

CESO Regulation No. 385-1-86	Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000	ER 385-1-86 26 Jul 94
	Safety GOVERNMENT EMPLOYEE DIVING OPERATIONS	
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DEPARTMENT OF ARMY
U.S. Army Corps of Engineers
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CESO
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Regulation
No. 385-1-86

26 July 1994

Safety
GOVERNMENT EMPLOYEE DIVING OPERATIONS

1. Purpose. This regulation prescribes policies and procedures for underwater diving operations performed by U.S. Army Corps of Engineers employees.
2. Applicability. This regulation is applicable to HQUSACE/OCE elements, major subordinate commands (MSC), districts, laboratories and field operating activities (FOA).
3. References.
 - a. 29 CFR 1910, Occupational Safety & Health Standards.
 - b. EM 385-1-1, Safety & Health Requirement Manual.
 - c. U.S. Navy Diving Manual, Volume I. (U.S. Navy)
 - d. The Physician's Guide to Diving Medicine (1984), Plenum Press, New York and London
4. Definitions. Definition of terms used in this regulation is in Appendix A.
5. Policy. It is the policy of the Corps of Engineers that all diving operations be conducted in a prudent manner, ensuring maximum efficiency while providing the best possible safeguards against personal injury and property damage. USACE Commands will not use divers if the objective can be more safely and efficiently accomplished by another means, e.g., using remote control television systems in lieu of divers. When diving operations are required, a "Surface Supplied Air" system is the preferred mode of operation. Snorkeling and breath-hold diving will not be used except in cases where SCUBA or Surface Supplied Air create a hazard for the diver. Snorkeling and breath-hold diving will be accomplished on a case-by-case basis and must be approved in writing by the local USACE Dive Coordinator (UDC) prior to the dive.
6. Responsibilities.
 - a. The MSC, district, laboratory or FOA commander is responsible for managing a diving safety program in compliance with this regulation. The commander shall appoint, in writing, a

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Dive Coordinator (DC) and alternate DC to organize, integrate and monitor the dive program.

b. The MSC DC shall provide program guidance and shall annually review subordinate dive programs. The Alternate DC will perform these duties in the absence of the DC.

c. The district/lab/FOA DC shall review all safe practices manuals, dive plans, medical certificates, and dive team qualifications and experience, etc., to assure compliance with this regulation. The Alternate DC will perform these duties in the absence of the DC.

d. The MSC, district, laboratory, and FOA Safety and Occupational Health Office (SOHO) shall assign a representative to be responsible for diving safety. The SOHO representative shall provide diving safety advice to operational elements and actively participate in the review and comment process for all diving plans and hazard analyses, as well as on-site monitoring of diving operations.

e. Each USACE dive team shall have a diving supervisor designated to be in charge of all aspects of the diving operation affecting the safety and health of dive team members.

f. The HQUSACE Safety and Occupational Health Office (CESO) shall promulgate and provide program and training guidance to all USACE elements. The CESO shall designate a team to provide periodic peer reviews of district/lab/FOA dive programs. The CESO will contact, by memorandum, each USACE element to be reviewed. Peer reviews will, at a minimum, specifically address: medical evaluations, training, equipment maintenance, record keeping, operational procedures (dive planning) and regulations.

7. General.

a. Divers will be:

(1) Medically fit to dive as attested by a licensed physician.

(2) Trained to be fully knowledgeable of prescribed safety procedures including the use of all equipment and/or tools necessary to safely perform assigned tasks.

(3) Certified in accordance with this regulation.

b. Verification of the qualifications and experience of dive team personnel, to include divers, diving supervisor, tender(s), shall be provided the UDC for review prior to commencement of

operations. Divers meeting these requirements must be provided a letter of authorization by the UDC. A lack of experience or qualifications to perform the tasks stated in the scope of work will be cause for rejection or cessation of operations. Diver's log books will be included in this review.

c. USACE commands, at their discretion, may elect to implement and enforce more stringent diving requirements than stated herein, but under no circumstances will the requirements be less than specified in this regulation.

d. Each dive team member shall have a current certification in cardiopulmonary resuscitation (CPR) and first aid. First aid training shall include the use of oxygen systems required by this regulation.

e. Divers will wait at least 12 hours before flying after any dive: this interval shall be extended to 24 hours following multiple days of repetitive dives.

8. Administration.

a. Safe Practices Manual. Each FOA shall develop and maintain a safe practices manual covering the entire diving program. The safe practices manual must be available at all times at the dive location. The safe practices manual will include, as a minimum, the following:

- (1) Safety procedures and checklists.
- (2) Assignments and responsibilities of dive team members.
- (3) Equipment procedures and checklists.
- (4) Emergency procedures for fire, equipment failure, adverse weather conditions, and medical illness and/or injury.

b. Medical Requirements. The government shall provide each dive team member who is, or is likely to be, exposed to hyperbaric pressure, with a diving medical examination. This examination will be performed by a licensed physician prior to an initial hyperbaric exposure and repeated at not more than 12 month intervals. As a minimum, the items specified in Appendix C will be included in the examination. All abnormal or questionable medical conditions, not covered in Appendix C must be referred to a Diving Medical Officer for further analysis/consideration. Verification of satisfactory completion of medical examinations shall be maintained in the individual's personnel and medical record files.

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c. Dive Plans. A diving operations plan shall be developed for each separate diving operation. This plan shall be submitted to the UDC and approved prior to commencement of diving operations and be at the diving location at all times. All dive plans will become a part of the project file. As a minimum, the plan shall contain the following:

- (1) Detailed description of the mission.
- (2) Names and duties of dive team members, including diving supervisor.
- (3) Date, time, and location of operation.
- (4) Diving mode utilized (SCUBA, Surface Supplied Air, Breath-hold, etc.) including a description of the backup air supply, as required.
- (5) Nature of work to be performed by the divers.
- (6) Surface and underwater conditions, to include visibility, temperature, currents, etc. Thermal protection will be considered as appropriate.
- (7) Activity hazard analysis for each phase of work, to include the hazards associated with flying after diving.
- (8) Maximum depth and bottom time. Altitude adjustments to dive tables shall be calculated for dives made at altitudes of 1000 feet or more above sea level. See Appendix B.
- (9) Emergency management plan to include telephone numbers for ambulance, doctors, hyperbaric chamber, evacuation route, nearest Coast Guard rescue center, etc.
- (10) Lock out/tag out procedures and procedures for dealing with differential pressures shall be included if appropriate.
- (11) Special tools if appropriate.

NOTE: The dive plan shall include the following statement:
"If for any reason the dive plan is altered in mission, depth, personnel, or equipment, the USACE Diving Coordinator shall be contacted in order to review and approve the alteration prior to actual operation."

d. Pre-dive Conference. Prior to any dive, a pre-dive conference shall be held at the scene of the dive among all dive team members to review all aspects of the upcoming operation.

(1) Prior to any diving mission, the entire dive team will, as a minimum, be briefed in detail on the mission and location of the dive. Briefing will include drawings and/or photographs pertinent to the mission as well as an introduction of the equipment and materials to be installed as parts of the mission. Specifically, the briefing will include the following:

(a) Description of diving apparatus/equipment and craft to be used.

(b) Information on the maximum working depth with estimated bottom times.

(c) Names and duties of personnel on the team. (When possible, incorporate at least one person on the dive team that has previously performed the same or similar mission.)

(d) Discussion of the activity hazard analysis.

(e) Emergency procedures.

(2) Alteration of the mission. If for any reason the dive mission is altered, the DC shall be contacted and a revised dive plan established and reviewed prior to the operation continuance.

e. For each diver and dive, the information below, as a minimum, shall be recorded and maintained at the dive location by using ENG Form 4615-R Diving Log. In addition, ENG Form 4616-R, Repetitive Dive Worksheet may also be used if and when considered appropriate. ENG Forms 4615-R and 4616-R are illustrated at Appendix D.

(1) Name.

(2) Date and location of dive.

(3) Maximum depth and bottom time.

(4) Surface interval between dives.

(5) Type of equipment used.

(6) Group classification at beginning and end of each interval.

(7) Water and ambient air temperature.

(8) Depth(s) and duration(s) of any decompression stops.

f. For each dive in which a decompression sickness and/or pulmonary barotrauma is suspected or symptoms are evident, the following additional information shall be recorded and maintained:

(1) Description of signs and symptoms (including depth and time of onset).

(2) Description of results of treatment.

(3) Name, address, phone number, etc., of attending physician.

9. Training.

a. Corps Divers. Corps divers must be a graduate of a HQUSACE-approved Diving Safety training course prior to performing diving activities. Certification through a nationally recognized SCUBA certification agency is a prerequisite for this training. Divers must complete 12 annual working/training dives to retain certification as a Corps diver. Working/training dives should be distributed throughout the year to maintain optimum diver proficiency. Divers not performing 12 annual dives will have their letter of authorization revoked and will revert to diver-in-training status until such time as the required 12 dives are performed. Divers may perform training dives in normal mode of operation for the USACE command after the 12 month time period. If required working/training dives are not accomplished within 18 months, diver must attend a HQUSACE-sponsored Diving Refresher course to regain certification. The annual required time period shall commence upon graduation from a HQUSACE-approved Diving Safety, Diving Supervisor or Diving Refresher course.

b. Diving Supervisors. Diving supervisors must be a graduate of a HQUSACE-approved Diving Supervisor training course prior to supervising diving activities. It is recommended that supervisors be able to swim and be capable of performing in-water rescue activities during the HQUSACE Diving Supervisor Training Course. Diving supervisors must participate in 12 working/training dives per year to maintain proficiency. If required working/training dives are not accomplished within 18 months, diving supervisor must attend a HQUSACE-sponsored Diving Refresher course to regain certification.

c. USACE Dive Coordinator (UDC). The UDC must be a graduate of a HQUSACE-approved Diving Safety or Diving Supervisor course. The UDC must maintain certification by successfully completing the USACE diving refresher course every four years. The UDC is not required to perform 12 working/training dives to maintain

certification unless otherwise required by the position.

d. Diver-in-Training. The diver-in-training program is intended to determine the suitability of an individual for certification as a Corps diver. This individual must always dive under the direct, in-water supervision of a certified Corps diver. The diver-in-training must be certified as a SCUBA diver by a nationally recognized SCUBA certification agency. Dives made by a diver-in-training are restricted to SCUBA only, to a maximum depth of 33 feet, and must comply with the remainder of these regulations. The diver-in-training may remain on diver-in-training status for a maximum of 12 months. The diver-in-training may not be used as a working diver and shall be considered as an addition to the minimum dive team manning level as required in Appendix E.

e. Dive Tender. USACE Commands will provide formalized training for dive tenders. This training will encompass all pertinent aspects of tending in order to provide safe and efficient support to divers. Tenders receiving on-the-job training shall be utilized only under the supervision of a trained, qualified dive team member.

f. SOHO Dive Representative. The SOHO dive representative must be a graduate of a HQUSACE-approved Diving Safety, Diving Supervisor or Diving Inspector course.

g. Refresher Training. HQUSACE-approved refresher training is required at four-year intervals to retain certification as a USACE diver, diving supervisor, safety and occupational health office dive representative or diving coordinator.

10. SCUBA Diving Operations.

a. SCUBA diving operations shall not be conducted:

(1) At depths greater than 60 feet, unless line tended with diver/surface two-way voice communication. Maximum depth for SCUBA diving operations is 100 feet.

(2) On dives outside the no-decompression limits unless a dual lock, multi-place, recompression chamber is located at the dive location and is immediately available for use, and a diving physician or trained chamber operator, in communication with a diving physician, is present. Chamber shall be of sufficient size to accommodate patient as well as chamber attendant.

(3) Against currents exceeding one knot unless line tended.

(4) In enclosed or physically confining spaces unless

line-tended with diver/surface two-way voice communication.

(5) Using closed circuit or semi-closed circuit SCUBA.

(6) In visibility less than three feet unless line-tended with diver/surface two-way voice communication.

b. SCUBA teams shall be manned in accordance with the criteria established in Appendix E.

c. Specific operational requirements for SCUBA operations are as follows:

(1) Each SCUBA diver shall be equipped with an alternate air source; e.g., octopus or bail out bottle with a minimum of 30 cu. ft. of air and separate regulator. The safest method shall be analyzed and used during each dive operation.

(2) A buoyancy compensation device (BCD) capable of maintaining the diver at the surface in a face-up position, shall be used for all SCUBA diving operations to include diving with variable volume dry suits.

(3) SCUBA divers shall be equipped with a submersible cylinder pressure gauge capable of being monitored by the diver.

(4) Each SCUBA diver shall be equipped with a weight belt capable of quick release.

(5) A timekeeping device shall be used for recording diving times for all SCUBA operations.

(6) SCUBA air cylinders shall comply with the requirements listed in Appendix F.

(7) Each SCUBA diver shall be equipped with a depth gauge and knife.

(8) Each tethered SCUBA diver shall wear a safety harness with a positive buckling device, attachment point for the safety line, and a lifting point to distribute the pull force of the line over the diver's body.

(9) A line-tended diver, with diver/surface two-way voice communication, will be stationed at the underwater point of entry when diving is conducted in enclosed or physically confining spaces.

(10) Use of full face SCUBA equipment and appropriate wet/dry suit will be considered in cold water diving operations.

(11) A SCUBA standby diver will be dressed out and ready for immediate deployment while a diver is in the water.

11. Surface Supplied Air Operations.

a. Surface supplied air operations shall not be conducted at depths greater than 100 feet.

b. Dual lock, multi-place, recompression chambers shall be available and ready for use at the dive location for any dive outside the no-decompression limits. A diving physician or a trained chamber operator, in communication with a diving physician, shall be in attendance with the chamber.

c. Each surface supplied air diving team will be manned in accordance with the criteria established in Appendix E.

d. Minimum specific operational requirements for surface supplied air diving operations are as follows:

(1) Each diver shall be continuously tended while in the water, i.e., one diver-one tender, regardless of depth.

(2) A surface supplied air 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 air supply sufficient to support divers for the duration of the planned dive, including emergency decompression.

(4) A surface supplied standby diver will be dressed out and ready for immediate deployment while a diver is in the water.

(5) Each diver must have a diver-carried reserve breathing supply with a 30 cubic foot capacity which can be turned on immediately by the diver in the event of loss of air.

(6) Each dive location shall have a reserve breathing air supply in-line capable of supporting the total dive operation.

(7) Electronic communication systems shall be incorporated in all surface supplied air diving operations. All dives shall be terminated if voice communications are lost.

(8) Use of the Jack Browne or like mask is prohibited on all USACE dive operations.

12. Mixed Gas Diving Operations. Mixed gas diving operations will not be performed by USACE divers.

13. Snorkeling/Breath-hold Diving Operations.

a. Snorkeling/breath-hold diving shall only be conducted for scientific diving purposes in the observation of plant and animal life.

b. Snorkeling/breath-hold diving operations shall not be conducted:

(1) At depths greater than five (5) feet.

(2) In enclosed or physically confining areas.

(3) In association with construction or equipment setting activities.

c. Snorkeling/breath-hold diving teams shall be manned in accordance with the criteria established in Appendix E.

d. Specific operational requirements for snorkeling/breath-hold diving operations are as follows:

(1) Snorkeling/breath-hold divers must be certified Corps divers.

(2) A bouyancy compensation device (BCD) or snorkeling vest, capable of maintaining the diver at the surface in a face-up position shall be used for all snorkeling/breath-hold diving operations.

(3) Each snorkeler/breath-hold diver must be equipped with mask, fins, snorkel and knife.

(4) A snorkeler/breath-hold standby diver must be dressed out and ready for immediate deployment while a snorkeler/breath-hold diver is in the water.

14. Equipment Requirements.

a. Equipment modifications, repairs, tests, calibrations, or maintenance shall be recorded by means of a tagging or logging system, and include the date and nature of work performed and the name of the individual performing the work. Equipment modifications may not be performed except by approval of the manufacturer. The UDC will maintain records of the above referenced activities.

b. Air compressor systems used to supply air to surface supplied air divers 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. Compressors shall be of sufficient capacity to overcome any line loss or other losses and deliver a minimum 4.5 actual cubic feet per minute (acfm) to each diver at the maximum diving depth. Air compressor intakes shall be located away from areas containing exhaust or other contaminants. Air compressor systems, both high pressure (SCUBA) and low pressure (surface supplied) will be tested for air purity on a six month basis by means of sampling at the connection to the distribution system. Proof of air certification will be maintained by the UDC. Purchased air will likewise be tested and certified. Compressors purchased by USACE will be tested prior to initial utilization. Air purity standards are as follows:

(1) Air shall not contain a level of carbon monoxide greater than 10 parts per million (ppm).

(2) Air shall not contain a level of carbon dioxide greater than 1,000 ppm.

(3) Air shall not contain a level of oil mist greater than five milligrams per cubic meter.

(4) Air shall not contain a noxious or pronounced odor.

c. Breathing air supply hoses (SCUBA/surface-supplied) shall:

(1) Have a working pressure at least equal to the working pressure of the total breathing gas system and have a rated bursting pressure at least four times the working pressure. Hoses must be tested at least annually to 1.5 times the working pressure. When hoses are not in use, their open ends must be closed by taping or other means.

(2) Have connectors made of corrosion resistant materials and have a working pressure at least equal to the working pressure of the hose to which they are attached. Connectors must not be able to become accidentally disengaged.

(3) Have umbilicals marked in 10-foot increments to 100 feet, beginning at the diver's end and in 50-foot increments thereafter. Umbilicals shall be made of kink resistant materials. A safety line of at least 3/8 inch, synthetic material, shall be included as an integral part of each umbilical.

d. Surface supplied air helmets and masks shall have a non-return valve at the attachment between the helmet or mask and

hose which will close readily and also have an exhaust valve. Helmets and masks shall have a minimum ventilation rate capacity of 4.5 acfm at the depth at which they are operated, or the capability of maintaining the diver's inspired carbon dioxide partial pressure below 0.02 atmospheres absolute (ATA) when the diver is producing carbon dioxide at the rate of 1.6 standard liters per minute.

e. Weights and harnesses.

(1) Except when heavy gear is worn, divers shall be equipped with a weight belt capable of quick release.

(2) Each diver shall wear a safety harness with a positive buckling device, an attachment point for the umbilical, and a lifting point to distribute the pull of the line over the diver's body.

f. Emergency/First Aid Equipment. The following equipment shall be located at all dive sites:

(1) A first aid kit meeting the requirements of EM 385-1-1, Section 03.B.

(2) An oxygen resuscitation system capable of a 100% inspired deliverance for a minimum of 50 minutes. The oxygen cylinder shall have a minimum 600 liter capacity and shall be charged with 100% oxygen.

(3) Stokes litter or backboard with attached floatation device.

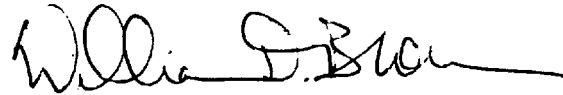
g. Dive Flag. An appropriate dive flag at least one meter in height will be displayed at the dive location during diving operations.

h. Hand-held power tools shall be de-energized before being placed into or retrieved from the water and shall not be supplied with power until requested by the diver.

i. SCUBA Tethers. SCUBA tether shall be of a line of at least 3/8 inch synthetic material. Tethers shall be marked in 10-foot increments to 100 feet, beginning at the diver's end and in 50-foot increments thereafter.

j. Inspections. All dive equipment shall be inspected by the dive supervisor prior to and after each dive operation. Each USACE command shall perform an annual formal inspection of all dive equipment. Results of the inspection shall be maintained by the UDC.

FOR THE COMMANDER:

A handwritten signature in black ink, appearing to read "William D. Brown". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

WILLIAM D. BROWN
Colonel, Corps of Engineers
Chief of Staff

6 Appendices

App A - Definitions of Terms

App B - High Alt. Diving Tables

App C - Diving Medical Requirements

App D - Sample Diving Log Form

App E - Minimum Manning Levels for Dive Teams

APPENDIX A

DEFINITIONS OF TERMS

BOTTOM TIME - The total elapsed time measured in minutes from the time the diver leaves the surface in descent to the time the diver begins ascent.

RECOMPRESSION CHAMBER - A pressure vessel for human occupancy such as a surface recompression chamber, closed bell, or deep diving system used to recompress divers to treat decompression sickness.

DECOMPRESSION SICKNESS - A condition with a variety of symptoms which may result from gas or bubbles in the tissues of the diver after pressure reduction.

DIVE LOCATION - A surface or vessel from which a diving operation is conducted.

DIVE TEAM - Divers and support personnel involved in a diving operation, including the diving supervisor.

MIXED-GAS DIVING - A diving mode in which the diver breathes a mixture other than air, e.g., helium-oxygen.

NO-DECOMPRESSION LIMITS - The depth-time limits of the "no-decompression limits and repetitive dive group designation table for no-decompression air dives" as specified in the U.S. Navy Diving Manual or equivalent.

STANDBY DIVER - A diver at the dive location available to assist a diver in the water.

TRAINING DIVE - A training dive is one which is performed to maintain diver competence. A training dive must meet all requirements of this regulation. A recreational dive does not meet the qualifications of a training dive.

“High Altitude Diving and Decompression”

By: Richard H. Geyer © 1972

SECTION I

Introduction:

The convenience of travel has made formerly remote inland areas readily accessible to the diving fraternity. Included are environments of “High Altitude.” Yet, in the field of diver education “High Altitude Diving and Decompression” is seldom discussed. In the interest of diving safety, for all certification levels, the instructor should include this aspect in his course content.

Diving at any increased elevation greater than 1000 feet presents some very complex problems and added hazards for the uninformed.

Problems arise because physical laws concerning absolute pressures and gas partial pressures are affected. For instance, lower oxygen partial pressure in breathing air at high altitude can result in anoxia, causing unconsciousness, after surfacing from a dive, and, susceptibility to nitrogen narcosis or decompression sickness at unusually shallow depths must be anticipated due to the increased percentage of nitrogen.

I. Presentation:

In a lecture covering “High Altitude Diving” it is wise for the instructor first to point out to his students all areas of the diving technique that require changes to compensate for increased elevation.

Areas to be considered include:

1. Conversion Factor for finding theoretical dive depths and decompression stop depths at altitude.
2. Atmospheric pressure at altitude.
3. Depth of dive.
4. Ascent rates.
5. Decompression stops.
6. “No Decompression Limits” and Repetitive Dives.
7. Compressor Output Adjustment for surface supplied diving.
8. Flying after diving.

Discussion:

1. *Conversion Factor* – The most vital detail necessary for the diver to develop is a workable conversion factor which places all aspects of diving that are influenced by high altitude in their proper perspective.

Finding a factor for any altitude is rather simple provided the diver knows the atmospheric pressure at sea level (760 mm Hg), which is a constant, by the atmospheric pressure for his altitude (in mm Hg), the variable.

eg: For a dive site altitude of 6000 feet the atmospheric pressure is 610 mm Hg.

$$\text{C.F.} = \frac{760 \text{ mm Hg @ Sea Level}}{610 \text{ mm Hg @ 6000 feet}} = 1.245$$

Rule: When applying C.F. to find theoretical dive depth, multiply.

When using C.F. to find atmospheric pressure, ascent rates, and theoretical decompression stop depths, divide.

2. *Atmospheric Pressure* - At 6000 feet the pressure of one atmosphere is 11.8 psi instead of 14.7 psi found at sea level. This is due to the change in partial pressure of oxygen (2.36 pp or 16%) and nitrogen (9.44 pp or 84%).

One atmosphere of depth in a lake at 6000 feet of altitude would be 27 feet instead of 34 feet found at sea level.

3. *Depth of Dive* - Due to the decreased pressure at altitude, the actual diving depth of a dive must be converted to a theoretical depth for use in the standard decompression tables.

eg: Diving in a lake at 6000 feet to an actual depth of 110 feet, the theoretical depth would be 137 feet. (110 ft. actual X 1.245 C.F. = 137 ft. Theoretical)

NOTE: See table ADT-2 for depth conversions.

4. *Ascent Rates* - Especially on decompression dives ascent rates must be changed to correspond with the pressure differential ratio of altitude.

eg: The rate of ascent from dives at sea level is 60 fpm. By dividing the C.F. 1.245, for 6000 feet of altitude, into 60 fpm, the adjusted rate of ascent is 48 fpm. (60 fpm ÷ 1.245 C.F. = 48 fpm)

"High Altitude Diving and Decompression"
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5. *Decompression Stops* – Diving at high altitude predisposes the diver to increased partial pressures of nitrogen. If there is a need for decompression the depths of decompression stops will need conversion in order to end the dive safely.

When figuring theoretical diving depth for decompression schedules, the rule of next greater depth still applies.

eg: If the "Tables" require decompression stops at 30 ft., 20 ft., and 10 ft. for a diver at an altitude of 6000 feet, the theoretical decompression stop depths would be at 24 ft., 16 ft., and 8 ft., (Actual stop depths divided by C.F. 1.245)

Note: See table ADT-3 for conversion of stop depths.

6. *"No Decompression Limits and Repetitive Dives"* - Single dives that fall within the "No Decompression Limits" are arrived at by using the theoretical depth of the dive.

When using the repetitive dive schedules, the diver must determine his repetitive group designations from the theoretical depth and residual nitrogen time to be applied to a second dive must be determined based on the theoretical depth of the repetitive dive.

NOTE: Time is not a function of altitude diving, therefore, the "Surface Interval Credit Table" (1-12) remains unchanged.

7. *Compressor Output for Surface Supplied Diving* – Any high altitude environment affects output power on gasoline or diesel motors. Generally, engines will have a decrease in horse power of about 3½% for each 1000 feet above sea level. This power reduction results in a cutback of engine rpm and subsequently lowers the air output from the diver's compressor.

In other words, a diver using surface supplied equipment at high altitude will experience less cfm of free air available to his mask, Hookah, etc., and this could be a determining factor in how deep the diver can perform his work.

When using S. AS. gear for altitude diving, consult the engine compressor manual for the unit involved to get correct details on power reductions caused by altitude.

8. *Flying After Diving* If it is necessary to use air transportation within 12 hours after diving at high altitude, the diver must plan his dive(s) in advance as though the dive(s) is at an altitude equal to the airplane cabin's pressurized altitude.

If the plane does not have a pressurized cabin, then the dive(s) must be based on the highest altitude the airplane will reach.

Individual air lines can inform the diver of the altitude and pressure differential that their cabins will be pressurized to in flight.

NOTE: See Sec. III, Additional Notes and Cautions, A-2.

SECTION II

Example Dives (Use Tables ADT-1, ADT-2, ADT-3 for this section):

Example A – Single Dive

The day's diving will be in a lake at an elevation of 4800 ft. above sea level. A recovery job requires that the diver goes to an actual depth of 93 ft. for 18 min. bottom time.

1. Go to next highest altitude -5000 ft.
Atm. Press. @ 5000 ft. = 633 mm Hg (from Table ADT-1)
2. Conversion Factor = 1.20 (from Table ADT-1)
3. Ascent Rate = 50 fpm – (60 fpm : 1.20 = 50 fpm)

Actual Dive

93 ft - 18 min.

No Decompression Required

Theoretical Dive

120 ft. – 18 min. (from Table ADT-2)

Decompress 2 min. @ 8 ft. (Table ADT-3)

NOTE: Make certain that the ascent rate from depth to the 8 foot decompression stop is 50 fpm.

"High Altitude Diving and Decompression"
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Example B – Repetitive Dive

The first dive of the day will be to a depth of 80 ft. for 18 min. at an altitude site of 8000 ft. Following this dive there is a surface interval of 2 hours 43 min. in order to re-arrange topside equipment. Then a repetitive dive is carried out at a depth of 82 ft. for 18 min. bottom time.

1. Atm. Press. @ 8000 ft. = 565 mm Hg.
2. C.F. = 1.345.
3. Ascent Rate = 45 fpm.

Actual Dive

80 ft - 18 min. (E)
S.I. = 2:43 (C)
82 ft. - 18 min.
+ - 11 min. N₂
82 ft - 29 min. Total B.T.

No Decompression Required

Theoretical Dive

108 ft. - 18 min. (G)
S.I. = 2:43 (D)
121 ft. - 18 min.
+ 11 min. N₂

121 ft. - 29 min. Total B.T.

Decompression Required:

3 min. @ 15 ft. and 18 min. @ 7 ft.

Note: Check rate of ascent at 45 fpm to the first stop.

Example C – First dive at altitude, repeat dive at sea level. A diver makes his first dive at an altitude of 4000 feet, to a depth of 90 feet, bottom time 35 minutes. After a surface interval of 2 hours 19 minutes, during which time the diver travels to sea level, he makes a repetitive dive to a depth of 60 feet for 10 minutes in the ocean.

1. Theoretical Depth @ 4000 ft. = 104 ft.
2. C.F. = 1.155.
3. Ascent Rate = 51 fpm.

Actual Dive

60 ft. - 10 min.
+ 44 min. N₂
54 min. Total B.T.

No decompression required for repetitive dive.

Theoretical Dive

104 ft. - 35 min. Decompress 2 min. @ 17 ft. and 21 min. @ 9 ft. (L)
S.I. = 2:19 (G)

Note: Check rate of ascent at 51 fpm to the 17 ft. stop.

Example D – First dive at sea level, repetitive dive at altitude. The diver makes his first dive at sea level to a depth of 74 feet for 20 minutes. *Following the dive, it takes him 3 hours to fill his tanks and pack all the necessary gear for a dive trip to a mountain lake at an altitude of 4300 feet (Surface interval @ sea level). The diver then drives to the dive site in 2 hours 8 minutes and begins his dive to 66 feet for 25 minutes.

1. Theoretical Depth @ 5000 ft. = 84 ft.
2. C.F. = 1.20.
3. Ascent Rate = 50 fpm.

Actual Dive

74 ft. - 20 min. (E) No decompression required.
96 ft. - 20 min. (F)
S.I. = 5.18

Theoretical Dive

84 ft. - 25 min.
+ 7 min. N₂
84 ft. - 32 min. Total B.T. Decompress 7 min. @ 8 ft.

NOTE: Check rate of ascent at 50 fpm to the 8 ft. stop.

*Surface Interval at sea level must be a minimum of 2 hrs. before traveling to any altitude dive site.
See Sec. III, Additional Notes and Cautions, A-2.

"High Altitude Diving and Decompression"
By: Richard H. Geyer © 1972

SECTION III

Additional Notes and Cautions:

- A. There may be some occasions when a diver will need to make a dive at some high altitude and then return to sea level for a repetitive dive within a 12-hour period, or, make his first dive at sea level followed by a repetitive dive in a lake at high altitude.

1. For a single dive or repetitive dives made at high altitude, the diver will follow the procedure of planning that considers theoretical dive depth and any decompression for his dive. After his trip to sea level (Surface Interval) he may assume the previous dive(s) and any decompression was made to actual sea level depths.
2. If the diver makes his first dive or repetitive dives at sea level and then travels to some high altitude for subsequent dives he must assume that the sea level dive(s) was made at the altitude of his new dive site.

NOTE: Based on a research report authored by Edel, Carroll, Honaker, and Beckman published in "Aerospace Medicine," October 1969, it is advised by this author that the surface interval following a "No Decompression" dive(s) at sea level should be a minimum of 2 hours, at sea level, before attempting trips to dive sites at high altitude.

It is further recommended that a diver who exceeds the "No Decompression Limits," for a dive(s) regardless of decompression carried out, must allow a surface interval of 24 hours, at sea level, prior to traveling to high altitude for other dives.

The above cautions are to be followed when considering airline travel as well, even in planes with pressurized cabins.

- B. Two cautionary notes on maladies peculiar to high altitude environments are included for divers who may be considering dive trips to elevations greater than 7000 feet.

The following remarks are reproduced from a personal communication written by W. Brandon Wright, Research Medical Officer at the U.S. Navy's Experimental Diving Unit for that activity's archives.

Acute Mountain Sickness

Altitudes greater than 7,000 - 9,000 feet have decreased partial pressures of oxygen which cause arterial hypoxemia. In response to hypoxic stimulation, hyperventilation occurs with secondary lowering of arterial CO₂ and production of alkalosis. The newcomer to high altitude typically experiences dyspnea (shortness of breath), rapid heart rate, headache, insomnia, and general malaise. These symptoms usually disappear within 3 to 10 days and general graded exercise may hasten acclimatization. Acclimatization is lost within a week at lower altitudes.

Altitude Pulmonary Edema

Pulmonary edema can occur in non-acclimatized persons who travel within a day or two to altitudes greater than 9,000 feet. Symptoms usually appear 6 to 36 hours after arrival and consist of dry cough, dyspnea and a feeling of pain in the chest. Treatment includes transportation to lower altitude, hospitalization with bed rest, oxygen and diuretic therapy. Prevention consists of taking adequate time for altitude ascent, and upon reaching altitude avoid over-exertion which can cause pulmonary edema even in well acclimatized individuals.

Diving is strenuous and should not be done at high altitude without adequate acclimatization. This might require as much as three months of graded increasing exercise programs at altitude.

Increasing the oxygen partial pressure in the diver's gas supply to account for the decreased atmospheric pressure may be helpful. However, the exertion of a dive may precipitate pulmonary edema which could severely interfere with respiration while diving and afterwards as well. The symptoms may be indistinguishable from the chokes type of decompression sickness. Recompression with oxygen therapy would probably relieve the symptoms during treatment but they might well recur following therapy.

The pulmonary edema of altitude exposure can be a serious, even fatal illness. No one should dive who has the slightest evidence of shortness of breath, cough, or tightness in the chest. Anyone who has obvious symptoms of this altitude disease should receive 100% oxygen to breathe and be rapidly transported to a hospital for prompt vigorous therapy.

ALTITUDE DIVING TABLES

Table ADT - 1
Atmospheric Pressures (in mm Hg) and conversion Factors
for altitudes to 10,000 feet

	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
mm Hg	734	708	681	658	633	610	589	565	543	524
C.F.	1.035	1.073	1.116	1.155	1.200	1.245	1.292	1.345	1.396	1.450

Table ADT - 2
Theoretical Depth at Various Altitudes (FFW)

Actual Depth	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
0	0	0	0	0	0	0	0	0	0	0
10	10	11	11	12	12	12	13	13	14	15
20	21	21	22	23	24	25	26	27	28	29
30	31	32	33	35	36	37	39	40	42	44
40	41	43	45	46	48	50	52	54	56	58
50	52	54	56	58	60	62	65	67	70	73
60	62	64	67	69	72	75	78	81	84	87
70	72	75	78	81	84	87	91	94	98	102
80	83	86	89	92	96	100	103	108	112	116
90	93	97	100	104	108	112	116	121	126	131
100	103	107	111	116	120	124	129	134	140	145
110	114	118	122	127	132	137	142	148	153	160
120	124	129	134	139	144	149	155	161	167	174
130	135	140	145	150	156	162	168	175	181	189
140	145	150	156	162	168	174	181	188	195	203
150	155	161	167	173	180	187	194	202	209	218
160	166	172	178	185	192	199	207	215	223	232
170	176	182	189	196	204	212	220	228	237	247
180	186	193	200	208	216	224	233	242	251	261
190	197	204	212	220	228	237	246	255	265	276
200	207	215	223	231	240	249	259	269	279	290
210	217	225	234	243	252	261	272	282	293	305
220	228	236	245	254	264	274	284	296	307	319
230	238	247	256	266	276	286	297	309	321	334
240	248	258	267	277	288	299	310	323	335	348
250	259	268	278	289	300	311	323	336	349	363

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Instructions for ADT - 2: Table ADT - 2 lists theoretical dive depths at altitudes to 10,000 feet for actual dive depth to 250 feet of fresh water (FFW). To use this table, enter the left column (actual diving depth) to the actual, or next greater, depth for the dive. At the top of the depth column find the altitude of the dive site, or the next highest altitude if altitude falls between those listed. The figure given in the selected altitude column for the actual depth is the theoretical dive depth for that altitude.

Table ADT - 3
Theoretical Depth of Decompression Stop (FFW)

Prescribed Depth	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
0	0	0	0	0	0	0	0	0	0	0
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	22	21
40	39	37	36	35	33	32	31	30	29	28

Table ADT - 4
Changes in Ascent Rates (in FPM)
for altitudes to 10,000 feet.

Sea Level	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
60 fpm	58	56	54	52	50	48	46	45	43	41

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APPENDIX C

DIVING MEDICAL REQUIREMENTS
FOR
GOVERNMENT PERSONNEL

1. A negative response to any of the following physical requirements 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. These items, to include recommendations, will be included in the physician's report of medical examination.

a. Height and weight. The diver examination must contain an evaluation of muscular development and lean muscle mass in reference to capability to perform the tasks described on the SF 78, including the indicated functional requirements and environmental factors.

b. Ears, nose and throat. Audiometric testing must be carried out on every prospective diver. A hearing loss of 35dB or more at frequencies up to 3000 Hz and 50dB or more at frequencies above 3000Hz to a minimum of 6000Hz is an indication for referral of the person to a specialist for further opinion.

(1) Anatomic abnormalities such as perforated eardrums with marked scarring or thickening of the drum are not in themselves disqualifying.

(2) Inability to equalize pressure on both sides of the eardrum is disqualifying.

(3) Acute or chronic suppurative infection of the nose and sinuses may be disqualifying dependent on severity.

(4) Acute or chronic semicircular canal disease will disqualify a diver.

c. Eyes. Vision testing should be carried out on every prospective diver. Vision at distance should be 20/30 in best eye with correction.

d. Cardiovascular system. Severe valvular disease, cardiac arrhythmias, angina, uncontrolled hypertension, severe peripheral vascular disease should disqualify a diver. Any operations performed to correct the above condition should also disqualify a diver.

e. Pulmonary. A history of spontaneous pneumothorax, bleb disease, significant asthma, clinically apparent TB, or significant scarring from TB, cystic disease, emphysematous bullae should all be considered disqualifying.

f. Gastrointestinal system. Gastrointestinal illness that produces chronic illness or debilitation shall be disqualifying unless further evaluated. A clinically apparent inguinal, femoral, large umbilical or incisional hernia should disqualify the diver until it has been repaired. Hiatal hernias are not disqualifying unless the severity of their symptoms affect the diver's ability to work.

g. Central nervous system. Disorders of the vestibular system or a history of seizures are disqualifying. Any history of significant psychoneurotic disorders is disqualifying.

h. Endocrine system. Persons with severe diabetes shall be disqualified unless further evaluated.

i. Musculoskeletal. A history of aseptic necrosis of the head of the femur, the shoulders or the knees is disqualifying.

j. Hematological. Laboratory evidence of sickle cell disease or trait is disqualifying.

k. Genitourinary system. Any significant disease of the kidney which has a systemic effect is disqualifying.

l. Behavior. A history of drug or alcohol abuse may be disqualifying.

2. Recommended Examination.

a. Preemployment.

- (1) Central nervous system.
- (2) Musculoskeletal with X-Ray of knees, shoulders, and head of femur.
- (3) Ears, nose and throat with audiogram.
- (4) Eye examination with vision screening.
- (5) Cardiovascular with EKG.
- (6) Pulmonary evaluation with chest film.
- (7) Gastrointestinal evaluation with check for hernias.

(8) Laboratory. Sickle Cell testing.

SMA - 12

CBC with differential

Urinalysis

b. Annually. Annually the diver must receive a complete physical as above with the exception of Musculoskeletal X Rays, a chest film and Sickle Cell testing.

NOTE: Sickle Cell testing and Musculoskeletal X-Rays need only be accomplished during an initial physical.

c. Tri-annually. Tri-annually the diver must receive an updated chest film.

FOR ILLUSTRATION PURPOSES ONLY
(Local reproduction authorized - blank masters available from local FMO)

DIVING LOG										
NAME (LAST, FIRST, MIDDLE I.)										
DATE OF LAST PHYSICAL:			TENDER:			DISTRICT & PROJECT:				
1. DIVE										
DATE:		DEPTH OF DIVE:		REPETITIVE DIVE:		BOTTOM TIME				
		FT.		<input type="checkbox"/> YES <input type="checkbox"/> NO						
2. DIVING CONDITIONS										
WATER DEPTH:		WATER TEMP.:		CURRENT:		TYPE BOTTOM:		BOTTOM VISIBILITY:		
FT.		° F.		KTS				FT.		
3. TYPE WORK				4. EQUIPMENT						
NONE MILD, MODERATE, HEAVY:				<input type="checkbox"/> DEEP SEA		<input type="checkbox"/> SCUBA (OPEN)		<input type="checkbox"/> HEL-OXYGEN		
				<input type="checkbox"/> MASK		<input type="checkbox"/> SCUBA (CLOSED)		<input type="checkbox"/> OTHER: _____		
5. BREATHING MEDIUM					6. SOURCE OF BREATHING MEDIUM					
AIR	HELIUM		OXYGEN		NITROGEN	<input type="checkbox"/> AIR BANKS <input type="checkbox"/> HEO BANKS <input type="checkbox"/> COMP.				
	%		%		%					
7. REPETITIVE NO-DECOMP. DIVES										
	1	2	3	4						
TIME OUT										
TIME IN										
TIME (MIN.)										
DISTANCE (YARDS)										
AIR OUT (PSI)										
AIR IN (PSI)										
AIR USED (CU FEET)										
MAX. DEPTH (FEET)										
<input type="checkbox"/> SUIT USED	BOT. VOL. (CU. FT.)		TOT. TIME (MIN.)		TOT. DIST. (YDS.)					
10. TOTAL TIME OF DIVE(S)										
THIS/ THESE			CUMULATIVE							
MIN.			HRS.			MIN.				
11. WORK SCHEDULES AND ACCOMPLISHED:										
12. REMARKS:										
_____ DIVING SUPERVISOR					_____ DIVING INSPECTOR					

APPENDIX E

MINIMUM MANNING LEVELS FOR DIVE TEAMS

TABLE I. SCUBA (UNTETHERED) (0 - 60')

A. Untethered SCUBA divers shall always be accompanied by another diver in continuous visual contact.

B. When depth of dive is 0 - 60', the minimum dive team will be composed as follows:

DIVING SUPERVISOR	1
DIVERS (In Visual Contact)	2
*STANDBY DIVER	1
TOTAL TEAM MEMBERS	4

TABLE II. SCUBA (TETHERED WITH COMMUNICATIONS) (0 - 100')

When the depth of dive is 0 - 100', the minimum dive team will be composed as follows:

DIVING SUPERVISOR	1
DIVER	1
*STANDBY DIVER	1
**TENDER	1
TOTAL TEAM MEMBERS	4

*The standby diver will be rested and capable of performing emergency rescue assistance. The standby diver shall be sufficiently free of residual nitrogen to allow for 25 minutes of bottom time at the working depth without exceeding "No Decompression Limits".

**For each additional diver in the water, one tender will be added to the team. In an emergency, the diving supervisor may serve as tender for the standby diver.

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TABLE III. SURFACE AIR (0 - 100')

For all Surface Supplied Air Operations, the minimum dive team will be composed as follows:

DIVING SUPERVISOR	1
DIVER	1
*STANDBY DIVER	1
**TENDER	1
TIMEKEEPER/STANDBY TENDER	1
TOTAL TEAM MEMBERS	5

*The standby diver will be rested and capable of performing emergency rescue assistance. The standby diver shall be sufficiently free of residual nitrogen to allow for 25 minutes of bottom time at the working depth without exceeding "No Decompression Limits".

**For each additional diver in the water, one tender will be added to the team. In an emergency, the diving supervisor may serve as tender for the standby diver.

TABLE IV. SNORKELING/BREATH-HOLD DIVING (0 - 5')

For all snorkeling/breath-hold diving operations, the minimum dive team will be composed as follows:

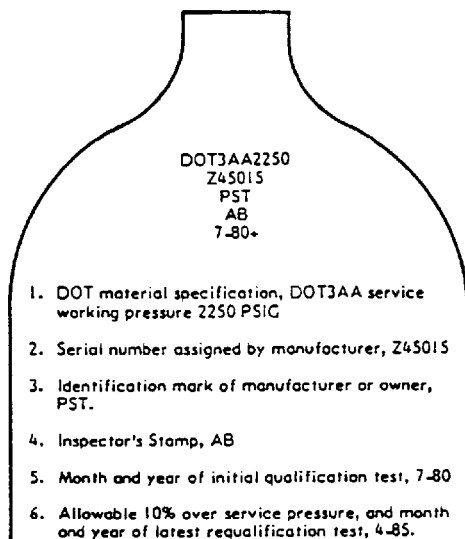
DIVING SUPERVISOR	1
SNORKELER/DIVER	1
*STANDBY SNORKELER/DIVER	1
TOTAL TEAM MEMBERS	3

*The standby snorkeler/diver will be rested and capable of performing emergency rescue assistance.

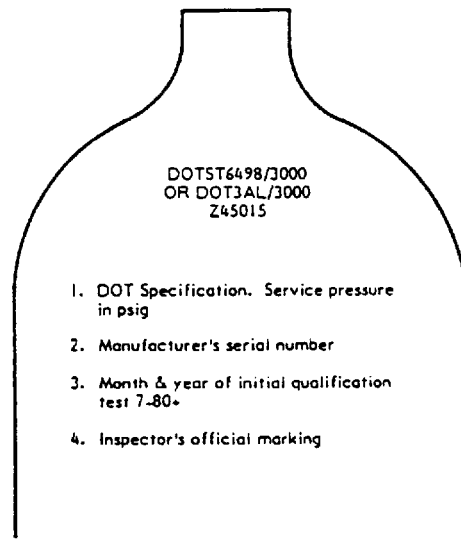
APPENDIX F

SCUBA CYLINDER MARKINGS

1. Air cylinders of seamless steel or aluminum which meet U.S. Department of Transportation (DOT) 3AA, DOT SP6498, and DOT E6498 specifications are approved on USACE projects.
2. Each cylinder used on USACE projects must have identification symbols stamped into the shoulder of the tank as shown below.
3. SCUBA tanks used on USACE projects must be visually inspected internally at least annually and hydrostatically tested at least once every five years in accordance with DOT and the Compressed Gas Association regulations. Test dates will be stamped into the shoulder of each tank.



STEEL CYLINDERS



ALUMINUM CYLINDERS