to ensure the limit is not exceeded. If the analyzer is physically located within the chamber no correction is needed.

Selection of analysis equipment must follow the same requirements used when selecting any diving life support equipment (see Section 10.4.3). [OSHA 1910.430 (e)(3)(i) and USCG 197.328(d) (14-15)]

Q-15 Chamber Testing Requirements

Q-15.1 Double Lock Chamber Pressure Test

Chamber pressure testing is required to ensure chamber pressure integrity. The pressure tests used are adopted from the USN diving manual.

- Pressurize the closed Inner Lock to 100 fsw (45 psi), leak check all penetrations, dog seals, doors, hull valve connections, pipe joints, and shell weldments. Mark all leaks and resurface the lock, if necessary. Adjust, repair, or replace components to eliminate all leaks. Repeat this step until all leaks are repaired and eliminated.

Appendix Q Continued

- Pressurize the IL to 225 fsw (100 psi) (or to maximum working depth); hold for 5 minutes.

- Exhaust the lock to 165 fsw (73.4 psi); hold the pressure for one hour. If the pressure drops below 145 fsw (65 psi), the test is a failure. Locate all leaks and repeat until satisfactory results are achieved.

- Repeat all test steps leaving the Inner Lock door open for pressurization of the Inner Lock and Outer Lock together to test the Outer Lock. It is only necessary to leak test the Outer Lock components not previously tested.

Q-15.2 Inflatable Hyperbaric Stretcher Pressure Test

Assemble the bag and control box, inspect all components, then pressurize the chamber to 60 fsw (26.7 psi) and leak check all hull penetrations, bag seals, umbilical hoses, joints, and bag fabric lamination. Soap-bubble leak check, listen, and verify pressure drop; **a leak rate of 1.5 fsw per hour is permitted through the Kevlar fabric.** Mark all leaks and surface if necessary. Adjust, repair, or replace components to eliminate all leaks (follow bag repair procedures. **Only authorized repair technicians should make repairs)**. Repeat the step until all leaks are repaired and eliminated.

- Pressurize the hyperlite stretcher to 66 (29.3 psi) fsw and check the cracking pressure of the relief valve. The relief should crack at 66 fsw and reset at 63 fsw. Exhaust back to 60 fsw.

- Hold pressure at 60 fsw (26.7 psi) for 30 minutes. The test should be considered a failure if the pressure drops below 52 fsw (23.1 psi). Locate all leaks and repeat test until satisfactory results are achieved.

- Exhaust the chamber to surface pressure, ensure that the bag is dry, and then clean outside of bag.

Q-16 Hyperbaric Medical Kits

Each chamber must be outfitted with a hyperbaric medical kit. The hyperbaric chamber kits are an extension of the equipment listed in the diving first aid kit. Each chamber must have both kits with the chamber and ready for immediate use.

Some items cannot be pressurized without venting or are maintained in a sterile condition, so the kits are separated – items that can always be locked in immediately are placed in the "Primary Kit". Controlled drugs must be kept secured and in the custody of a responsible authorized person. USCG recommends the Vessel Master; however, if this is not possible, the Dive Master, Person-In-Charge and/or Dive Medic must have control of the controlled substance(s). The lists provided are only the minimums and should be modified as needed to meet local and specific job needs.

Q-16.1 Primary Examination Kit

The Primary Examination Kit should contain the examination and first aid equipment needed for immediate evaluation and handling of a diving accident victim.

Q-16.2 Secondary Ancillary Hyperbaric Treatment Kit

The Secondary Ancillary Hyperbaric Treatment Kit contains the medicines and equipment possibly needed for recompression treatment or handling of a diving accident. Sterile supplies should be adequately sealed against moisture and atmospheric pressure. If a sterile item is locked in, it should be replaced or re-sterilized as soon as practical.

Stoppered multidose vials must be vented with a needle during pressurization then properly discarded if not used. All unused medicines must be disposed of properly. All drugs in the kits have an expiration date—expired drugs will be replaced.

Q-17 Chamber Emergency Procedures

Each chamber must have approved chamber emergency procedures. Emergency procedures are provided for training and guidance for emergency situations that affect hyperbaric chamber operations. The Dive Supervisor has the final responsibility to ensure safe operation of the chamber and prevent such emergencies from occurring. In all situations the safety of the chamber occupants is the primary concern. The Dive Supervisor shall take all actions to properly decompress chamber occupants and prevent further injury or diving-related illnesses.

Each Chamber should have the following emergency procedures as a minimum.

CHAM EP-1	Loss of Atmosphere Control
CHAM EP-2	Loss of Air Supply
CHAM EP-3	Uncontrolled Decompression or Ascent
CHAM EP-4	Uncontrolled Pressurization or Compression
CHAM EP-5	Loss of Communications
CHAM EP-6	Loss of Electrical Power
CHAM EP-7	Fire In the Chamber
CHAM EP-8	Fire on the Surface outside of the Chamber
CHAM EP-9	Loss of Atmosphere Analysis Capability

Appendix R: OSHA Safe Practices Manual — 1910.401

ELECTRONIC CODE OF FEDERAL REGULATIONS

e-CFR data is current as of August 21, 2020

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EQUIPMENT PROCEDURES AND REQUIREMENTS

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§1910.440 Recordkeeping requirements.
Appendix A to Subpart T of Part 1910—Examples of Conditions Which May Restrict or Limit Exposure to Hyperbaric Conditions
Appendix B to Subpart T of Part 1910—Guidelines for Scientific Diving

Appendix C to Subpart T of Part 1910—Alternative Conditions Under §1910.401(a)(3) for Recreational Diving Instructors and Diving Guides (Mandatory)

AUTHORITY: 29 U.S.C. 653, 655, 657; 40 U.S.C. 333; 33 U.S.C. 941; Secretary of Labor's Order No. 8-76 (41 FR 25059), 9-83 (48 FR 35736), 1-90 (55 FR 9033), 6-96 (62 FR 111), 3-2000 (65 FR 50017), 5-2002 (67 FR 65008), 5-2007 (72 FR 31160), or 4-2010 (75 FR 55355) as applicable, and 29 CFR 1911.

SOURCE: 42 FR 37668, July 22, 1977, unless otherwise noted.

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§1910.401 Scope and application.

(a) *Scope.* (1) This subpart (standard) applies to every place of employment within the waters of the United States, or within any State, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, American Samoa, Guam, the Trust Territory of the Pacific Islands, Wake Island, Johnston Island, the Canal Zone, or within the Outer Continental Shelf lands as defined in the Outer Continental Shelf Lands Act (67 Stat. 462, 43 U.S.C. 1331), where diving and related support operations are performed.

(2) This standard applies to diving and related support operations conducted in connection with all types of work and employments, including general industry, construction, ship repairing, shipbuilding, shipbreaking and longshoring. However, this standard does not apply to any diving operation:

(i) Performed solely for instructional purposes, using open-circuit, compressed-air SCUBA and conducted within the no-decompression limits;

(ii) Performed solely for search, rescue, or related public safety purposes by or under the control of a governmental agency; or

(iii) 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.

(iv) Defined as scientific diving and which is under the direction and control of a diving program containing at least the following elements:

(A) Diving safety manual which includes at a minimum: Procedures covering all diving operations specific to the program; procedures for emergency care, including recompression and evacuation; and criteria for diver training and certification.

(B) Diving control (safety) board, with the majority of its members being active divers, which shall at a minimum have the authority to: Approve and monitor diving projects; review

and revise the diving safety manual; assure compliance with the manual; certify the depths to which a diver has been trained; take disciplinary action for unsafe practices; and, assure adherence to the buddy system (a diver is accompanied by and is in continuous contact with another diver in the water) for SCUBA diving.

(3) *Alternative requirements for recreational diving instructors and diving guides*. Employers of recreational diving instructors and diving guides are not required to comply with the decompression-chamber requirements specified by paragraphs (b)(2) and (c)(3)(iii) of §1910.423 and paragraph (b)(1) of §1910.426 when they meet all of the following conditions:

(i) The instructor or guide is engaging solely in recreational diving instruction or dive-guiding operations;

(ii) The instructor or guide is diving within the no-decompression limits in these operations;

(iii) The instructor or guide is using a nitrox breathing-gas mixture consisting of a high percentage of oxygen (more than 22% by volume) mixed with nitrogen;

(iv) The instructor or guide is using an open-circuit, semi-closed-circuit, or closed-circuit self-contained underwater breathing apparatus (SCUBA); and

(v) The employer of the instructor or guide is complying with all requirements of appendix C of this subpart.

(b) *Application in emergencies*. An employer may deviate from the requirements of this standard to the extent necessary to prevent or minimize a situation which is likely to cause death, serious physical harm, or major environmental damage, provided that the employer:

(1) Notifies the Area Director, Occupational Safety and Health Administration within 48 hours of the onset of the emergency situation indicating the nature of the emergency and extent of the deviation from the prescribed regulations; and

(2) Upon request from the Area Director, submits such information in writing.

(c) *Employer obligation*. The employer shall be responsible for compliance with:

(1) All provisions of this standard of general applicability; and

(2) All requirements pertaining to specific diving modes to the extent diving operations in such modes are conducted.

[42 FR 37668, July 22, 1977, as amended at 47 FR 53365, Nov. 26, 1982; 58 FR 35310, June 30, 1993; 69 FR 7363, Feb. 17, 2004]

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§1910.402 Definitions.

As used in this standard, the listed terms are defined as follows:

Acfm: Actual cubic feet per minute.

ASME Code or equivalent: ASME (American Society of Mechanical Engineers) Boiler and Pressure Vessel Code, Section VIII, or an equivalent code which the employer can demonstrate to be equally effective.

ATA: Atmosphere absolute.

Bell: An enclosed compartment, pressurized (closed bell) or unpressurized (open bell), which allows the diver to be transported to and from the underwater work area and which may be used as a temporary refuge during diving operations.

Bottom time: The total elasped time measured in minutes from the time when the diver leaves the surface in descent to the time that the diver begins ascent.

Bursting pressure: The pressure at which a pressure containment device would fail structurally.

Cylinder: A pressure vessel for the storage of gases.

Decompression chamber: A pressure vessel for human occupancy such as a surface decompression chamber, closed bell, or deep diving system used to decompress divers and to treat decompression sickness.

Decompression sickness: A condition with a variety of symptoms which may result from gas or bubbles in the tissues of divers after pressure reduction.

Decompression table: A profile or set of profiles of depth-time relationships for ascent rates and breathing mixtures to be followed after a specific depth-time exposure or exposures.

Dive-guiding operations means leading groups of sports divers, who use an open-circuit, semi-closed-circuit, or closed-circuit self-contained underwater breathing apparatus, to local undersea diving locations for recreational purposes.

Dive location: A surface or vessel from which a diving operation is conducted.

Dive-location reserve breathing gas: A supply system of air or mixed-gas (as appropriate) at the dive location which is independent of the primary supply system and sufficient to support divers during the planned decompression.

Dive team: Divers and support employees involved in a diving operation, including the designated person-in-charge.

Diver: An employee working in water using underwater apparatus which supplies compressed breathing gas at the ambient pressure.

Diver-carried reserve breathing gas: A diver-carried 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 a standby diver.

Diving mode: A type of diving requiring specific equipment, procedures and techniques (SCUBA, surface-supplied air, or mixed gas).

Fsw: Feet of seawater (or equivalent static pressure head).

Heavy gear: Diver-wom deep-sea dress including helmet, breastplate, dry suit, and weighted shoes.

Hyperbaric conditions: Pressure conditions in excess of surface pressure.

Inwater stage: A suspended underwater platform which supports a diver in the water.

Liveboating: The practice of supporting a surfaced-supplied air or mixed gas diver from a vessel which is underway.

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

No-decompression limits: The depth-time limits of the "no-decompression limits and repetitive dive group designation table for no-decompression air dives", U.S. Navy Diving Manual or equivalent limits which the employer can demonstrate to be equally effective.

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

Recreational diving instruction means training diving students in the use of recreational diving procedures and the safe operation of diving equipment, including an open-circuit, semi-closed-circuit, or closed-circuit self-contained underwater breathing apparatus, during dives.

Scientific diving means 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 does not include performing any tasks usually associated with commercial diving such as: Placing or removing heavy objects underwater; inspection of pipelines and similar objects; construction; demolition; cutting or welding; or the use of explosives.

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

Standby diver: A diver at the dive location available to assist a diver in the water.

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

Treatment table: A depth-time and breathing gas profile designed to treat decompression sickness.

Umbilical: The composite hose bundle between a dive location and a diver or bell, or between a diver and a bell, which supplies the 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.

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

Working pressure: The maximum pressure to which a pressure containment device may be exposed under standard operating conditions.

[42 FR 37668, July 22, 1977, as amended at 47 FR 53365, Nov. 26, 1982; 69 FR 7363, Feb. 17, 2004]

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§1910.410 Qualifications of dive team.

(a) *General.* (1) Each dive team member shall have the experience or training necessary to perform assigned tasks in a safe and healthful manner.

(2) Each dive team member shall have experience or training in the following:

(i) The use of tools, equipment and systems relevant to assigned tasks;

(ii) Techniques of the assigned diving mode: and

(iii) Diving operations and emergency procedures.

(3) All dive team members shall be trained in cardiopulmonary resuscitation and first aid (American Red Cross standard course or equivalent).

(4) Dive team members who are exposed to or control the exposure of others to hyperbaric conditions shall be trained in diving-related physics and physiology.

(b) *Assignments.* (1) Each dive team member shall be assigned tasks in accordance with the employee's experience or training, except that limited additional tasks may be assigned to an employee undergoing training provided that these tasks are performed under the direct supervision of an experienced dive team member.

(2) The employer shall not require a dive team member to be exposed to hyperbaric conditions against the employee's will, except when necessary to complete decompression

or treatment procedures.

(3) The employer shall not permit a dive team member to dive or be otherwise exposed to hyperbaric conditions for the duration of any temporary physical impairment or condition which is known to the employer and is likely to affect adversely the safety or health of a dive team member.

(c) *Designated person-in-charge.* (1) The employer or an employee designated by the employer shall be at the dive location in charge of all aspects of the diving operation affecting the safety and health of dive team members.

(2) The designated person-in-charge shall have experience and training in the conduct of the assigned diving operation.

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§1910.420 Safe practices manual.

(a) *General.* The employer shall develop and maintain a safe practices manual which shall be made available at the dive location to each dive team member.

(b) *Contents.* (1) The safe practices manual shall contain a copy of this standard and the employer's policies for implementing the requirements of this standard.

(2) For each diving mode engaged in, the safe practices manual shall include:

(i) Safety procedures and checklists for diving operations;

(ii) Assignments and responsibilities of the dive team members;

(iii) Equipment procedures and checklists; and

(iv) Emergency procedures for fire, equipment failure, adverse environmental conditions, and medical illness and injury.

[42 FR 37668, July 22, 1977, as amended at 49 FR 18295, Apr. 30, 1984]

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§1910.421 Pre-dive procedures.

(a) *General.* The employer shall comply with the following requirements prior to each diving operation, unless otherwise specified.

(b) *Emergency aid.* A list shall be kept at the dive location of the telephone or call numbers of the following:

(1) An operational decompression chamber (if not at the dive location);

(2) Accessible hospitals;

(3) Available physicians;

(4) Available means of transportation; and

(5) The nearest U.S. Coast Guard Rescue Coordination Center.

(c) *First aid supplies.* (1) A first aid kit appropriate for the diving operation and approved by a physician shall be available at the dive location.

(2) When used in a decompression chamber or bell, the first aid kit shall be suitable for use under hyperbaric conditions.

(3) In addition to any other first aid supplies, an American Red Cross standard first aid handbook or equivalent, and a bag-type manual resuscitator with transparent mask and tubing shall be available at the dive location.

(d) *Planning and assessment.* Planning of a diving operation shall include an assessment of the safety and health aspects of the following:

(1) Diving mode;

(2) Surface and underwater conditions and hazards;

(3) Breathing gas supply (including reserves);

(4) Thermal protection;

(5) Diving equipment and systems;

(6) Dive team assignments and physical fitness of dive team members (including any impairment known to the employer);

(7) Repetitive dive designation or residual inert gas status of dive team members;

(8) Decompression and treatment procedures (including altitude corrections); and

(9) Emergency procedures.

(e) *Hazardous activities.* To minimize hazards to the dive team, diving operations shall be coordinated with other activities in the vicinity which are likely to interfere with the diving operation.

(f) *Employee briefing.* (1) Dive team members shall be briefed on:

(i) The tasks to be undertaken;

(ii) Safety procedures for the diving mode;

(iii) Any unusual hazards or environmental conditions likely to affect the safety of the diving operation; and

(iv) Any modifications to operating procedures necessitated by the specific diving operation.

(2) Prior to making individual dive team member assignments, the employer shall inquire into the dive team member's current state of physical fitness, and indicate to the dive team member the procedure for reporting physical problems or adverse physiological effects during and after the dive.

(g) *Equipment inspection.* The breathing gas supply system including reserve breathing gas supplies, masks, helmets, thermal protection, and bell handling mechanism (when appropriate) shall be inspected prior to each dive.

(h) *Warning signal.* When diving from surfaces other than vessels in areas capable of supporting marine traffic, a rigid replica of the international code flag "A" at least one meter in height shall be displayed at the dive location in a manner which allows all-round visibility, and shall be illuminated during night diving operations.

[42 FR 37668, July 22, 1977, as amended at 47 FR 14706, Apr. 6, 1982; 54 FR 24334, June 7, 1989]

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§1910.422 Procedures during dive.

(a) *General.* The employer shall comply with the following requirements which are applicable to each diving operation unless otherwise specified.

(b) *Water entry and exit.* (1) A means capable of supporting the diver shall be provided for entering and exiting the water.

(2) The means provided for exiting the water shall extend below the water surface.

(3) A means shall be provided to assist an injured diver from the water or into a bell.

(c) *Communications.* (1) An operational two-way voice communication system shall be used between:

(i) Each surface-supplied air or mixed-gas diver and a dive team member at the dive location or bell (when provided or required); and

(ii) The bell and the dive location.

(2) An operational, two-way communication system shall be available at the dive location to obtain emergency assistance.

(d) *Decompression tables.* Decompression, repetitive, and no-decompression tables (as appropriate) shall be at the dive location.

(e) *Dive profiles.* A depth-time profile, including when appropriate any breathing gas changes, shall be maintained for each diver during the dive including decompression.

(f) *Hand-held power tools and equipment.* (1) Hand-held electrical tools and equipment shall be de-energized before being placed into or retrieved from the water.

(2) Hand-held power tools shall not be supplied with power from the dive location until requested by the diver.

(g) *Welding and burning.* (1) A current supply switch to interrupt the current flow to the welding or burning electrode shall be:

(i) Tended by a dive team member in voice communication with the diver performing the welding or burning; and

(ii) Kept in the open position except when the diver is welding or burning.

(2) The welding machine frame shall be grounded.

(3) Welding and burning cables, electrode holders, and connections shall be capable of carrying the maximum current required by the work, and shall be properly insulated.

(4) Insulated gloves shall be provided to divers performing welding and burning operations.

(5) Prior to welding or burning on closed compartments, structures or pipes, which contain a flammable vapor or in which a flammable vapor may be generated by the work, they shall be vented, flooded, or purged with a mixture of gases which will not support combustion.

(h) *Explosives.* (1) Employers shall transport, store, and use explosives in accordance with this section and the applicable provisions of §§1910.109 and 1926.912 of Title 29 of the Code of Federal Regulations.

(2) Electrical continuity of explosive circuits shall not be tested until the diver is out of the water.

(3) Explosives shall not be detonated while the diver is in the water.

(i) *Termination of dive.* The working interval of a dive shall be terminated when:

(1) A diver requests termination;

(2) A diver fails to respond correctly to communications or signals from a dive team member;

(3) Communications are lost and can not be quickly re-established between the diver and a dive team member at the dive location, and between the designated person-in-charge and the person controlling the vessel in liveboating operations; or

(4) A diver begins to use diver-carried reserve breathing gas or the dive-location reserve breathing gas.

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§1910.423 Post-dive procedures.

(a) *General.* The employer shall comply with the following requirements which are applicable after each diving operation, unless otherwise specified.

(b) *Precautions.* (1) After the completion of any dive, the employer shall:

(i) Check the physical condition of the diver;

(ii) Instruct the diver to report any physical problems or adverse physiological effects including symptoms of decompression sickness;

(iii) Advise the diver of the location of a decompression chamber which is ready for use; and

(iv) Alert the diver to the potential hazards of flying after diving.

(2) For any dive outside the no-decompression limits, deeper than 100 fsw or using mixed gas as a breathing mixture, the employer shall instruct the diver to remain awake and in the vicinity of the decompression chamber which is at the dive location for at least one hour after the dive (including decompression or treatment as appropriate).

(c) *Recompression capability.* (1) A decompression chamber capable of recompressing the diver at the surface to a minimum of 165 fsw (6 ATA) shall be available at the dive location for:

(i) Surface-supplied air diving to depths deeper than 100 fsw and shallower than 220 fsw;

(ii) Mixed gas diving shallower than 300 fsw; or

(iii) Diving outside the no-decompression limits shallower than 300 fsw.

(2) A decompression chamber capable of recompressing the diver at the surface to the maximum depth of the dive shall be available at the dive location for dives deeper than 300 fsw.

(3) The decompression chamber shall be:

(i) Dual-lock;

(ii) Multiplace; and

(iii) Located within 5 minutes of the dive location.

(4) The decompression chamber shall be equipped with:

(i) A pressure gauge for each pressurized compartment designed for human occupancy;

(ii) A built-in-breathing-system with a minimum of one mask per occupant;

(iii) A two-way voice communication system between occupants and a dive team member at the dive location;

(iv) A viewport; and

(v) Illumination capability to light the interior.

(5) Treatment tables, treatment gas appropriate to the diving mode, and sufficient gas to conduct treatment shall be available at the dive location.

(6) A dive team member shall be available at the dive location during and for at least one hour after the dive to operate the decompression chamber (when required or provided).

(d) *Record of dive.* (1) The following information shall be recorded and maintained for each diving operation:

(i) Names of dive team members including designated person-in-charge;

(ii) Date, time, and location;

(iii) Diving modes used;

(iv) General nature of work performed;

(v) Approximate underwater and surface conditions (visibility, water temperature and current); and

(vi) Maximum depth and bottom time for each diver.

(2) For each dive outside the no-decompression limits, deeper than 100 fsw or using mixed gas, the following additional information shall be recorded and maintained:

(i) Depth-time and breathing gas profiles;

(ii) Decompression table designation (including modification); and

(iii) Elapsed time since last pressure exposure if less than 24 hours or repetitive dive designation for each diver.

(3) For each dive in which decompression sickness is suspected or symptoms are evident, the following additional information shall be recorded and maintained:

(i) Description of decompression sickness symptoms (including depth and time of onset); and

(ii) Description and results of treatment.

(e) *Decompression procedure assessment.* The employer shall:

(1) Investigate and evaluate each incident of decompression sickness based on the recorded information, consideration of the past performance of decompression table used, and individual susceptibility;

(2) Take appropriate corrective action to reduce the probability of recurrence of decompression sickness; and

(3) Prepare a written evaluation of the decompression procedure assessment, including any corrective action taken, within 45 days of the incident of decompression sickness.

[42 FR 37668, July 22, 1977, as amended at 49 FR 18295, Apr. 30, 1984]

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§1910.424 SCUBA diving.

(a) *General.* Employers engaged in SCUBA diving shall comply with the following requirements, unless otherwise specified.

(b) *Limits.* SCUBA diving shall not be conducted:

(1) At depths deeper than 130 fsw;

(2) At depths deeper than 100 fsw or outside the no-decompression limits unless a decompression chamber is ready for use;

(3) Against currents exceeding one (1) knot unless line-tended; or

(4) In enclosed or physically confining spaces unless line-tended.

(c) *Procedures.* (1) A standby diver shall be available while a diver is in the water.

(2) A diver shall be line-tended from the surface, or accompanied by another diver in the water in continuous visual contact during the diving operations.

(3) A diver shall be stationed at the underwater point of entry when diving is conducted in enclosed or physically confining spaces.

(4) A diver-carried reserve breathing gas supply shall be provided for each diver consisting of:

(i) A manual reserve (J valve); or

(ii) An independent reserve cylinder with a separate regulator or connected to the underwater breathing apparatus.

(5) The valve of the reserve breathing gas supply shall be in the closed position prior to the dive.

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§1910.425 Surface-supplied air diving.

(a) *General.* Employers engaged in surface-supplied air diving shall comply with the following requirements, unless otherwise specified.

(b) *Limits.* (1) Surface-supplied air diving shall not be conducted at depths deeper than 190 fsw, except that dives with bottom times of 30 minutes or less may be conducted to depths of 220 fsw.

(2) A decompression chamber shall be ready for use at the dive location for any dive outside the no-decompression limits or deeper than 100 fsw.

(3) A bell shall be used for dives with an inwater decompression time greater than 120 minutes, except when heavy gear is worn or diving is conducted in physically confining spaces.

(c) *Procedures.* (1) Each diver shall be continuously tended while in the water.

(2) A diver shall be stationed at the underwater point of entry when diving is conducted in enclosed or physically confining spaces.

(3) Each diving operation shall have a primary breathing gas supply sufficient to support divers for the duration of the planned dive including decompression.

(4) For dives deeper than 100 fsw or outside the no-decompression limits:

(i) A separate dive team member shall tend each diver in the water;

(ii) A standby diver shall be available while a diver is in the water;

(iii) A diver-carried reserve breathing gas supply shall be provided for each diver except when heavy gear is worn; and

(iv) A dive-location reserve breathing gas supply shall be provided.

(5) For heavy-gear diving deeper than 100 fsw or outside the no-decompression limits:

(i) An extra breathing gas hose capable of supplying breathing gas to the diver in the water shall be available to the standby diver.

(ii) An inwater stage shall be provided to divers in the water.

(6) Except when heavy gear is worn or where physical space does not permit, a diver-carried reserve breathing gas supply shall be provided whenever the diver is prevented by the configuration of the dive area from ascending directly to the surface.

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§1910.426 Mixed-gas diving.

(a) *General.* Employers engaged in mixed-gas diving shall comply with the following requirements, unless otherwise specified.

(b) *Limits.* Mixed-gas diving shall be conducted only when:

(1) A decompression chamber is ready for use at the dive location; and

(i) A bell is used at depths greater than 220 fsw or when the dive involves inwater decompression time of greater than 120 minutes, except when heavy gear is worn or when diving in physically confining spaces; or

(ii) A closed bell is used at depths greater than 300 fsw, except when diving is conducted in physically confining spaces.

(c) *Procedures.* (1) A separate dive team member shall tend each diver in the water.

(2) A standby diver shall be available while a diver is in the water.

(3) A diver shall be stationed at the underwater point of entry when diving is conducted in enclosed or physically confining spaces.

(4) Each diving operation shall have a primary breathing gas supply sufficient to support divers for the duration of the planned dive including decompression.

(5) Each diving operation shall have a dive-location reserve breathing gas supply.

(6) When heavy gear is worn:

(i) An extra breathing gas hose capable of supplying breathing gas to the diver in the water shall be available to the standby diver; and

(ii) An inwater stage shall be provided to divers in the water.

(7) An inwater stage shall be provided for divers without access to a bell for dives deeper than 100 fsw or outside the no-decompression limits.

(8) When a closed bell is used, one dive team member in the bell shall be available and tend the diver in the water.

(9) Except when heavy gear is worn or where physical space does not permit, a diver-carried reserve breathing gas supply shall be provided for each diver:

(i) Diving deeper than 100 fsw or outside the no-decompression limits; or

(ii) Prevented by the configuration of the dive area from directly ascending to the surface.

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§1910.427 Liveboating.

(a) *General.* Employers engaged in diving operations involving liveboating shall comply with the following requirements.

(b) *Limits.* Diving operations involving liveboating shall not be conducted:

(1) With an inwater decompression time of greater than 120 minutes;

(2) Using surface-supplied air at depths deeper than 190 fsw, except that dives with bottom times of 30 minutes or less may be conducted to depths of 220 fsw;

(3) Using mixed gas at depths greater than 220 fsw;

(4) In rough seas which significantly inpede diver mobility or work function; or

(5) In other than daylight hours.

(c) *Procedures.* (1) The propeller of the vessel shall be stopped before the diver enters or exits the water.

(2) A device shall be used which minimizes the possibility of entanglement of the diver's hose in the propeller of the vessel.

(3) Two-way voice communication between the designated person-in-charge and the person controlling the vessel shall be available while the diver is in the water.

(4) A standby diver shall be available while a diver is in the water.

(5) A diver-carried reserve breathing gas supply shall be carried by each diver engaged in liveboating operations.

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Equipment Procedures and Requirements

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§1910.430 Equipment.

(a) *General.* (1) All employers shall comply with the following requirements, unless otherwise specified.

(2) Each equipment modification, repair, test, calibration or maintenance service shall be recorded by means of a tagging or logging system, and include the date and nature of work performed, and the name or initials of the person performing the work.

(b) *Air compressor system.* (1) Compressors used to supply air to the diver shall be equipped with a volume tank with a check valve on the inlet side, a pressure gauge, a relief valve, and a drain valve.

(2) Air compressor intakes shall be located away from areas containing exhaust or other contaminants.

(3) Respirable air supplied to a diver shall not contain:

(i) A level of carbon monoxide (CO) greater than 20 p/m;

(ii) A level of carbon dioxide (CO_2) greater than 1,000 p/m;

(iii) A level of oil mist greater than 5 milligrams per cubic meter; or

(iv) A noxious or pronounced odor.

(4) The output of air compressor systems shall be tested for air purity every 6 months by means of samples taken at the connection to the distribution system, except that non-oil lubricated compressors need not be tested for oil mist.

(c) *Breathing gas supply hoses.* (1) Breathing gas supply hoses shall:

(i) Have a working pressure at least equal to the working pressure of the total breathing gas system;

(ii) Have a rated bursting pressure at least equal to 4 times the working pressure;

(iii) Be tested at least annually to 1.5 times their working pressure; and

(iv) Have their open ends taped, capped or plugged when not in use.

(2) Breathing gas supply hose connectors shall:

(i) Be made of corrosion-resistant materials;

(ii) Have a working pressure at least equal to the working pressure of the hose to which they are attached; and

(iii) Be resistant to accidental disengagement.

(3) Umbilicals shall:

(i) Be marked in 10-ft. increments to 100 feet beginning at the diver's end, and in 50 ft. increments thereafter;

(ii) Be made of kink-resistant materials; and

(iii) Have a working pressure greater than the pressure equivalent to the maximum depth of the dive (relative to the supply source) plus 100 psi.

(d) *Buoyancy control.* (1) Helmets or masks connected directly to the dry suit or other buoyancy-changing equipment shall be equipped with an exhaust valve.

(2) A dry suit or other buoyancy-changing equipment not directly connected to the helmet or mask shall be equipped with an exhaust valve.

(3) When used for SCUBA diving, a buoyancy compensator shall have an inflation source separate from the breathing gas supply.

(4) An inflatable flotation device capable of maintaining the diver at the surface in a face-up position, having a manually activated inflation source independent of the breathing supply, an oral inflation device, and an exhaust valve shall be used for SCUBA diving.

(e) *Compressed gas cylinders.* Compressed gas cylinders shall:

(1) Be designed, constructed and maintained in accordance with the applicable provisions of 29 CFR 1910.101 and 1910.169 through 1910.171.

(2) Be stored in a ventilated area and protected from excessive heat;

(3) Be secured from falling; and

(4) Have shut-off valves recessed into the cylinder or protected by a cap, except when in use or manifolded, or when used for SCUBA diving.

(f) *Decompression chambers.* (1) Each decompression chamber manufactured after the effective date of this standard, shall be built and maintained in accordance with the ASME Code or equivalent.

(2) Each decompression chamber manufactured prior to the effective date of this standard shall be maintained in conformity with the code requirements to which it was built, or equivalent.

(3) Each decompression chamber shall be equipped with:

(i) Means to maintain the atmosphere below a level of 25 percent oxygen by volume;

(ii) Mufflers on intake and exhaust lines, which shall be regularly inspected and maintained;

(iii) Suction guards on exhaust line openings; and

(iv) A means for extinguishing fire, and shall be maintained to minimize sources of ignition and combustible material.

(g) *Gauges and timekeeping devices.* (1) Gauges indicating diver depth which can be read at the dive location shall be used for all dives except SCUBA.

(2) Each depth gauge shall be deadweight tested or calibrated against a master reference gauge every 6 months, and when there is a discrepancy greater than two percent (2 percent) of full scale between any two equivalent gauges.

(3) A cylinder pressure gauge capable of being monitored by the diver during the dive shall be worn by each SCUBA diver.

(4) A timekeeping device shall be available at each dive location.

(h) *Masks and helmets.* (1) Surface-supplied air and mixed-gas masks and helmets shall have:

(i) A non-return valve at the attachment point between helmet or mask and hose which shall close readily and positively; and

(ii) An exhaust valve.

(2) Surface-supplied air masks and helmets shall have a minimum ventilation rate capability of 4.5 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 ATA when the diver is producing carbon dioxide at the rate of 1.6 standard liters per minute.

(i) *Oxygen safety.* (1) Equipment used with oxygen or mixtures containing over forty percent (40%) by volume oxygen shall be designed for oxygen service.

(2) Components (except umbilicals) exposed to oxygen or mixtures containing over forty percent (40%) by volume oxygen shall be cleaned of flammable materials before use.

(3) Oxygen systems over 125 psig and compressed air systems over 500 psig shall have slow-opening shut-off valves.

(j) *Weights and harnesses.* (1) Except when heavy gear is worn, divers shall be equipped with a weight belt or assembly capable of quick release.

(2) Except when heavy gear is worn or in SCUBA diving, each diver shall wear a safety harness with:

(i) A positive buckling device;

(ii) An attachment point for the umbilical to prevent strain on the mask or helmet; and

(iii) A lifting point to distribute the pull force of the line over the diver's body.

[39 FR 23502, June 27, 1974, as amended at 49 FR 18295, Apr. 30, 1984; 51 FR 33033, Sept. 18, 1986]

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RECORDKEEPING

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§1910.440 Recordkeeping requirements.

(a)(1) [Reserved]

(2) The employer shall record the occurrence of any diving-related injury or illness which requires any dive team member to be hospitalized for 24 hours or more, specifying the circumstances of the incident and the extent of any injuries or illnesses.

(b) *Availability of records.* (1) Upon the request of the Assistant Secretary of Labor for Occupational Safety and Health, or the Director, National Institute for Occupational Safety and Health, Department of Health and Human Services of their designees, the employer shall make available for inspection and copying any record or document required by this standard.

(2) Records and documents required by this standard shall be provided upon request to employees, designated representatives, and the Assistant Secretary in accordance with 29 CFR 1910.1020 (a)-(e) and (g)-(i). Safe practices manuals (§1910.420), depth-time profiles (§1910.422), recordings of dives (§1910.423), decompression procedure assessment evaluations (§1910.423), and records of hospitalizations (§1910.440) shall be provided in the same manner as employee exposure records or analyses using exposure or medical records. Equipment inspections and testing records which pertain to employees (§1910.430) shall also be provided upon request to employees and their designated representatives.

(3) Records and documents required by this standard shall be retained by the employer for the following period:

(i) [Reserved]

(ii) Safe practices manual (§1910.420)—current document only;

(iii) Depth-time profile (§1910.422)—until completion of the recording of dive, or until completion of decompression procedure assessment where there has been an incident of decompression sickness;

(iv) Recording of dive (§1910.423)—1 year, except 5 years where there has been an incident of decompression sickness;

(v) Decompression procedure assessment evaluations (§1910.423)—5 years;

(vi) Equipment inspections and testing records (§1910.430)—current entry or tag, or until equipment is withdrawn from service;

(vii) Records of hospitalizations (§1910.440)—5 years.

(4) The employer shall comply with any additional requirements set forth at 29 CFR 1910.1020,

(5) [Reserved]

[42 FR 37668, July 22, 1977, as amended at 45 FR 35281, May 23, 1980; 47 FR 14706, Apr. 6, 1982; 51 FR 34562, Sept. 29, 1986; 61 FR 9242, Mar. 7, 1996; 71 FR 16672, Apr. 3, 2006; 76 FR 33607, June 8, 2011; 76 FR 80740, Dec. 27, 2011]

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Appendix A to Subpart T of Part 1910—Examples of Conditions Which May Restrict or Limit Exposure to Hyperbaric Conditions

The following disorders may restrict or limit occupational exposure to hyperbaric conditions depending on severity, presence of residual effects, response to therapy, number of occurrences, diving mode, or degree and duration of isolation.

History of seizure disorder other than early febrile convulsions.

Malignancies (active) unless treated and without recurrence for 5 yrs.

Chronic inability to equalize sinus and/or middle ear pressure.

Cystic or cavitary disease of the lungs.

Impaired organ function caused by alcohol or drug use.

Conditions requiring continuous medication for control (e.g., antihistamines, steroids, barbiturates, moodaltering drugs, or insulin).

Meniere's disease.

Hemoglobinopathies.

Obstructive or restrictive lung disease.

Vestibular end organ destruction.

Pneumothorax.

Cardiac abnormalities (e.g., pathological heart block, valvular disease, intraventricular conduction defects other than isolated right bundle branch block, angina pectoris, arrhythmia, coronary artery disease).

Juxta-articular osteonecrosis.

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Appendix B to Subpart T of Part 1910—Guidelines for Scientific Diving

This appendix contains guidelines that will be used in conjunction with §1910.401(a)(2)(iv) to determine those scientific diving programs which are exempt from the requirements for commercial diving. The guidelines are as follows:

1. The Diving Control Board consists of a majority of active scientific divers and has autonomous and absolute authority over the scientific diving program's operations.

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.

[50 FR 1050, Jan. 9, 1985]

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Appendix C to Subpart T of Part 1910—Alternative Conditions Under §1910.401(a)(3) for Recreational Diving Instructors and Diving Guides (Mandatory)

Paragraph (a)(3) of §1910.401 specifies that an employer of recreational diving instructors and diving guides (hereafter, "divers" or "employees") who complies with all of the conditions of this appendix need not provide a decompression chamber for these divers as required under §§1910.423(b)(2) or (c)(3) or 1910.426(b)(1).

1. Equipment Requirements for Rebreathers

(a) The employer must ensure that each employee operates the rebreather (*i.e.*, semi-closed-circuit and closed-circuit self-contained underwater breathing apparatuses (hereafter, "SCUBAs")) according to the rebreather manufacturer's instructions.

(b) The employer must ensure that each rebreather has a counterlung that supplies a sufficient volume of breathing gas to their divers to sustain the divers' respiration rates, and contains a baffle system and/or other moisture separating system that keeps moisture from entering the scrubber.

(c) The employer must place a moisture trap in the breathing loop of the rebreather, and ensure that:

(i) The rebreather manufacturer approves both the moisture trap and its location in the breathing loop; and

(ii) Each employee uses the moisture trap according to the rebreather manufacturer's instructions.

(d) The employer must ensure that each rebreather has a continuously functioning moisture sensor, and that:

(i) The moisture sensor connects to a visual (*e.g.,* digital, graphic, analog) or auditory (*e.g.,* voice, pure tone) alarm that is readily detectable by the diver under the diving conditions in which the diver operates, and warns the diver of moisture in the breathing loop in sufficient time to terminate the dive and return safely to the surface; and

(ii) Each diver uses the moisture sensor according to the rebreather manufacturer's instructions.

(e) The employer must ensure that each rebreather contains a continuously functioning CO_2 sensor in the breathing loop, and that:

(i) The rebreather manufacturer approves the location of the CO_2 sensor in the breathing loop;

(ii) The CO_2 sensor is integrated with an alarm that operates in a visual (*e.g.,* digital, graphic, analog) or auditory (*e.g.,* voice, pure tone) mode that is readily detectable by each diver under the diving conditions in which the diver operates; and

(iii) The CO_2 alarm remains continuously activated when the inhaled CO_2 level reaches and exceeds 0.005 atmospheres absolute (ATA).

(f) Before each day's diving operations, and more often when necessary, the employer must calibrate the CO_2 sensor according to the sensor manufacturer's instructions, and ensure that:

(i) The equipment and procedures used to perform this calibration are accurate to within 10% of a CO_2 concentration of 0.005 ATA or less;

(ii) The equipment and procedures maintain this accuracy as required by the sensor manufacturer's instructions; and

(iii) The calibration of the CO_2 sensor is accurate to within 10% of a CO_2 concentration of 0.005 ATA or less.

(g) The employer must replace the CO_2 sensor when it fails to meet the accuracy requirements specified in paragraph 1(f)(iii) of this appendix, and ensure that the

replacement CO_2 sensor meets the accuracy requirements specified in paragraph 1(f)(iii) of this appendix before placing the rebreather in operation.

(h) As an alternative to using a continuously functioning CO_2 sensor, the employer may use a schedule for replacing CO_2-sorbent material provided by the rebreather manufacturer. The employer may use such a schedule only when the rebreather manufacturer has developed it according to the canister-testing protocol specified below in Condition 11, and must use the canister within the temperature range for which the manufacturer conducted its scrubber canister tests following that protocol. Variations above or below the range are acceptable only after the manufacturer adds that lower or higher temperature to the protocol.

(i) When using CO_2-sorbent replacement schedules, the employer must ensure that each rebreather uses a manufactured (*i.e.,* commercially pre-packed), disposable scrubber cartridge containing a CO_2-sorbent material that:

(i) Is approved by the rebreather manufacturer;

(ii) Removes CO_2 from the diver's exhaled gas; and

(iii) Maintains the CO_2 level in the breathable gas (*i.e.,* the gas that a diver inhales directly from the regulator) below a partial pressure of 0.01 ATA.

(j) As an alternative to manufactured, disposable scrubber cartridges, the employer may fill CO_2 scrubber cartridges manually with CO_2-sorbent material when:

(i) The rebreather manufacturer permits manual filling of scrubber cartridges;

(ii) The employer fills the scrubber cartridges according to the rebreather manufacturer's instructions;

(iii) The employer replaces the CO_2-sorbent material using a replacement schedule developed under paragraph 1(h) of this appendix; and

(iv) The employer demonstrates that manual filling meets the requirements specified in paragraph 1(i) of this appendix.

(k) The employer must ensure that each rebreather has an information module that provides:

(i) A visual (*e.g.,* digital, graphic, analog) or auditory (*e.g.,* voice, pure tone) display that effectively warns the diver of solenoid failure (when the rebreather uses solenoids) and other electrical weaknesses or failures (*e.g.,* low battery voltage);

(ii) For a semi-closed circuit rebreather, a visual display for the partial pressure of CO_2, or deviations above and below a preset CO_2 partial pressure of 0.005 ATA; and

(iii) For a closed-circuit rebreather, a visual display for: partial pressures of O_2 and CO_2, or deviations above and below a preset CO_2 partial pressure of 0.005 ATA and a preset O_2 partial pressure of 1.40 ATA or lower; gas temperature in the breathing loop; and water temperature.

(l) Before each day's diving operations, and more often when necessary, the employer must ensure that the electrical power supply and electrical and electronic circuits in each rebreather are operating as required by the rebreather manufacturer's instructions.

2. Special Requirements for Closed-Circuit Rebreathers

(a) The employer must ensure that each closed-circuit rebreather uses supply-pressure sensors for the O_2 and diluent (*i.e.*, air or nitrogen) gases and continuously functioning sensors for detecting temperature in the inhalation side of the gas-loop and the ambient water.

(b) The employer must ensure that:

(i) At least two O_2 sensors are located in the inhalation side of the breathing loop; and

(ii) The O_2 sensors are: functioning continuously; temperature compensated; and approved by the rebreather manufacturer.

(c) Before each day's diving operations, and more often when necessary, the employer must calibrate O_2 sensors as required by the sensor manufacturer's instructions. In doing so, the employer must:

(i) Ensure that the equipment and procedures used to perform the calibration are accurate to within 1% of the O_2 fraction by volume;

(ii) Maintain this accuracy as required by the manufacturer of the calibration equipment;

(iii) Ensure that the sensors are accurate to within 1% of the O_2 fraction by volume;

(iv) Replace O_2 sensors when they fail to meet the accuracy requirements specified in paragraph 2(c)(iii) of this appendix; and

(v) Ensure that the replacement O_2 sensors meet the accuracy requirements specified in paragraph 2(c)(iii) of this appendix before placing a rebreather in operation.

(d) The employer must ensure that each closed-circuit rebreather has:

(i) A gas-controller package with electrically operated solenoid O_2-supply valves;

(ii) A pressure-activated regulator with a second-stage diluent-gas addition valve;

(iii) A manually operated gas-supply bypass valve to add O_2 or diluent gas to the breathing loop; and

(iv) Separate O_2 and diluent-gas cylinders to supply the breathing-gas mixture.

3. O_2 Concentration in the Breathing Gas

The employer must ensure that the fraction of O_2 in the nitrox breathing-gas mixture:

(a) Is greater than the fraction of O_2 in compressed air (*i.e.*, exceeds 22% by volume);

(b) For open-circuit SCUBA, never exceeds a maximum fraction of breathable O_2 of 40% by volume or a maximum O_2 partial pressure of 1.40 ATA, whichever exposes divers to less O_2; and

(c) For a rebreather, never exceeds a maximum O_2 partial pressure of 1.40 ATA.

4. Regulating O_2 Exposures and Diving Depth

(a) Regarding O_2 exposure, the employer must:

(i) Ensure that the exposure of each diver to partial pressures of O_2 between 0.60 and 1.40 ATA does not exceed the 24-hour single-exposure time limits specified either by the 2001 National Oceanic and Atmospheric Administration Diving Manual (the "2001 NOAA Diving Manual"), or by the report entitled "Enriched Air Operations and Resource Guide" published in 1995 by the Professional Association of Diving Instructors (known commonly as the "1995 DSAT Oxygen Exposure Table"); and

(ii) Determine a diver's O_2-exposure duration using the diver's maximum O_2 exposure (partial pressure of O_2) during the dive and the total dive time (*i.e.*, from the time the diver leaves the surface until the diver returns to the surface).

(b) Regardless of the diving equipment used, the employer must ensure that no diver exceeds a depth of 130 feet of sea water ("fsw") or a maximum O_2 partial pressure of 1.40 ATA, whichever exposes the diver to less O_2.

5. Use of No-Decompression Limits

(a) For diving conducted while using nitrox breathing-gas mixtures, the employer must ensure that each diver remains within the no-decompression limits specified for single and repetitive air diving and published in the 2001 NOAA Diving Manual or the report entitled "Development and Validation of No-Stop Decompression Procedures for Recreational Diving: The DSAT Recreational Dive Planner," published in 1994 by Hamilton Research Ltd. (known commonly as the "1994 DSAT No-Decompression Tables").

(b) An employer may permit a diver to use a dive-decompression computer designed to regulate decompression when the dive-decompression computer uses the no-decompression limits specified in paragraph 5(a) of this appendix, and provides output that reliably represents those limits.

6. Mixing and Analyzing the Breathing Gas

(a) The employer must ensure that:

(i) Properly trained personnel mix nitrox-breathing gases, and that nitrogen is the only inert gas used in the breathing-gas mixture; and

(ii) When mixing nitrox-breathing gases, they mix the appropriate breathing gas before delivering the mixture to the breathing-gas cylinders, using the continuous-flow or partial-pressure mixing techniques specified in the 2001 NOAA Diving Manual, or using a filter-membrane system.

(b) Before the start of each day's diving operations, the employer must determine the O_2 fraction of the breathing-gas mixture using an O_2 analyzer. In doing so, the employer must:

(i) Ensure that the O_2 analyzer is accurate to within 1% of the O_2 fraction by volume.

(ii) Maintain this accuracy as required by the manufacturer of the analyzer.

(c) When the breathing gas is a commercially supplied nitrox breathing-gas mixture, the employer must ensure that the O_2 meets the medical USP specifications (Type I, Quality Verification Level A) or aviator's breathing-oxygen specifications (Type I, Quality Verification Level E) of CGA G-4.3-2000 (“Commodity Specification for Oxygen”). In addition, the commercial supplier must:

(i) Determine the O_2 fraction in the breathing-gas mixture using an analytic method that is accurate to within 1% of the O_2 fraction by volume;

(ii) Make this determination when the mixture is in the charged tank and after disconnecting the charged tank from the charging apparatus;

(iii) Include documentation of the O_2-analysis procedures and the O_2 fraction when delivering the charged tanks to the employer.

(d) Before producing nitrox breathing-gas mixtures using a compressor in which the gas pressure in any system component exceeds 125 pounds per square inch (psi), the:

(i) Compressor manufacturer must provide the employer with documentation that the compressor is suitable for mixing high-pressure air with the highest O_2 fraction used in the nitrox breathing-gas mixture when operated according to the manufacturer's operating and maintenance specifications;

(ii) Employer must comply with paragraph 6(e) of this appendix, unless the compressor is rated for O_2 service and is oil-less or oil-free; and

(iii) Employer must ensure that the compressor meets the requirements specified in paragraphs (i)(1) and (i)(2) of §1910.430 whenever the highest O_2 fraction used in the mixing process exceeds 40%.

(e) Before producing nitrox breathing-gas mixtures using an oil-lubricated compressor to mix high-pressure air with O_2, and regardless of the gas pressure in any system component, the:

(i) Employer must use only uncontaminated air (*i.e.*, air containing no hydrocarbon particulates) for the nitrox breathing-gas mixture;

(ii) Compressor manufacturer must provide the employer with documentation that the compressor is suitable for mixing the high-pressure air with the highest O_2 fraction used in the nitrox breathing-gas mixture when operated according to the manufacturer's operating and maintenance specifications;

(iii) Employer must filter the high-pressure air to produce O_2-compatible air;

(iv) The filter-system manufacturer must provide the employer with documentation that the filter system used for this purpose is suitable for producing O_2-compatible air when operated according to the manufacturer's operating and maintenance specifications; and

(v) Employer must continuously monitor the air downstream from the filter for hydrocarbon contamination.

(f) The employer must ensure that diving equipment using nitrox breathing-gas mixtures or pure O_2 under high pressure (*i.e.*, exceeding 125 psi) conforms to the O_2-service requirements specified in paragraphs (i)(1) and (i)(2) of §1910.430.

7. Emergency Egress

(a) Regardless of the type of diving equipment used by a diver (*i.e.*, open-circuit SCUBA or rebreathers), the employer must ensure that the equipment contains (or incorporates) an open-circuit emergency-egress system (a “bail-out” system) in which the second stage of the regulator connects to a separate supply of emergency breathing gas, and the emergency breathing gas consists of air or the same nitrox breathing-gas mixture used during the dive.

(b) As an alternative to the “bail-out” system specified in paragraph 7(a) of this appendix, the employer may use:

(i) For open-circuit SCUBA, an emergency-egress system as specified in §1910.424(c)(4); or

(ii) For a semi-closed-circuit and closed-circuit rebreather, a system configured so that the second stage of the regulator connects to a reserve supply of emergency breathing gas.

(c) The employer must obtain from the rebreather manufacturer sufficient information to ensure that the bail-out system performs reliably and has sufficient capacity to enable the diver to terminate the dive and return safely to the surface.

8. Treating Diving-Related Medical Emergencies

(a) Before each day's diving operations, the employer must:

(i) Verify that a hospital, qualified health-care professionals, and the nearest Coast Guard Coordination Center (or an equivalent rescue service operated by a state, county, or municipal agency) are available to treat diving-related medical emergencies;

(ii) Ensure that each dive site has a means to alert these treatment resources in a timely manner when a diving-related medical emergency occurs; and

(iii) Ensure that transportation to a suitable decompression chamber is readily available when no decompression chamber is at the dive site, and that this transportation can deliver the injured diver to the decompression chamber within four (4) hours travel time from the dive site.

(b) The employer must ensure that portable O_2 equipment is available at the dive site to treat injured divers. In doing so, the employer must ensure that:

(i) The equipment delivers medical-grade O_2 that meets the requirements for medical USP oxygen (Type I, Quality Verification Level A) of CGA G-4.3-2000 ("Commodity Specification for Oxygen");

(ii) The equipment delivers this O_2 to a transparent mask that covers the injured diver's nose and mouth; and

(iii) Sufficient O_2 is available for administration to the injured diver from the time the employer recognizes the symptoms of a diving-related medical emergency until the injured diver reaches a decompression chamber for treatment.

(c) Before each day's diving operations, the employer must:

(i) Ensure that at least two attendants, either employees or non-employees, qualified in first-aid and administering O_2 treatment, are available at the dive site to treat diving-related medical emergencies; and

(ii) Verify their qualifications for this task.

9. Diving Logs and No-Decompression Tables

(a) Before starting each day's diving operations, the employer must:

(i) Designate an employee or a non-employee to make entries in a diving log; and

(ii) Verify that this designee understands the diving and medical terminology, and proper procedures, for making correct entries in the diving log.

(b) The employer must:

(i) Ensure that the diving log conforms to the requirements specified by paragraph (d) ("Record of dive") of §1910.423; and

(ii) Maintain a record of the dive according to §1910.440 ("Recordkeeping requirements").

(c) The employer must ensure that a hard-copy of the no-decompression tables used for the dives (as specified in paragraph 6(a) of this appendix) is readily available at the dive site, whether or not the divers use dive-decompression computers.

10. Diver Training

The employer must ensure that each diver receives training that enables the diver to perform work safely and effectively while using open-circuit SCUBAs or rebreathers supplied with nitrox breathing-gas mixtures. Accordingly, each diver must be able to demonstrate the ability to perform critical tasks safely and effectively, including, but not limited to: recognizing the effects of breathing excessive CO_2 and O_2; taking appropriate action after detecting excessive levels of CO_2 and O_2; and properly evaluating, operating, and maintaining their diving equipment under the diving conditions they encounter.

11. Testing Protocol for Determining the CO_2 Limits of Rebreather Canisters

(a) The employer must ensure that the rebreather manufacturer has used the following procedures for determining that the CO_2-sorbent material meets the specifications of the sorbent material's manufacturer:

(i) The North Atlantic Treating Organization CO_2 absorbent-activity test;

(ii) The RoTap shaker and nested-sieves test;

(iii) The Navy Experimental Diving Unit ("NEDU")-derived Schlegel test; and

(iv) The NEDU MeshFit software.

(b) The employer must ensure that the rebreather manufacturer has applied the following canister-testing materials, methods, procedures, and statistical analyses:

(i) Use of a nitrox breathing-gas mixture that has an O_2 fraction maintained at 0.28 (equivalent to 1.4 ATA of O_2 at 130 fsw, the maximum O_2 concentration permitted at this depth);

(ii) While operating the rebreather at a maximum depth of 130 fsw, use of a breathing machine to continuously ventilate the rebreather with breathing gas that is at 100% humidity and warmed to a temperature of 98.6 degrees F (37 degrees C) in the heating-humidification chamber;

(iii) Measurement of the O_2 concentration of the inhalation breathing gas delivered to the mouthpiece;

(iv) Testing of the canisters using the three ventilation rates listed in Table I below (with the required breathing-machine tidal volumes and frequencies, and CO_2-injection rates, provided for each ventilation rate):

TABLE I—CANISTER TESTING PARAMETERS

Ventilation rates (Lpm, ATPS[1])	Breathing machine tidal volumes (L)	Breathing machine frequencies (breaths per min.)	CO_2 injection rates (Lpm, STPD[2])
22.5	1.5	15	0.90
40.0	2.0	20	1.35
62.5	2.5	25	2.25

[1]ATPS means ambient temperature and pressure, saturated with water.

[2]STPD means standard temperature and pressure, dry; the standard temperature is 32 degrees F (0 degrees C).

(v) When using a work rate (*i.e.*, breathing-machine tidal volume and frequency) other than the work rates listed in the table above, addition of the appropriate combinations of ventilation rates and CO_2-injection rates;

(vi) Performance of the CO_2 injection at a constant (steady) and continuous rate during each testing trial;

(vii) Determination of canister duration using a minimum of four (4) water temperatures, including 40, 50, 70, and 90 degrees F (4.4, 10.0, 21.1, and 32.2 degrees C, respectively);

(viii) Monitoring of the breathing-gas temperature at the rebreather mouthpiece (at the "chrome T" connector), and ensuring that this temperature conforms to the temperature of a diver's exhaled breath at the water temperature and ventilation rate used during the testing trial;[1]

[1]NEDU can provide the manufacturer with information on the temperature of a diver's exhaled breath at various water temperatures and ventilation rates, as well as techniques and procedures used to maintain these temperatures during the testing trials.

(ix) Implementation of at least eight (8) testing trials for each combination of temperature and ventilation-CO_2-injection rates (for example, eight testing trials at 40 degrees F using a ventilation rate of 22.5 Lpm at a CO_2-injection rate of 0.90 Lpm);

(x) Allowing the water temperature to vary no more than ±2.0 degrees F (±1.0 degree C) *between* each of the eight testing trials, and no more than ±1.0 degree F (±0.5 degree C) *within* each testing trial;

(xi) Use of the average temperature for each set of eight testing trials in the statistical analysis of the testing-trial results, with the testing-trial results being the time taken for the inhaled breathing gas to reach 0.005 ATA of CO_2 (*i.e.*, the canister-duration results);

(xii) Analysis of the canister-duration results using the repeated-measures statistics described in NEDU Report 2-99;

(xiii) Specification of the replacement schedule for the CO_2-sorbent materials in terms of the lower prediction line (or limit) of the 95% confidence interval; and

(xiv) Derivation of replacement schedules only by interpolating among, but not by extrapolating beyond, the depth, water temperatures, and exercise levels used during canister testing.

[69 FR 7363, Feb. 17, 2004]

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