DOCUMENT RESUME

ED 213 877 CE 031 500

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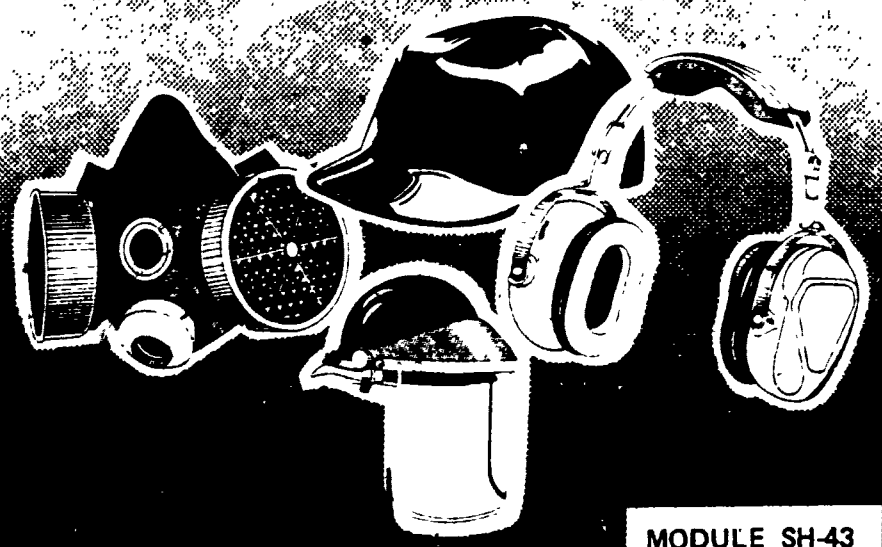
|---|---|
| TITLE | Safety Practices for Commercial Diving. Module SH-43. Safety and Health. |
| INSTITUTION | Center for Occupational Research and Development, Inc., Waco, Tex. |
| SPONS AGENCY | Office of Vocational and Adult Education (ED). Washington, DC. Div. of National Vocational Programs. |
| PUB DATE | 81 |
| CONTRACT | 300-79-0709 |
| NOTE | 28p.; For related documents see CE 031 450-507. |
| AVAILABLE FROM | The Center for Occupational Research and Development, 601 Lake Air Dr., Suite C, Waco, TX 76710 (Instructor Guides, $9.75 each; Learning Modules, $3.00 each. Entire set of Learning Modules available as two subsets: SH-21, SH-41, SH-43, SH-45, and SH-48, $12.00; remaining 45 modules, $97.50). |
| EDRS PRICE | MF01 Plus Postage. PC Not Available from EDRS. |
| DESCRIPTORS | Behavioral Objectives; *Equipment Utilization; *Health Education; Learning Activities; Learning Modules; Postsecondary Education; Safety; *Safety Education; Safety Equipment; Secondary Education; *Vocational Education |
| IDENTIFIERS | *Diving (Commercial); *Occupational Safety and Health |

ABSTRACT

This student module on safety practices for commercial diving is one of 50 modules concerned with job safety and health. This module provides a brief orientation to safety considerations for commercial diving. Following the introduction, nine objectives (each keyed to a page in the text) the student is expected to accomplish are listed (e.g., Name 10 physical requirements of divers). Then each objective is taught in detail, sometimes accompanied by illustrations. Learning activities are included. A list of references and answers to learning activities complete the module. (CT)

# SAFETY AND HEALTH

## SAFETY PRACTICES FOR COMMERCIAL DIVING



MODULE SH-43



ORD CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT

The activity which is the subject of this document was supported in whole or in part by the U. S. Department of Education. However, the opinions expressed herein do not necessarily reflect the position or policy of the Department of Education, and no official endorsement by the Department of Education should be inferred.

This work was developed under contract number 300790709 for the U. S. Department of Education, Office of Vocational and Adult Education.

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# INTRODUCTION

The global expansion of modern diving is a triumph of mankind over pressure. Every diver who enters the water must adjust to an alien atmosphere. During descent, pressure on the diver's body increases with every foot of depth. Inert breathing gas is rapidly absorbed into the tissue. Upon ascent, with diminished pressure, excess gas is released by the body, with potentially serious complications for the diver. Because of the hyperbaric (above-normal) pressure, divers must rely completely on life-supporting systems and on the competence and reliability of the persons who help to operate, monitor, maintain, and repair them.

Commercial diving is uniquely hazardous because the diver has a job to perform. Getting safely to the bottom is only the beginning - once down, there may be long hours of hard, dirty work in cold, rough water with little visibility. The exact length of most jobs is not known until they are finished, but they may last from a few hours to many months. Divers may perform a variety of operations: inspection, photography, construction, demolition, cutting or welding, salvage, pipe-fitting; the list could go on and on. Major contractors accept only applicants who have graduated from either a commercial or a military deep sea diving school.

With all the potential for danger, isolation, disorientation, and the possibility of entanglement, trench collapse, and falling objects, commercial diving nevertheless continues to thrive. The professionals continue to don the intricate gear and assemblies that will keep them alive at depth, and down they go, again and again.

This module provides a brief orientation to safety considerations for commercial diving. It is not intended as a statement of relevant OSHA standards in their entirety, a complete safety manual, or a book of diving instructions; rather, it is hoped that the student will gain an appreciation for the complex safety factors inherent in commercial diving.

# OBJECTIVES

Upon completion of this module, the student should be able to:

1. Name 10 physical requirements of divers. (Page 3)
2. Describe the requirements for medical exams for diving personnel. (Page 5)
3. List five injuries incurred by divers and explain preventive measures for each. (Page 6)
4. Name three physical conditions that should prevent a diver from entering the water. (Page 11)
5. Describe three types of breathing apparatus. (Page 11)
6. Discuss protective clothing for divers and describe situations where each is used. (Page 15)
7. List four questions that should be answered before a diver considers taking a particular job. (Page 19)
8. Discuss equipment that should be checked upon arrival of job site. (Page 20)
9. Name the equipment that should be inspected before entering water. (Page 22)

## SUBJECT MATTER

**OBJECTIVE 1:** Name 10 physical requirements of divers.

The primary prerequisite for divers is very good health and mental stability. Each candidate should be medically screened against a set of physical requirements. Some OSHA standards prohibit diving for people with certain specific disabilities.

Oral hygiene should be established through a dental check-up, with X-rays and inspection of gums and inner walls of the mouth. Cavities should be very compactly filled to avoid the possibility of toothache while diving. If a tooth has an air pocket beneath a filling or inlay, the pressure increase can cause excruciating pain.

Vision should be adequate for all normal purposes, but in diving, requirements will vary from job to job. Color-blindness should ground a diver for an operation involving signal flags, but would not prevent him or her from handling a low-visibility assignment. Divers must frequently work in visibility conditions of less than 10 feet.

Chronic disorders of the ears must be corrected before the student is allowed to dive. Blockage of the eustachian tubes that lead to the ear drums can cause extreme pain during descent, possibly followed by rupture of the drum. Meniere's disease of the inner ear, dizziness, or chronic inability to equalize middle ear pressure will restrict or prohibit a person's chances of diving.

Nose and throat conditions such as rhinitis (inflammation of nasal mucous membrane with post-nasal drip into the throat) are considered suspect in a potential diver. Chronic rhinitis interferes with clearing of the middle ear or sinuses. Laryngitis can lead to choking. Any nose/throat problem that does not respond to medical treatment may disqualify a person from diving.

Lungs must be X-rayed for evidences of damage. Enlarged lymph nodes at the root of the lungs suggest some serious disorder requiring medical inves-

tigation. A bleb (enlarged air pocket just under the surface of the lungs) represents another hazard: it may rupture without warning, resulting in collapse of the lung. Either of the foregoing conditions can rule out diving. Cystic or cavitary disease, chronic asthma, emphysema, or bronchitis can also bar a person from a diving career.

The cardiovascular system keeps the heart beating and the blood circulating through the body. The condition of the heart/arterial function should be medically determined by an EKG (electrocardiogram). If abnormalities show up, such as heart block, valvular disease, skipping heartbeat, angina, the candidate may be disqualified. Other prohibitive factors could be chronically high blood pressure and history of stroke.

The gastrointestinal system should function adequately. While diving, however, a "normal" person may sometimes feel bloated, or suffer more serious pain and cramping followed by fainting. Swallowed or trapped air in the stomach expands on ascent, and if not released becomes uncomfortable and potentially harmful. Eating gassy foods prior to diving, swallowing air or chewing gum during the dive are to be avoided. Temporary bowel or stomach upsets will ground the diver until recovery. Chronic gastrointestinal disorders may rule out a diving career.

The genitourinary system must be free of organ damage caused by alcohol, drugs, or disease. Under hyperbaric pressure, many ailments are subjected to additional stress. Kidney, bladder, and urethra should be checked during the medical examination. Diabetics on perpetual insulin therapy should not attempt to enter commercial diving, even though many well-controlled diabetics are able to participate in skin-diving. Generally speaking, anyone who must be regularly medicated (for any reason) by antihistamines, steroids, barbiturates, or mood-altering drugs is better off on dry land.

Skin diseases may be bad news for prospective divers because of the enveloping diving dress - it is an invitation to the outbreak of itching rashes that a diver would not be able to relieve at the bottom of the sea. Persons with chronically recurring skin disease, or with allergies leading to hives and other eruptions, may be restricted from a diving career.

Pressure equalization, as used in diving, is the process of equalizing the pressure difference between the middle ear and the body of water you happen to be in. Ability to equalize varies with the individual. Failure to equalize can result in some unpleasant symptoms - dizziness, ringing in the ears, even hearing loss. Sometimes the eustachian tubes become so blocked that the inner ear is affected and may rupture under the unequal pressure (inner ear bends). Since the inner ear controls equilibrium, full vertigo can result as well. Such blockages prohibit diving if they cannot be relieved.

Oxygen tolerance is a highly individual matter. A diver can become toxic when breathing high concentrations of oxygen under increased pressure for a prolonged time. Symptoms range from nausea, dizziness, and visual disturbances to numbness and convulsions. Except for headache and listlessness, symptoms usually disappear when air is substituted for oxygen and the partial pressure is reduced.

**ACTIVITY 1:***

List at least three chronic physical disorders that could disqualify a person from diving.

1. _____
2. _____
3. _____

**OBJECTIVE 2:** Describe the requirements for medical exams for diving personnel.

The employer in a commercial operation must determine that all members of a diving team who may be exposed to pressure through diving are physically fit to do so. These employees must undergo a medical examination

*Answers to Activities appear on 23.

before their first diving operations with the employer, or must obtain the results of a medical exam given within the past year. Besides an initial medical check-up, annual physicals should be administered to divers. In certain types of diving, a check-up is advisable every six months. If a diver becomes ill or is injured, and is hospitalized for more than 24 hours as a result, medical fitness for diving must be re-established through a checkup. Initial physicals are paid for by the employer, although free lance divers may have to pay for their own physicals. Employers are not required to pay for subsequent physical examinations.

The medical exam should include chest X-rays, EKG, visual acuity and color blindness tests, hearing test, hemocrit or hemoglobin count, sickle cell index, white blood count, and urinalysis.

**ACTIVITY 2:**

1. Name eight tests that should be included in a diving medical examination. _____

_____

_____

2. How often should medical exams be administered for most divers? _____

**OBJECTIVE 3:** List five injuries incurred by divers and explain medical emergency provisions required of employers.

Most injuries in commercial diving are due to some type of industrial accident during work in the depths. Other common and potentially hazardous injuries are detailed in this section.

The employer must be prepared for emergencies at the dive site and is required to keep on location the telephone numbers or call numbers of the following sources of emergency aid:

- An operational decompression chamber.

- Accessible hospitals.
- Available means of transportation.
- The nearest Coast Guard Rescue Coordination Center.

A first aid kit appropriate to the diving operation and approved by a physician must be provided, as well as a standard first aid handbook (Red Cross or equivalent), and a bag-type manual resuscitator. In addition, all dive team members must be trained in CPR (cardiopulmonary resuscitation) and first aid, and have experience or training in diving operations and emergency procedures.

Air embolism is one of the most serious complications that can occur in diving. The term means, literally, that an air bubble has entered into the heart/arterial circulatory system. Rupture of the alveoli walls (air sacs in the lungs) forces air into the diver's bloodstream. Blood vessels become plugged by air bubbles entering the circulatory system directly from the lungs. This condition is caused by over-pressurization within the lungs, and may result from any of the following practices:

- Too rapid an ascent.
- Holding one's breath during ascent.
- Diving while experiencing a cold or lung disorder.

Symptoms of air embolism usually occur after surfacing - within seconds and up to five minutes. Symptoms may include weakness, dizziness, paralysis of arms and legs, visual disturbance, chest pains, and convulsions. Sometimes bloody froth at the mouth appears, and the end result is unconsciousness. Air embolism must be treated immediately.

Any diver who is unconscious upon surfacing should be suspected of having air embolism, and immediately efforts should be made to get medical aid. These precautionary measures can help divers to avoid air embolism:

- Do not ascend at a rate faster than 60 feet per minute.
- Do not hold breath during ascent: breathe normally.
- Exhale continously when making "free ascent."
- Never dive when suffering a respiratory disorder.

Nosebleed usually originates from the inner ear or nasal sinuses. Too rapid a dive or overly strenuous efforts to equalize pressure can bring on

bleeding. Even with no medical complications, a beginner may experience some nasal bleeding during the first few dives.

Barring complications, revoery from nosebleed is spontaneous. A doctor may be consulted, and nose drops or nasal spray may be prescribed as a preventive measure. Always observe the correct descension/ascension rates. Make sure that your diving dress is properly inflated.

Squeeze is a term used when pressure is greater on one part of the body than on any other part. Bleeding from the lungs (rupture of the lung tissue) is one symptom of squeeze. Squeeze can be caused by these incorrect practices:

- Too deep a descent during skin diving.
- Holding breath upon descent when using scuba.
- Faulty inflation of the diving dress.

Internal ear squeeze (hemorrhage within the tympanic membrane and middle ear) is caused by a difference in pressure on each of the eardrums. Inability to clear the ears and equalize the pressure may be due to inexperience but is usually the result of inflammation and/or excess tissue growth in the eustachian tubes which lead to the eardrums (Figure 1).

The blockage will cause extreme pain in the ears during descent. There may be sudden relief if the eardrum ruptures, only to be followed by bleeding into the eardrum or middle space, and spitting up of blood. DO NOT try first aid on the stricken diver - seek professional medical help at once! The diver must avoid pressure changes until the rupture is completely healed. Only then is it safe to attempt another dive.

To avoid internal ear squeeze, you should take these measures:

- Equalize ear pressure prior to diving and during descent (move jaws, blow gently against closed nostrils).
- Never dive with a head cold or infection. Either condition can block the eustachian tubes - they must be kept open to compensate for pressure change.

External ear squeeze may be caused by the use of ear plugs during a dive, if air becomes trapped between plug and eardrum. Another contributing factor is the sealing over of the external ear by the hood of your wet or dry suit. During descent, there may be pain in or on the ear, even after

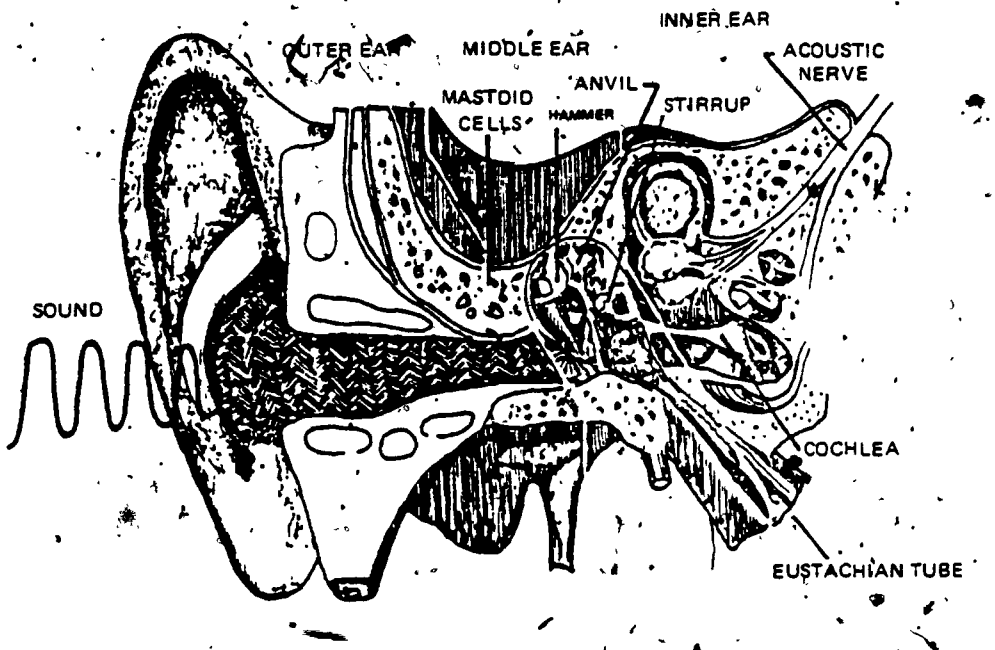


Figure 1. The human ear.

clearing--a pain quite similar to that of middle ear squeeze. In such cases, a doctor should be seen and pressure avoided until the damage heals.

These are the precautions against external ear squeeze:

- Never use ear plugs when diving.
- Allow air or water (depending on the type of suit) to enter the hood and prevent squeeze.

Exhaustion can occur when a diver tries to work beyond a certain capacity. In this condition, the diver experiences a feeling of suffocation, an inability to breathe deeply enough for comfort. Exhaustion may be due to overexertion, or poor physical condition. Fatigue, weakness, and labored breathing characterize this state. When exhausted, the diver may develop extreme anxiety and a tendency toward panic. The appropriate treatment is rest. To avoid exhaustion in the water, these guidelines should be kept in mind:

- Know and respect your physical limitations.
- Know the limitations of your equipment.
- Train in order to eliminate panic (under any circumstances).

Compressed air illness, or bends, is a serious condition which results from inadequate decompression. When pressure is released too rapidly, inert gas bubbles of nitrogen or helium are formed. This excessive amount of gas in the bodily tissues can result in local pain, dizziness, shortness of breath, extreme fatigue, paralysis, collapse, and unconsciousness. The victim of bends should be immediately treated by recompression.

Depending on their individual tolerances, divers using $N_2$ mixtures may feel a narcotic effect, known as nitrogen narcosis, when they are at and below 99 feet. In this condition, the diver may experience a physical and mental slowdown, and difficulty in concentration similar to that undergone with alcohol intoxication. The diver may develop a blissful state of euphoria but be unable to perform the simplest task.

Carbon monoxide poisoning is a toxic condition resulting from displacement of oxygen in the blood by carbon monoxide (CO). CO toxicity is a perennial problem for divers. The gas may be present in their compressed air tanks or surface air supply due to the entrance of engine exhaust into the air intake manifold. Improper lubrication of air compressors is another factor: if cylinder temperature becomes high enough, it can cause partial combustion of the lube oil.

In a CO intoxication condition, divers may develop headaches, nausea, dizziness, and confusion. The air may "taste bad." Lips and fingernail beds turn cherry red. A sufficient degree of toxicity will cause unconsciousness.

**ACTIVITY 3:**

List five diving injuries and name measures to prevent them other than correct descension/ascension rates.

1. _____
2. _____
3. _____
4. _____
5. _____

**OBJECTIVE 4:** Name three physical conditions that should prevent a diver from entering the water.

Even a perfect physical specimen will sometimes develop a temporary illness. With a cold or any nasal/sinus condition, with a sore throat, a minor bowel or stomach upset, and particularly with any kind of ear problem, DO NOT DIVE.

A precautionary word about drinking and diving - they do not mix. Alcohol, like CO and $N_2$, is a toxic poison which takes time to dissipate. NEVER dive immediately following a celebration! Sleep it off and wait for another day. Many drugs, even some over-the-counter medicines, have an effect on the diver's alertness and awareness. Diving should not be undertaken by persons who are under the influence of drugs that impair mental or physical functioning.

**ACTIVITY 4:**

(Fill in the blanks.)

Three temporary physical conditions that should prevent a diver from entering the water are:

1. _____
2. _____
3. _____

**OBJECTIVE 5:** Describe three types of breathing apparatus.

Of all the protective equipment required by a diver, the breathing air supply is paramount. There are three basic types of breathing apparatus, each requiring its own specific equipment, procedures, and techniques:

- Scuba - self-contained compressed air.
- Surface-supplied compressed air - standard diving gear.
- Mixed gas - a combination of oxygen rebreathing apparatus and oxygen/nitrogen gear.

In all diving operations described here, the term "tending" refers to the monitoring of the diver by another person who stays in communication with the diver, and ready to assist the diver if necessary. The tender brings out the diver's equipment from storage, prepares it and assists the diver in donning the gear. When the diver goes into the water, the tender in surface-supplied diving holds the safety and air lines and communicates through an intercom system or hand signals. In scuba diving, tenders rarely communicate with the divers.

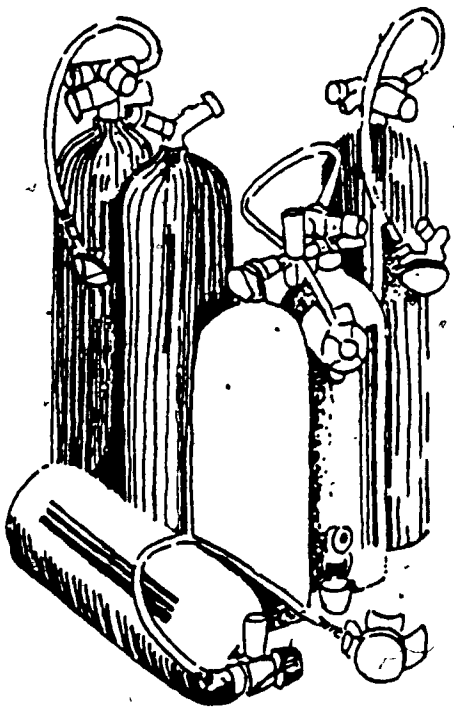

Figure 2. Self-contained air.

A scuba diver, equipped with open circuit-contained air, Figure 2, is independent of the surface for the duration of the air supply. The scuba mode, though popular with sports divers, has its limitations with regard to commercial requirements. If your air should run out at a critical point in the job, you would have to resurface and start all over again. There is rarely any means of voice communication with those on the surface, the diver need a "buddy" in constant visual contact. As there is frequently little visibility in the depths, you would more than likely have to be tended from the surface. A standby diver must be available as well when a scuba diver is in the water.

It is almost impossible to predict how long a job may take, and carrying extra air is more expensive than using a surface-supplied technique to begin with. As a result of these limitations, scuba has a very minor role in commercial diving.

In surface-supplied compressed air diving, the essentials come down from above: air, 2-way telephone communication, instructions, information, and rescue. A complex system of lines and hoses, collectively called the umbilical, affords contact at all times between dive location and diver as well as between diver and bell, or between bell and location.

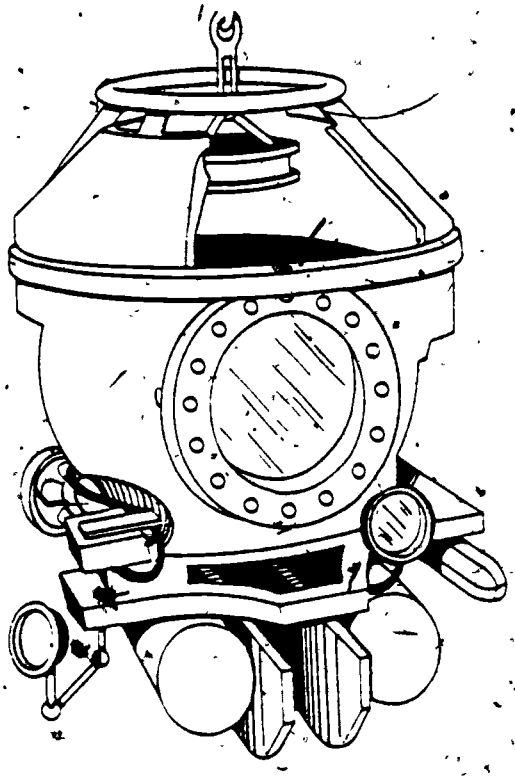

Figure 3. A fixed buoyancy manipulator bell.

According to OSHA standards, surface-supplied divers should not exceed a depth of 190 feet unless the bottom time is 30 minutes or less. In that event, the diver may go to 220 feet. Beyond these limits, air diving is considered unsafe because of the danger of nitrogen narcosis.

A decompression chamber must be ready for use at the dive location when operations require diving deeper than 100 feet, making mixed gas dives or decompression dives. A bell (Figure 3) is necessary for divers having an inwater decompression time of more than two hours. Other uses for the bell include transportation to and from the underwater work area and temporary refuge during operations, particularly in the case of an injured diver.

Separate dive team members tend each diver in the water, and a standby diver must be available as well. For heavy-gear diving, below 100 feet, or decompression dives, the standby should have access to an extra breathing hose ready for use in an emergency.

There must be on-site a primary breathing gas supply sufficient to support all divers for the duration of the dive, including the decompression interval. Diver-carried gas reserves are provided for each team member. In addition, a reserve breathing gas supply is maintained at the dive location.

For the duration of any dive, an inwater platform or ladder must be rigged and tended to assist divers as they enter or leave the water. Often they must enter/exit under extremely hazardous conditions, such as rough or cold seas.

Mixed-gas diving is a diving operation in which the diver is supplied in the water with a breathing gas other than air. In the mixed-gas mode, the diver is surface-supplied with oxygen rebreathing apparatus and a mixture of oxygen/nitrogen (or of $HeO_2$, or of all three). Mixed-gas diving should be conducted only under certain conditions:

- When a decompression chamber (Figure 4) is ready for use at the dive location (because of the greater risk of decompression sickness).
- When a bell is used at depths greater than 220 feet.
- When the dive involves an inwater decompression time of more than two hours.
- When a closed bell is used at or below 300 feet.

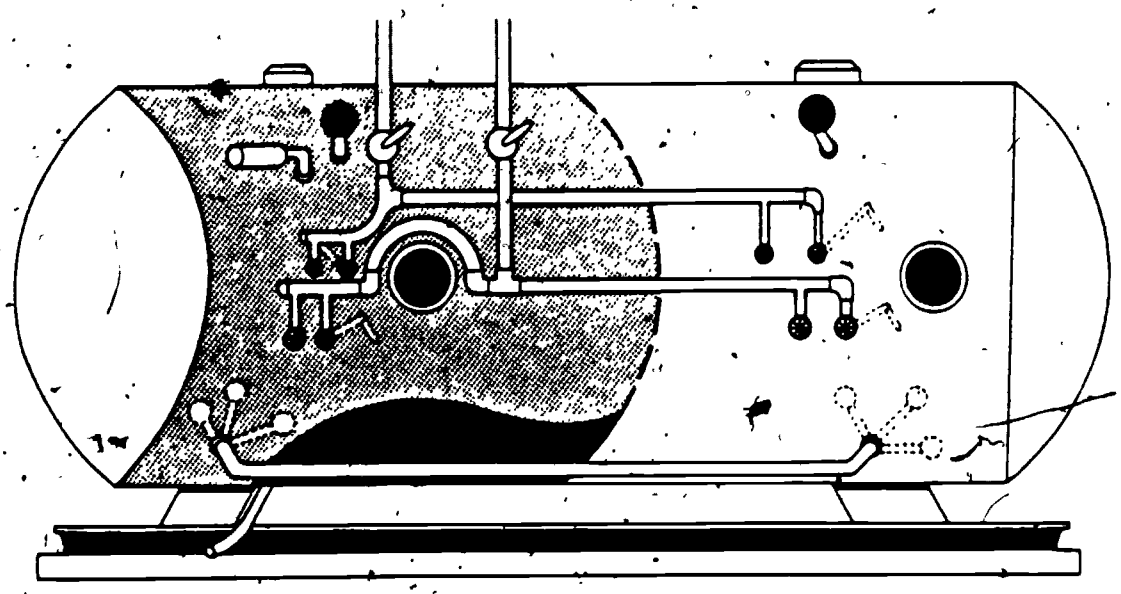

Figure 4. A decompression chamber.

Other OSHA requirements of mixed-gas diving, are the same as those for surface-supplied air diving.

**ACTIVITY 5:**

List the three types of breathing apparatus, and describe the function depth and limitations of each.

1. _____
2. _____
3. _____

**OBJECTIVE 6:** Discuss protective clothing for divers and describe situations where each is used.

The gear a diver wears will vary from job to job, depending upon these factors:

- The nature of the work.
- The mode of diving.
- The depth of the dive.
- The water temperature and other water conditions.
- The conditions of the bottom.
- The duration of the dive.

A distinction is made between heavy gear and light gear. Heavy gear is often used for dives of long duration, such as in welding and rigging. Light gear is generally more appropriate for shorter dives, where more maneuverablity is desired, or when the diver is using a dry habitat in the water. (A dry habitat is a chamber in which the diver can rest and recuperate, wait, etc.).

The ocean floor is full of booby traps for divers: jagged coral to snag a life-line; falling rocks to be dodged; slippery marine life (Figure 5). A silt/clay mud bottom makes walking very difficult. Divers can sink up to their knees in the loose, sticky mixture. The slightest movement will stir up the bottom and create conditions of zero visibility.

Routinely, a diver wears vulcanized rubber boots or fins for protection from bottom debris. Gloves are necessary for prevention of hand injuries.

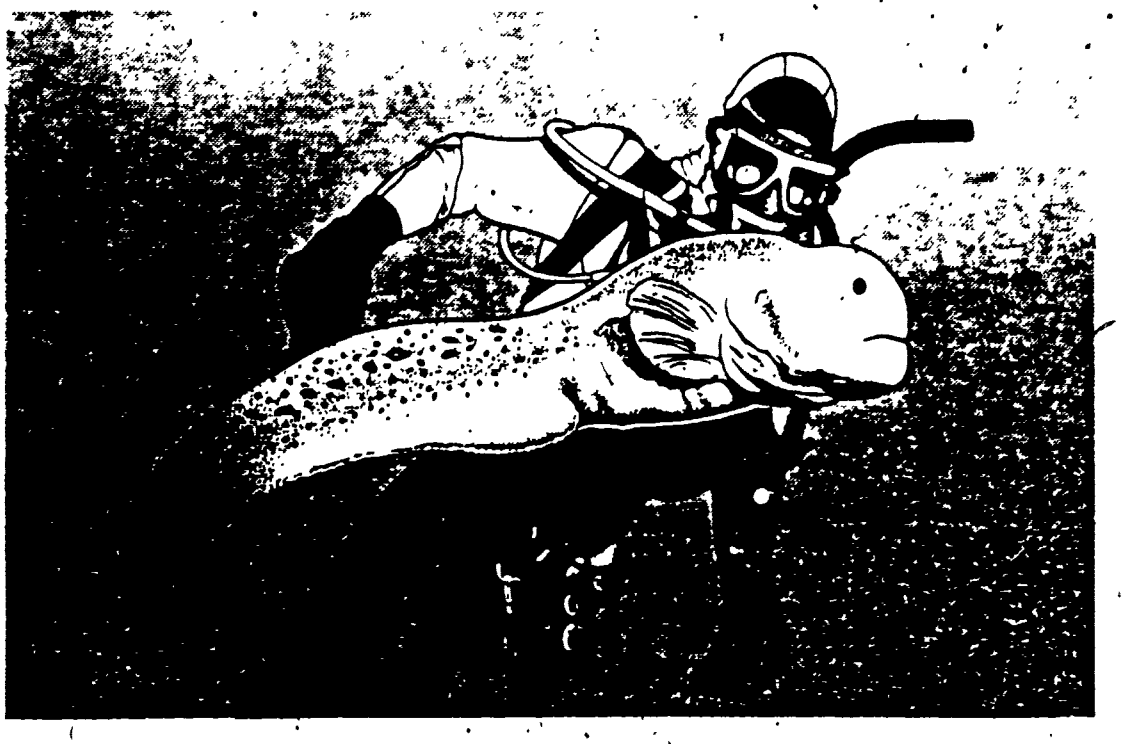

Figure 5. Marine life can create diving hazards.

They may be standard rubber gloves, or cotton work gloves of sufficient strength to survive barnacles, splinters, and scrap metal.

A wetsuit or exposure suit (Figure 6) for holding heat is worn next to the body, often under coveralls that minimize damage to the wetsuit.

A dry suit comes all in one piece: neck, arms, legs, and headgear. The dry suit acts as a buoyancy compensator and must have its own exhaust valve if directly connected to helmet or mask. When used in scuba diving, any buoyancy compensator must have an inflation source separate from the breathing gas supply, according to OSHA standards. Scuba divers must also have a floatation device capable of keeping them in a face-up position at the surface. Fins may be worn as appropriate, usually for any work that requires traveling in the water.

Each diver must wear a safety harness which has -

- A fool-proof buckling device.

- An attachment point for the umbilical, to prevent strain on mask or helmet.
- A lifting point at which the safety line's pull force will be evenly distributed over the diver's body.

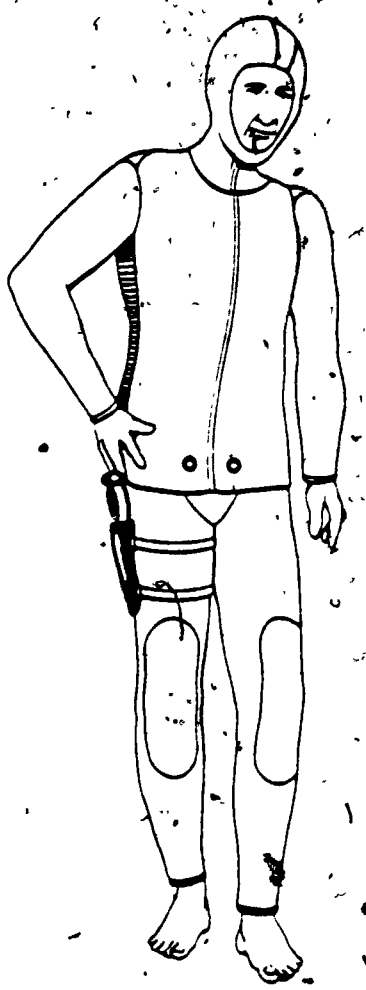

Figure 6. A diving wetsuit.

Head gear may be a face mask (Figure 7), a helmet, a hard-hat, or a rubber hood, according to the circumstances of the dive.

In surface-supplied air diving, masks and/or helmets must have an exhaust valve and a nonreturn valve located at the attachment point between helmet/mask and the gas supply hose. These valves must close easily and conclusively.

The exhaust valve automatically balances the air pressure in the helmet and makes it possible for the diver to change the buoyancy of some diving rigs. The nonreturn valve allows air to enter the helmet but not to flow back out, or return. It is the most important valve in a diver's line. The above (OSHA) standards apply equally to the mixed-gas mode of diving.

A diver using light-weight gear (Figure 8) must wear safety harness, weight belt, light-weight face mask with associated valves and connections, diving dress, consisting of wet or dry suit, gloves, shoes, or fins, ankle weights, watch, and knife.

A diver using heavy gear must wear helmet and breastplate (Figure 9) with associated valves and connections, weight belt, diving dress that encloses the body (except for head and hands) in a tough, waterproof cover, life line, gloves, knife, helmet cushion; and lead-bottomed weighted shoes

of 24 lbs each. The diver may wear metal ankle weights attached to the shoes by straps in lieu of weighted shoes.

Figure 7. Commercial diving gear.

A helmet may have a telephone recess, with an air "gooseneck" attachment at the back of the helmet; breastplate is secured to the diving dress by straps. A jockstrap passed between the legs holds the belt in place and keeps helmet from floating off the diver's shoulders.

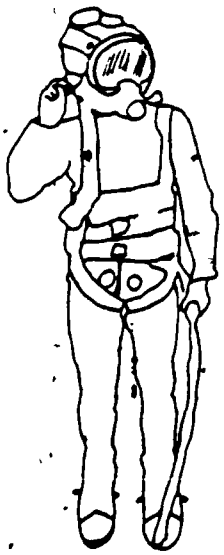

Figure 8. Light-weight diving gear.

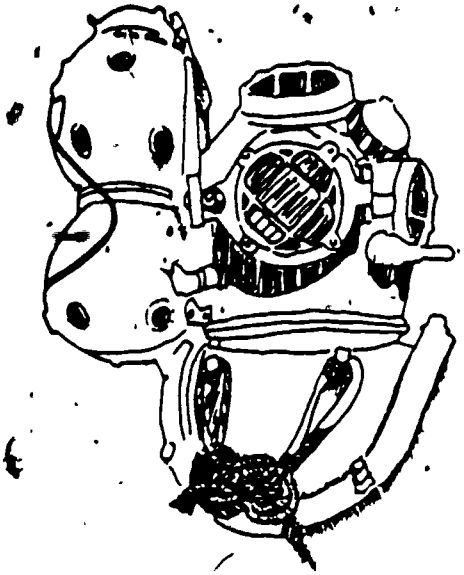

Figure 9. Diving helmet and breastplate.

**ACTIVITY 6:**

Name four items of protective gear that should be worn by a diver using heavy gear.

1. _____
2. _____
3. _____
4. _____

**OBJECTIVE 7:** List four questions that should be answered before a diver considers taking a particular job.

All dive team members must have either experience or training in the use of the tools, equipment, systems, the techniques, operations and emergency procedures relevant to both the task and the diving mode. Each member should also have had training in cardiopulmonary resuscitation and first aid.

A great deal of preplanning is necessary before a dive actually takes place. Prospective members of the dive team should be briefed as to the following:

- The diving mode to be used.
- The depth at which they must work.
- The equipment needed for the dive.
- The type of work to be done.
- The tools to be used.

If a diver is in doubt about any of the job requirements, if he or she is temporarily ill, or simply inexperienced in some phase of the operation, then it is wise to refuse to take part in the dive. No diver is obliged to participate in a dive, and employers are often the first to agree.

OSHA requires that a person be designated by the employer to oversee all safety and health aspects of the dive. Because diving is such a high-risk occupation, this person should have knowledge of the physiological as well as psychological stresses involved.

**ACTIVITY 7:**

Name four items of predive information that a diver should ask about before signing on for a job.

1. _____
2. _____
3. _____
4. _____

**OBJECTIVE 8:** Discuss equipment that should be checked upon arrival at the site.

Faulty equipment can cost lives! Upon arrival at the site, every item involved in the dive should be thoroughly tested.

Air compressor systems, as illustrated in Figure 10, that are used to supply divers must be equipped with a volume tank that has a check valve on the inlet side (to prevent loss of air if compressor fails), a pressure gage, a relief valve, and a drain valve (to drain water from the volume tank). Air compressor intakes must be located away from exhaust or other contaminants (OSHA). The system must be inspected feature by feature: the oil, fuel, and battery water should be checked. The engines should be started and stopped to make sure that they run well.

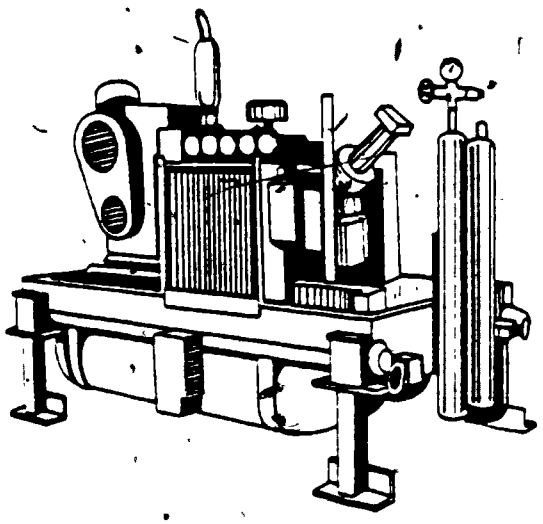

Figure 10. Air compressor system.

The bell-handling mechanism, if it is to be used, must pass rigid inspection. Special attention must be given to the diver's exhaust and non-return valves; to their air hoses

and telephone lines. OSHA requires that each diver's depth-time profile must be monitored by a depth gage which can be read at the dive location. Scuba divers who have no communication with the surface carry their own gage.

There must be a check of all tools to be used in the operation, including underwater flashlights. Certain emergency tools are to be set aside to be sent down with the standby diver who must be available at the location to assist any member of the team; they are 12" crescent wrench, 12" pipe wrench, #4 hammer, and underwater flashlight.

Hand-held power tools must be de-energized before put into or retrieved from the water, and they should not be supplied with power from the dive site except as requested by the diver. For welding and burning operations, insulated gloves are required and must be inspected (OSHA).

A functioning decompression chamber should be available and read for instant use if dives are to be deeper than 100 feet. The decompression chamber must be checked before each dive to see that all equipment is working properly.

The tender must also set up and test the diving phones and is required, when the chamber is in use, to remain constantly beside the chamber and near the phones.

Other necessary equipment includes the Red Cross handbook on first aid; a first aid kit for diving, capable of use under hyperbaric pressure; and a bag-type manual resuscitator with transparent mask and tubing. These items, too, should be safety-tested (OSHA standards).

**ACTIVITY 8:**

Name three pieces of equipment to be inspected predive; name the items to be inspected on each piece.

1. _____
2. _____
3. _____

**OBJECTIVE 9:** Name the equipment that should be inspected before entering the water.

Just before the dive takes place, there should be inspection of every device that concerns a diver's personal safety. The breathing gas supply system, including reserve gas, needs particular attention.

Masks, helmets, and thermal protection must be guaranteed secure. Control valves of helmets should be opened to bleed off air in the hose. All clasps, buckles, release features, and joinings of the harness/safety-belt rig should be tested; tenders should double-check life lines.

An operational two-way voice communication system must be used between each surface-supplied air (or mixed-gas) diver and a member of the team who remains at the dive location. It is extremely important for this system to operate without fault. Once in the water, the diver must depend on surface-supplied information that is often vital. There must be, in addition, a two-way communication system (not necessarily voice) available for obtaining emergency aid (OSHA requirements).

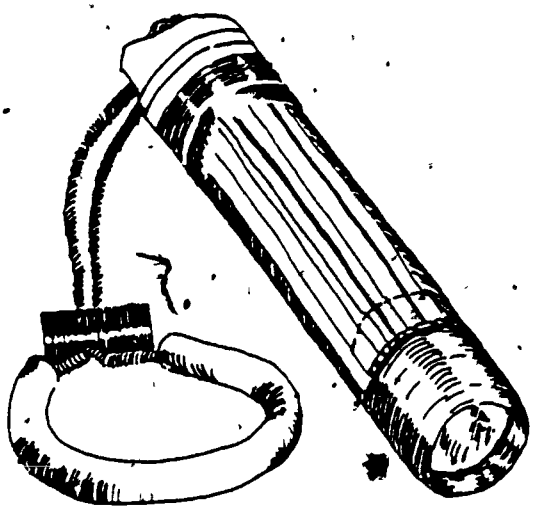

Figure 11. A diver's flashlight.

Make sure that the divers carry their accessories: flashlights (Figure 11), watches, and knives. A diving knife is an ingenious protective tool. One side of it is a saw; the other a blade. When not in use, the knives are placed in the sheath, which has a ring on the back so that the knife may be secured to the diver by a piece of line. If the knife should fall, it can be pulled back up rather than disappear into the depths. A knife is sometimes essential for cutting oneself loose in the event of entanglements; for cutting rigging, for minor sawing, and for other odd jobs.

Wind all underwater stopwatches and let them run for half-an-hour before the dive begins. Check to see that the watches remain synchronized - never issue one that has malfunctioned.

A timekeeping device to monitor the diver's depth and downtime must be kept at every dive location.

Unique hazards (strong currents, no visibility, treacherous bottom, jagged rocks, frigid water) must be identified and provided for. Sometimes hazards are caused by other diving activity in the area, or diving takes place near a busy shipping lane. In these cases, OSHA requires that you attempt to coordinate your operations with those of other parties involved.

**ACTIVITY 9:**

Of the equipment which should be inspected predive, name the items you consider most vital.

_____

_____

## REFERENCES


U.S. Dept. of Labor. Questions and Answers About the OSHA Standards for Commercial Diving Operations. Washington, DC: OSHA, 1979.

_____. General Industry. Revised November 7, 1978. (29 CFR 1910).

U.S. Navy. U.S. Navy Diving Manual.


## ANSWERS TO ACTIVITIES

ACTIVITY 1

(Any three.)

1. Meniere's disease (dizziness, vertigo).
2. Heart block.
3. Diabetes.

4. Skin diseases.
5. Blockage of eustachian tubes.
6. Nose/throat problem that does not respond to treatment.
7. Pneumothorax (collapsed lung).
8. Necessity for regular medication (anthihistamines, steroids, barbiturates, mood-altering drugs).

ACTIVITY 2

(Any eight.)

1. Chest X-ray, EKG, visual acuity and color blindness tests, hearing tests, hemocrit or hemoglobin count, sickle cell index, white blood count, and urinalysis.
2. Yearly.

ACTIVITY 3

1. Internal ear squeeze - prevent by: equalizing ear pressure upon descent; never diving with blocked eustachian tubes.
2. Exhaustion - know your physical limitations; know your equipment's limitations; try never to panic.
3. Nitrogen narcosis - locate air compressor away from exhaust; reduce partial pressure of $N_2$.
4. Carbon monoxide poisoning - use less CO in diver's air; use proper machine lubricants.
5. Hyperventilation - reduce hyperventilation during descent; breathe normally - avoid deep breathing to the point of light-headedness.

ACTIVITY 4

(Any three.)

1. Colds.
2. Nasal/sinus conditions.
3. Sore throat.
4. Nausea or bowel or stomach upset.
5. Any ear problem.
6. Overindulgence in alcohol.

ACTIVITY 5

1. Scuba diver - carried compressed air; depth limit 130 feet.

2. Surface-supplied air - depth limit -190' unless bottom time is 30 minutes or less, in which case, 220'.
3. Mixed-gas surface-supplied oxygen rebreathing apparatus and oxygen.

ACTIVITY 6

(Any four.)

1. Helmet.
2. Breastplate.
3. Weight belts.
4. Tough, waterproof diving dress.
5. Life line.
6. Gloves.
7. Knife.
8. Watch.
9. Helmet cushion.
10. Lead-weighted shoes.
11. Ankle weights.

ACTIVITY 7

(Any four.)

1. Diving mode to be used.
2. Depth at which diver must work.
3. Equipment needed for dive.
4. Type of work to be done.
5. Tools to be used.

ACTIVITY 8

1. Air compressor.
2. Bell-handling mechanism.
3. Decompression chamber.
4. Red Cross first aid kit for diving, usable under hyperbaric conditions.

ACTIVITY 9

Every device that concerns a diver's personal safety.