OCCUPATIONAL SAFETY AND HEALTH STANDARDS FOR GREAT LAKES COMMERCIAL DIVING OPERATIONS

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PREFACE

The purpose of this report is to provide a basis for development of occupational safety and health standards for diving contractors and divers working in the Great Lakes area and to provide guidelines to regulatory agencies for preparation of governmental regulations in commercial and industrial diving operations. It is not intended that provisions in this report or standard are to supercede any governmental regulations, present or proposed.

INTRODUCTION

Persons involved in underwater diving operations are subject to certain occupational risks. In order to protect workers from unnecessary injury or unacceptable risks, certain standards of medical fitness, operational procedure, and equipment must be recognized and compiled. Such standards must be specific and enforceable for adequate protection of the individual worker, but must not be so "unreasonable" as to prohibit underwater work from an economic and operational requirement standpoint.

Diving technology is a rapidly expanding science, and the variations in technique and task complexity experienced throughout the industry are vast. For many years industry, standards committees, federal agencies, scientific/educational groups, diver's associations, and so forth have studied and assessed regional differences in diving practices, personnel requirements, and equipment. In addition to regional differences in these areas, there is a significant difference in these same areas between different diving groups or activities. Although all divers do work in the marine environment and are subject to the same inherent physiological effects of exposure to hyperbaric conditions, there is a vast difference in the extent of exposure, task complexity, and philosophy between the various groups. A single standard should not be applied to all underwater workers.

The various diver/operational categories that currently appear to be significantly different include:

1) Recreational scuba diving
2) Recreational scuba diving instruction
3) Search, rescue, and related public safety diving
4) Experimental diving involving human subject experimentation and diving apparatus/ procedure research
5) Scientific/educational diving involving primarily, but not exclusively, marine environment research
6) Shallow-water inland or inshore commercial diving
7) Deepwater or offshore saturation diving
8) Scientific saturation diving
9) Industrial saturation diving
10) Military diving

It is likely that two or more of the above categories could be addressed in the same standard. However, it is unreasonable to address all categories of civilian diving under one general standard. The diving mode and philosophy of one group may be so completely different from that of another that the presentation of a standard based primarily on the mode and philosophy of one group may actually provide a basis for erosion of the community consensus standard of safe diving practices of the other group(s).

Consequently, this report is limited to: (1) diving in commercial and industrial situations, (2) operations in inland and territorial waters of the United States defined as the Great Lakes Basin, and (3) shallow-water diving operations in which the diver's working depth does not exceed 220 fsw and compressed air is the primary breathing gas.

BACKGROUND INFORMATION

The most recent activity in the development of occupational safety and health standards for diving was initiated on 8 August 1975 by a petition from the United Brotherhood of Carpenters and Joiners of America, AFL-CIO, presented to the Secretary of Labor. This petition stated that a situation of grave danger existed within the diving industry and urged that an emergency temporary standard be issued covering diving operations to protect exposed employees. Hearings followed and an Emergency Temporary Standard (ETS) was issued on 15 June 1976 (Federal Register, Vol. 41, No. 116). Diving contractors filed suit in the U.S. Court of Appeals of the Fifth Circuit and an indefinite stay of the ETS was issued on 11 August 1976 pending a final decision on the validity of the agency's (OSHA) action. The ETS was not enforced by OSHA.

A proposed permanent standard for Commercial Diving was published on 5 November 1976 (Federal Register, Vol. 41, No. 215) and public hearings were scheduled in New Orleans during December 1976 and January 1977. A total of 81 individuals representing virtually all facets of the diving community and supporting groups appeared at the hearings as witnesses.

Based on a review of the record of the hearings plus numerous items of information submitted to OSHA, a final standard for Commercial Diving Operations was issued on 22 July 1977 (Federal Register, Vol. 42, No. 141). This standard is to be effective on 20 October 1977, except provisions requiring decompression chambers or bells. If such equipment is not yet available, employers shall comply as soon as possible thereafter but in no case later than six months after the effective date of the standard. For further historical information on OSHA involvement in commercial diving standards consult the Federal Register, Vol. 42, No. 141 (Appendix B); Vol. 41, No. 215, and Vol. 41, No. 116.

If the existing OSHA standard is, in fact, law, why is this publication being prepared? Regardless of the conclusions of the Occupational Safety and Health Administration, the standard is <u>not</u> applicable to the entire diving community. It is a commercial diving standard designed for operations where surface-supply is the primary diving mode and the task complexity and risk exposure are extremely greater than that of other diving groups. There are fundamental weaknesses in personnel requirements and operational practices as well as unnecessary and unreasonable requirements imposed on other areas of diving by the OSHA regulations. There is a basis for variances from OSHA regulations as they now stand, especially for scientific/educational diving.

The Department of Labor has only recently become involved in the development of health and safety standards for diving. The American National Standards Institute Z-135 Committee activities began early in 1968 under the sponsorship of the Marine Technology Society's Committee on Man's Underwater Activities. Work continued on the development of commercial diving standards until 1973 when, for a number of complex and emotional reasons, work ceased. In 1975 a committee of the Association of Diving Contractors reviewed the drafts of the Z-135 standards and published its Manual of Safe Practices in Commercial Diving Operations based largely upon the Z-135 work.

The Z-135 project was reorganized in 1974. Both OSHA and the United States Coast Guard gave general encouragement, particularly citing the importance of ANSI industry consensus standard techniques. At the time of reorganization both labor (the Carpenter's Union) and diving management took a positive and supportive position. In 1976 and early 1977 the re-constituted ANSI Z-135 Committee combined previously proposed standards into a final draft standard which was circulated in accordance with ANSI procedures for vote and comment. The historical comments on the Z-135 Committee were taken in part from testimony given at the OSHA Public Hearing on American Diving Standards by Capt. W.F. Searle, U.S.N. (Ret), December 1976 at New Orleans.

It should also be noted that historically the various procedural manuals of the United States Navy have provided a basis of many of the standards of safe diving practices within the civilian diving community. However, the scope and magnitude of commercial diving has changed so radically during the last decade, most industrial authorities agree that the U.S. Navy standards and procedures, in themselves, are unacceptable for application, in their entirety, to today's commercial diving operations.

The scientific/educational diving community has operated under community consensus standards for nearly two decades. Scientific/educational applications of scuba diving developed extensively at the Scripps Institution of Oceanography, University of California in the 1950's. Although several colleges, universities, and research agencies used diving to varying degrees in their programs, Scripps, under the early leadership of Conrad Linbaugh and, later, James R. Stewart, took the lead in scientific diver training, certification and the development of health and safety standards for scientific/educational divers. The University of California's The University Guide for Diving Safety has served as a basis for the development of numerous diving safety programs at colleges, universities, and research agencies throughout the country. This publication is periodically reviewed and revised by University of California campus Diving Officers and Environmental Health and Safety Officers.

On 27 March 1973 representatives of diving safety boards and committees of ten major institutions participating in scientific/educational diving met at the University of Washington in Seattle to discuss University diving safety. At that meeting it was a consensus agreement that the Univeristy of California standards for scientific/educational scuba diving safety would continue to serve as a primary basis for scientific/educational diving programs throughout the country. A significant number of institutions presently adhere to these standards with certain modifications for regional and operational variations in diving. The University of Miami developed a specific diving training and safety standard which differs in specifics but agrees in concept with that of the University of California. The National Oceanic and Atmospheric Administration operates under a separate and distinct standard specifically developed for that agency's scientific divers.

Clearly, the scientific/educational community has and adheres to specific and rigid diving health and safety standards. The success of these standards is evident by the historically low accident rate in scientific/educational diving operations.

STANDARD PREPARATION

The University of Michigan researchers are well aware of the problems involved with both inshore and offshore diving operations. An active diving program including hyperbaric chamber operation, lake and ocean diving operations, diving research, saturation diving and related activities has been conducted at the University since 1966. In addition to standard scuba used by many scientific/educational divers, surface-supplied diving apparatus of the type commonly used by military and commercial offshore divers is used extensively in the University's program. Based on ten years of operational diving at the University of Michigan and a relatively comprehensive understanding of commercial diving, the authors are in a position to objectively evaluate various existing standards.

Sources of Information

As previously stated there are considerable variations in diving techniques, task complexity, and working environments throughout the diving industry. Consequently, data for this project was collected from a variety of sources. The Department of Labor's Occupational Safety and Health Administration Emergency Temporary Standard for Diving Operations (Federal Register, Vol. 41, No. 116), the Proposed Commercial Diving Standards (Federal Register, Vol. 41, No. 215) and the Commercial Diving Operations Occupational Safety and Health Requirements (Federal Register, Vol. 42, No. 141) provided a substantial amount of the information that is used in this report.

In addition to the various OSHA proposed standards, the OSHA/U.S. Coast Guard public hearings on the proposed standards held in New Orleans on 16-21 December 1976 and 10-14 January 1977, provided extensive insight into the views and opinions of offshore and shallow-water divers, diving contractors, large corporate and small business employers, instructors, marine scientists, hyperbaric physiology and medicine specialists, equipment specialists, and other interested parties. These hearings and the International Diving Symposium '77 provided an excellent opportunity to interview numerous divers, contractors, equipment specialists, and others.

Dr. Somers served as a member of the American National Standards Institute/Marine Technology Society Z-135 Committee on Safety in Commercial and Professional Diving Operations.

Data from notes made during these committee meetings and various draft standards provided considerable insight into the opinions of contractors, labor, and other authorities. It should be noted that the collective opinion of this group of authorities did differ significantly in some areas from that of OSHA.

In addition to OSHA, the current Z-135 Committee and interviews, the following publications were also reviewed:

Association of Diving Contractors, "Manual of Safe Practices in Commercial Diving Operations" (New Orleans: Association of Diving Contractors, 1975).

Compressed Gas Association, "Methods for Hydrostatic Testing of Compressed Gas Cylinders", Pamphlet No. C-1 (New York: Compressed Gas Association).

Compressed Gas Association, "Standards for Visual Inspection Of Compressed Gas Cylinder", Pamphlet No. C-6 (New York: Compressed Gas Association).

Compressed Gas Association, "Suggestions for the Care of High-Pressure Air Cylinders for Underwater Breathing", Pamphlet No. P-5 (New York: Compressed Gas Association).

Compressed Gas Association, "Compressed Air for Human Respiration", Pamphlet No. G-7.0 (New York: Compressed Gas Association).

Compressed Gas Association, "Commodity Specification for Air", Pamphlet No. G-7.1 (New York: Compressed Gas Association).

Department of the Interior, "Underwater Operations", BCF Manual (Washington, D.C.: Bureau of Commercial Fisheries, 1970).

Federal Register (Department of Labor, Occupational Safety and Health Standards, Vol. 36, No. 105, Part 11, 1971).

Federal Register (Department of Labor, Occupational Safety and Health Administration, Safety and Health Standards for Maritine Employment Volume 37, No. 203, Part 11, 1972).

Federal Register (Department of Labor, Occupational Safety and Health Standards, Vol. 37, No. 202, Part 11, 1972).

Federal Register (Department of Labor, Occupational Safety and Health Administration, Safety and Health Regulations for Construction, Vol. 37, No. 243, Part 11, 1972).

Flemming, N. and Miles, D. (ed.), "Underwater Association Code of Practice for Scientific Diving " (London: Natural Environment Research Council, 1974).

Galletti, J., "Proposed Safety Standards for Commercial Diving Equipment", Undercurrents (January, 1970).

Galletti, J., "Diving Equipment Standards", Recommendations of the American National Standards Institute Z-135 Committee (1972).

Graziano, R. "Tarill No. 27: Hazardous Materials Regulations of the Department of Transportation" (1973).

Hughes, M., "Diving Procedures Standard", Preliminary Recommendations of the American National Standards Institute Z-135 Committee (1971).

Interstate Electronics Corporation, "Oceanics Division Diving Manual", (Anaheim, California: Interstate Electronics Corporation, 1971).

National Oceanic and Atmospheric Administration, "Diving", NOAA Circular.

Neary, R., "Equipment Cleaned for Oxygen Service", Pamphlet No. G-4.1 (New York: Compressed Gas Association, 1959).

Oregon State University, "Diving Guide" (Portland: Department of Oceanography, Oregon State University, 1971).

Schroeder, W. and W. Fife, "University Guide for Diving Safety", Sea Grant Publication No. TAMU-SG-70-602 (College Station, Texas: Texas A & M University, 1970).

Somers, L., "Diving Safety Bulletin", Technical Report 4 (Ann Arbor: Sea Grant Program, The University of Michigan, 1971).

Somers, L., "Research Diver's Manual", MICHU-SG-71-212, Technical Report No. 16 (Ann Arbor: Sea Grant Program, The University of Michigan, 1972).

Somers, L. and M. Nemiroff, "University of Michigan Hyperbaric Chamber Attendant's Handbook", MICHU-SG-74-601 (Ann Arbor: Sea Grant Program, The University of Michigan, 1974).

State of Michigan, Marine Safety Act of 1967.

State of Oregon, "Commercial Diving and Compressed Air Work", Chapter 25 of the Oregon Safety Code for Places of Employment (Salem, Oregon: Workman's Compensation Board,' 1972).

Stewart, J., "Procedures for Shipboard Diving and the University Guide for Diving Safety", IMR TR-23, Sea Grant Publications No. 15 (La Jolla, California: Scripps Institution of Oceanography, 1971).

University of Southern California, "Diving Regulations", (Los Angeles: Santa Catalina Marine Biological Laboratory, University of Southern California, 1973).

University of Washington, "Guide for Diving Safety and Interim Implementation of Guide for Diving Safety" (Seattle: University of Washington, Environmental Health and Safety Department, 1972).

U.S. Navy, "U.S. Navy Diving Manual", NAVSHIPS 0994-001-9010 (Washington D.C.: U.S. Government Printing Office, 1970).

U.S. Navy, "U.S. Navy Recompression Chamber Operator's Handbook", NAVSHIPS 0994-014-5010 (Washington, D.C.: Department of the Navy, 1973).

Format

The format used in the presentation of this standard differs from that used by OSHA or ANSI/MTS Z-135. This standard consists of the following sections:

Section 1: Purpose, Scope, and Application
Section 2: Definitions
Section 3: Personnel Qualifications/Requirements
Section 4: Medical Requirements
Section 5: General Operations Requirements
Section 6: Self-Contained Air Diving
Section 7: Surface-Supplied Air Diving
Section 8: Decompression Chambers
Section 9: Recordkeeping Requirements

Equipment requirements for self-contained air diving, surface-supplied air diving, and decompression chambers were separated into separate respective sections instead of having one section on equipment. Many groups will use shallow-water scuba diving exclusively and have no need for the sections on surface-supplied diving or decompression chambers. The separation of diving modes is less confusing and more convenient.

Where possible the wording used by OSHA in the final publication of the Commercial Diving Operations Occupational Safety and Health Requirement was incorporated into this standard. In some areas the specific wording from proposed standards of the ANSI/MST Z-135 Committee was used.

DISCUSSION

Purpose, Scope and Application

The Occupational Safety and Health Administration clearly designates that, by law, the Commercial Diving Operations Occupational Safety and Health Requirements shall apply wherever OSHA has statutory jurisdiction. Diving outside of the Outer Continental Shelf is not covered by an OSHA standard nor is diving in coastal or inland waters not specifically designated as "United States and possessions" as listed in Section 4(a) of the Act 29 U.S. 655. United States citizens and employed divers operating in foreign waters may be subject to regulations or standards imposed by foreign governments. However, in many instances there are no suitable standards enforced. Consequently, standards should be extended to cover such situations so that the employee and employer are protected by a standard equivalent to those imposed within United States waters. This is extremely important in the Great Lakes since U.S. employed divers may easily operate in Canadian waters. An employer or employee could "technically" ignore the United States OSHA standard on a basis of statutory jurisdiction and thus endanger the health and safety of the diver.

The 22 July OSHA Commercial Diving Operations Standard specifically applies to diving and related support operations conducted with all types of work and employments over which OSHA has jurisdiction, except in cases where exclusions from the standard have been explicitly provided. Specific exclusions have been provided where the nature of the diving operation is such that inclusion in this standard would be inappropriate, or where the safety and health of divers is governed by rules or regulations of another federal agency. The three exclusions are:

(1) Instructional diving utilizing only open-circuit compressed air scuba within the no-decompression limits;

(2) Search, rescue, and related public safety diving by or under the control of a governmental agency; and

(3) Diving governed by the Protection of Human Subjects Regulations of the Department of Health, Education and Welfare, (HEW) or equally effective rules or regulations of another federal agency.

In earlier versions of the OSHA standard scientific/educational divers whose operations utilized open-circuit compressed air scuba and were conducted within the no-decompression depth-time limits were excluded. In addition, no distinction was made between the shallow-water inland or inshore diving operations and the deep-water offshore diving operations.

OSHA apparently concurred with the opinion of several parties including the Construction Advisory Committee that the record does not support a conclusion that "the work conditions and risk exposure of scientific divers differ measurably from those of commercial diving (p. 37655, Federal Register, Vol. 42, No. 141)." It is further stated that "no valid distinction can be drawn between commercial diving and that performed by the excluded groups (scientific/educational divers), because divers in both groups are employees, both work in the same marine environment, and both are subject to some of the same inherent hazards and physiological effects. It has been stated that scuba diving is at least as hazardous as surface supplied diving (p. 37654, Federal Register, Vol. 42, No. 141)."

In our opinion scientific/educational diving operations should be excluded from the present OSHA Commercial Diving Operations Standard (Part 1910 of Title 29 of the Code of Federal Regulations, Subpart T). The following reasons are stated:

(1) Based on data provided by Glen Egstrom, Ph.D., of the University of California, Los Angeles Sea Grant Diving Safety Research Project (17 August 1976, personal communication) the accident rate in scientific/educational diving is not sufficient to warrant the imposing of rigid and, in some cases, unreasonable or unjustifiable standards by OSHA. During the period of 1965-1975 13 colleges or universities and 24 other scientific and research agencies documented 219,016 research dives, 15,149 training dives, 360 decompression dives and 7,697 recreational dives, with only 4 pressure related accidents. The accidents included 2 cases of decompression sickness and 2 fatalities. The fatal accidents included one surface drowning and one apparent "congenital defect." Minor occurrences of ear infections, cuts and abrasions, and so forth were not documented.

(2) The present OSHA standards impose some requirements that are unjustifiable and unreasonable for the scientific/educational community to comply with. Mandatory compliance will, in many instances, result in alternative actions such as cancellation of research projects vital to the study of the marine environment because of unacceptable logistical and economic burdens; severe limitations on the development and advancement of scientific educational diving; and forcing researchers to pursue in-water research activities "on-their-own-time"

technically outside of their scope of employment thus circumventing both existing local agency/ university standards and OSHA standards and thus constituting potentially uncontrollable hazardous situations.

(3) The provisions of the present OSHA Commercial Diving Operations standard are in some instances inadequate and suggest acceptable standards of practice below the present "standard of the scientific/educational community." This is particularly significant in the area of scuba diving and personnel training and qualifications.

(4) In contrast to commercial diving operations the location and subsequent environmental conditions are not generally determined by the particular task and the diving operations are not generally conducted under adverse environmental conditions. The scientific/ educational diver can select both the task and environmental conditions consistant with his/her training, physical condition, and experience. For the most part, scientific/educational diving task assignments and environmental exposure are rigidly controlled by the university, agency, or individual diver.

(5) In contrast to the surface-supplied diving mode orientation of the commercial diving community, the scientific/educational diver is oriented toward the scuba diving mode. Consequently, procedures and standards that are deemed unsafe or unreasonable by the "commercial" diver, and in fact may constitute significant hazard in commercial diving, are readily accepted as "safe practices" by the scuba-oriented "scientific/educational" diver.

(6) With very few isolated exceptions, scientific/educational divers do not utilize construction tools, handle explosives, or use welding or burning equipment.

(7) Scientific/educational diving operations are shallow water oriented. Of 220,411 dives reported in the UCLA study previously mentioned, 191,952 (87%) were conducted in depths of 60 fsw or less. Only 360 (0.16%) involved decompression.

(8) Because of the nature of underwater scientific investigation, the scientific/educational diver is rarely exposed to adverse sea states, great depths, or heavy work loads, some or all of which are common to the great majority of commercial diving operations.

(9) The scientific/educational diver, with few exceptions, is not employed as a diver. He/she is employed as a scientist, researcher, or scientific technician. Diving is secondary to the primary job description.

(10) The scientific/educational diving community has operated under explicit, self-imposed diving regulations or standards for over two decades. Most universities, colleges, and research agencies engaged in significant diving operations have published and proven standards. Many have diving safety control boards or committees and diving safety officers or coordinators. Many base their standards and diving programs on those developed and continuously upgraded by the University of California. For the most part these standards are more rigid than those proposed in the OSHA Commercial Diving Operations Standard. The success of these scientific/educational diving community consensus standards is evident, in part, by the very low accident rate in scientific/educational diving operations.

Should the same standard apply to shallow-water diving operations where air is the primary breathing gas as to the offshore deep water diving operations where breathing mixtures other than air are used more extensively? Many shallow-water commercial diver employers object to being covered by the same standard which is used for offshore diving operations.

The following comments taken from the Occupational Safety and Health Reporter: Current Report (1976) reflect opinions consistent with those of many inland or inshore small diving representatives:

P. 891

Juan F. Crofton, president of the Crofton Diving Corporation, Norfolk, Va., said he 'does not object to standards and rules as applied to the safety of our personnel . . . but we do strongly object to the federally proposed rules as they are not applicable to the shallow water diving industry and are grossly inflationary and could possibly force the dissolvement of our corporation.'

'These standards are directed solely toward the deep diving industry, the hazards of deep water diving, and in no way reflect the working conditions of the shallow water harbor diving industry,' Crofton said.

C.F. Logan, president of the Logan Engineering and Contracting Company, Jacksonville, Fla., criticized the proposed standards for making no distinction between shallow water and deep sea divers. Logan said these are 'two completely different professions.'

Jack S. Mixer, vice president of Logan Diving, Inc., Jacksonville, Fla., disagreed with the proposed medical requirements 'as being largely unnecessary for shallow water diving, which composes all of my business.'

'Upon repeated request to OSHA, the Coast Guard, and other knowledgeable bodies, I have not received any evidence of any diving accident caused by non-compliance with medical requirements,' Mixer said.

Crofton also disagreed with the medical requirements of the proposed standard. 'We feel that a general physical examination of a diver upon employment is sufficient for shallow water diving and all other physical requirements as specified in the proposed standards are unnecessary,' he said.

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OSHA's inflation impact assessment for the proposed standard 'borders on the ridiculous,' Wilson said. He noted that of the approximately 400 diving contractors in the United States, OSHA only interviewed nine on the cost of the proposed regulations.

Russell J. Judah, director of environmental and industry affairs, Transcontinental Gas Pipe Line Corporation, criticized OSHA's inflation impact assessment because it did not consider the cost of additional equipment required by the proposal. For example, he said that a fully manned barge to support a diving bell would cost his company $20,000 per day in rental fees and that OSHA did not talk about such costs in its assessment.

Gaspar, who said that his company usually employs three to eight divers, said that he expected his initial cost of compliance to be between $90,000 and $100,000, adding that this would put him out of business. His business is financed with a small business loan obligating all of his assests, which, Gaspar explained, would mean that he would 'probably have to declare bankruptcy.'

After the initial costs, Gaspar estimated the annual cost of compliance at $36,800.

'Don't take the attitude that industrial divers will have to merge with other divers or go out of business,' Gaspar said. In its inflation impact assessment, OSHA found that ' a limited number of firms may be forced to merge or go out of business as a result of the proposed standard.'

Harter, who is a small in-shore diving contractor, estimated that his first year compliance costs would be $53,000.

Judah said that any increased cost will be paid by the public, not by industry, and noted that in the case of his company it will mean higher prices for natural gas.

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The Council on Wage and Price Stability criticized the Occupational Safey and Health Administration's proposed standard for commercial diving operations because, it said, 'there is no evidence that the standards will measurably lower the industry's fatality rate' and because the cost of compliance would have a 'sever' impact on smaller firms.

The council also said that 'OSHA's estimate of annual costs of compliance appears to understate total costs that will be passed on to consumers' and that the proposal may 'adversely affect the nation's energy supply.'

William Lilley III, the council's acting director urged OSHA 'to acquire a sense of perspective about this issue. Here is an industry composed of a large number of individual entrepreneurs, many of whom are ex-divers. The divers are true professionals who know well the risks attendent on their jobs; their pay, ranging from $20,000 to over $45,000 per year, reflects the skill and risk involved. If these standards were effective in reducing those risks - an assumption which is questioned in this anaylsis - this high level of compensation might well be reduced.'

The council made its statement on the proposed standard before OSHA and the Coast Guard, at joint public hearings in New Orleans, La, held to consider the proposal (Current Report, January 20, p. 1080).

Concern was expressed by the council that the proposed standard's cost of compliance might put small firms out of business and increase the concentration in an industry where the 10 largest firms already employ more than half the divers currently working. The other divers are spread out among more than 400 firms.

OSHA concluded in its inflation impact assessment that the standards would cost $22 million per year, but the council cited industry figures stating that the cost may well exceed $70 million per year. The council's statement questioned OSHA's conclusion that the cost of the standard did not require the preparation of an inflation impact statement.

The council noted that a large proportion of divers are employed by petroleum firms to monitor undersea pipelines and to respond to accidental breakages. It then suggested that the imposition of these standards might create a temporary shortage of divers and suggested that the increased expense could lead to lower maintenance on these pipelines and thus to greater loss of energy and frequent environmental threats through breakages.

The effectiveness of the proposed standard was questioned by the council, which cited evidence that many fatalities are attributed to 'human error.'

'It seems to us that first priority should be given to the problem of developing properly trained and responsible personnel, an issue which the standards do not address,' the council said.

James C. Miller III, the council's assistant director for governmental operations and research, expressed concern about OSHA's overall approach, stating that 'not only are engineering controls less cost-effective than some means of financial incentive (such as fines or penalties), but the idea that each work environment must be equally safe and healthful ignores the realities of cost, different preferences among workers about the riskiness of the work environment and wages earned, and the public's interest in having the greatest impact on worker health and safety for the resources spent.'

Mr. David L. Groover, Commercial Diving Service, Grand Rapids, Michigan kindly supplied the authors with his comments relative to the Emergency Temporary Standard for Diving Operations (Federal Register, Vol. 42, No. 116, June 15, 1976). Mr. Groover operates a small operation, engaged almost strictly in construction diving on and around Lake Michigan. Several of the comments directed toward the Emergency Temporary Standard are also relevant to the present OSHA Commercial Diving Operation Standard (Federal Register, Vol. 42, No. 141, July 22, 1977). It is probable that Mr. Groover's comments also reflect the opinions of other "small" diving firm employers operating in the Great Lakes area. Mr. Groover clearly states, however that "the comments are purely mine, based on my own opinions and experience; I have not acted as a spokesman for any other one or organization (personal communication, 17 February 1977)." The following comments are taken from Mr. Groover's comments on the Emergency Temporary Standard:

Medical Requirements

I agree that perhaps for large-scale operations, particularly those conducted offshore in deep water, and those using saturation and mix gas techniques, physicals of some sort should be carried out on the divers. However, as my situation does not involve such operations, I must reserve my comments on that point of view, and present my own.

This is perhaps the most objectionable part of the standard in regards to small operators such as myself. My business is seasonal, (though I do work the year round when there is work and I can get it) and there is no way that I can keep a crew

on a regular basis. Most of the jobs that do come in, do so on very short notice, sometimes only a matter of hours. In such cases, I must go the rounds of any number of people who have and do work for me, to see who can make himself available. There is certainly no time for extensive medical prequalifications; and to give these examinations to all potential employees at the season's start, on the off chance that they may work sometime during the year, is an economically impossible gamble.

On the other hand, these men are all quite well known to me on a regular basis, including non-commercial diving expeditions. One does not have to be a doctor to determine whether a man has sinus trouble, epilepsy, is drunk, or otherwise unsuited for work. Aside from that, I, and every small operator with whom I am familiar, are very discriminating about whom we hire, as a matter of survival and common sense. Those of us who work on these levels do not view the world from report folders, memorandum sheets, and staff reports. We work on the front lines, and can see with our own eyes what is going on.

Again, I can not speak for large firms, but this particular standard is a little ridiculus for small operators; indeed, it is impossible regardless of how well it looks on paper.

Safe Practices Manual

In general, for certain items, this is a good idea. However, the wording ... 'develop and maintain a safe practices manual and shall follow the procedures set out in such manual for all diving operations' tends to eliminate the flexibility which divers need in order to work and ensure their own safety. It is also in conflict with the statement contained in the preamble to the Standards that recognizes that '... no single set of procedures can anticipate all operating situations. Sound judgement, an ability to recognize present or developing hazards, and maximum attention to personnel safety must continue to be the cornerstones of safe diving operations.'

The above sentence contains a lot of truth. Each and every diving job is different; no two are ever exactly alike, and no set of rules or procedures is ever going to cover all situations. For this reason, it is virtually impossible to develop a specific safe practices manual.

At the same time, small firms such as mine do not command a large staff of Harvard graduates capable of authoring a work of literary art. Nor can we afford the luxury of hiring consultants for such in-house work. This does not mean that we are incapable of burning off a mooring cell or floating a barge, but it does mean we can not give precise, step-by-step operational details beforehand.

I do agree that lists of emergency aid, first aid suppliers, fire-fighting equipment, and general or specific (as practicable) directions for given emergencies, such as those listed, are desirable. But foreseen emergencies are almost always circumvented, and unforeseen emergencies must be handled as they have been in the past, by having capable people with 'sound judgement' on the scene. Judgements must be made to reflect reality, rather than hoped-for conditions.

As for pre-dive instructions, no one begins a job without first learning as much about it as he can.

Scuba Diving Buddy System/Comments

In principle, I agree that phones should be used if possible, but there are circumstances when a lone SCUBA diver, without the aid of a tender or buddy, can or must be used. Such instances include dives around a dock, in the old ditch, etc., where the diver need only stand to get out of the water. Also, even in open water, under good conditions, a lone SCUBA diver may be safer. I will even be specific - in pitch darkness due to heavy silt, etc, a buddy diver is of little help, if any, value. At the same time, the risks of fouling a signal line are increased, which may hold the diver down. This is a rule that should not be strictly enforced under given circumstances, which have to be determined at the time.

I strongly advocate the mandatory use of a life vest, and a line from the diver to a surface float if he is required to operate at any distance from his platform. Personally, I have more faith in a

surface float than a buddy diver, but, again, all this has to reflect the conditions present at the time, and can not be adequately reckoned with beforehand.

Scuba Diving Air Supply Requirements

I agree with this for bottom times, but feel that a diver should be able to utilize auxiliary tanks tied off on the decompression line for use in decompressing. He need not even change tanks, merely insert the regulator in his mouth. This procedure is routine to anyone who calls himself a diver.

Ventilation Requirements for Surface-Supplied Helmets and Masks

We, as divers, have little or no control of this, except to buy appropriate equipment. I agree with the ventilating requirements, but feel that this should be directed more to the manufacturers. Also, (and I am not qualified to state with any certainty) it may be that some of the newer, light-weight open-circuit rigs on the market today, though they may not be able to pass 4.5 cfm, never-the-less do meet the requirements of a diver just the same.

Two-Way Audio-Communication Requirements

This is fine, and almost always done. However, I must point out two points for consideration.

First, I fail to see a significant difference between a hat diver's umbilical and a SCUBA diver's signal line for the purposes of relaying signals; why should one require a phone and the other not? Admittedly, the phone is more desirable and practical, but there is a certain inconsistancy in the rules here.

Secondly, under certain conditions, such as the old ditch again, a phone is not necessary, though I can not myself see a hat or mask not being provided with one. The point is, that the rule applies a blanket provision to all hats/masks under all conditions, with no allowances for specific conditions which may allow that the absence of a phone does not detract from a safe operation. Please allow us some flexibility.

Interval Marking of Gas Hoses

This is good, but I do not see that it should be anything but voluntary. Almost always, no more hose will be out than is necessary to reach the diver, and markings will not affect this distance. Also, shallow water hoses are often short enough that one can easily tell how much is out. I would agree to marking long hoses (in excess of 300 feet) used for deep-water work.

Oxygen Cleaning of Hoses

I am not familiar with this, but assume it involves mixed-gas operations; I use strictly air.

Equipment Records

As for the equipment log, I do maintain a system of records, but feel that your record requirements are a little far-reaching when applied to small operators. We know all of the items of our equipment individually, and well, because we are the ones who use them. Again, we run our affairs from the field, not a far-distant office building, through a staff. I know the history and condition of all my gear without having to open a record file. I think your records requirements could be toned down a bit.

Definitions

The list of definitions for the standard is relatively extensive. The purpose in providing definitions is to clarify the intent of specific terms as used in substantive provisions of the standard. In some cases, the same word or term has a different meaning, depending upon geographic location or segment of the diving community using the term. For example, "live boating" in commercial diving refers only to a surface-supplied diving practice where a diver is working from a vessel which is underway. On the other hand, the scientific/educational diver uses "live boating" in the context of a scuba diver towed behind a boat on an underwater diver's plane or shot line.

This report will be reviewed by many non-diving scientists, government officials, university officials, and members of the general public who are not familiar with diving terminology. In addition, many scientific/educational divers now subject to OSHA standards are completely unfamiliar with commercial diving terminology.

Personnel Qualifications

This is a very difficult section to prepare. Unlike the scientific/educational diving community, the commercial diving community does not appear to have a common standard of training or personnel advancement on a basis of experience. The Z-135 Committee has prepared a protocol for training, diving proficiency, and field experience. Unfortunately, at this time, there is significant dissatisfaction with this portion of the Z-135 standard. Imposing the scientific/educational community standard on the commercial diving community would be unacceptable. Consequently, we consider this as an area that will require further study. In the meantime, the standard requirements imposed by OSHA are included in this standard. Unfortunately, the OSHA standard is not adequate to provide guidelines for personnel training, qualification advancement or task assignment. For more information on the OSHA position on personnel qualifications see Appendix B.

Medical Requirements

The medical examination is, in our opinion, an important aspect of diving health and safety. Consequently, we support the requirement for the annual medical examination. The contents of the annual examination have been modified slightly from that required by OSHA.

One of the major deviations from the OSHA requirement is the designation of who shall bear the expense of the examination. OSHA requires the employer to bear all medical examination and test costs. This is acceptable for larger firms with relatively stable groups of diving employees. However, this is a very difficult and often unreasonable requirement for small firms which operate on a seasonal basis or use independent divers on a daily basis. It is virtually impossible and impractical to expect an employer to arrange for and bear the cost of examination for daily employees or seasonal employees who dive on a limited basis. In this case we feel that it is the responsibility of the employee to provide the employer with a notarized copy of his/her current medical examination report.

The medical requirement test which appears in this standard are basic examination requirements. The chest x-ray is necessary to detect gross pulmonary abnormalities and the physician is encouraged, at his discretion, to use pulmonary function evaluations. The standard EKG identifies certain cardiac abnormalities not detectable by auscultation. Many diving physicians prefer the use of a stress EKG for persons working in strenuous occupations. A hearing test is essential because hearing degradation is more probable in diving and high noise level environments (in chambers) than in many other industrial employments. Hearing is essential if the critical voice communications requirements specified in the standard are to be effective. Unfortunately, the level of hearing degradation that is considered disqualifying is not defined in either the OSHA or Z-135 standards. This is an area worthy of further study. Eventually this will have to be defined.

A visual acuity test is necessary to the extent vision may be relevant to job performance. As in hearing, the level of visual acuity that is disqualifying has not been defined by either OSHA or Z-135 standards. The basic medical examination and possible corrective measures. Vision is critical for safety, especially when working at the dive station as a tender, supervising overhead lifting, or for scuba divers on the surface. On the other hand, the diver working in poor visibility waters common to the Great Lakes would generally not find visual deficiency restricting. It is more vital that surface support personnel have adequate visual acuity. A color blindness test has been indicated because color coding is commonly used for piping and hose markings. Although not disqualifying in itself, the person-in-charge must be aware of color perception deficiencies so appropriate work assisgnments or adjustments can be made. Blood and urine tests are important because some conditions such as anemia and diabetes are generally detected this way. Diabetes can produce unconsciousness; anemia reduces work capacity and therefore produces fatigue and exhaustion. A white

blood count is an indicator for acute infections. The sickle cell index test for hemoglobinopathies is included. Abnormal hemoglobins produce sickling under conditions of hypoxia, which causes blockage of blood vessels throughout the body and injury to many organs and tissues; exposure to low oxygen partial pressure might precipitate a sickling crisis, which would be incapacitating underwater. Since the incidence of cardiovascular disease and related mortality is much higher in the over 35 age group, medical discretion is to be used in the requirements for more complete testing such as annual EKG and stress EKG.

Although there is considerable concern regarding the qualifications of examining physicians, the use of several physicians to obtain a qualification to work by majority rule as indicated in the OSHA standard appears to be an unacceptable practice. The OSHA regulation states,

> If the examining physician has recommended a restriction or limitation on the dive team member's exposure to hyperbaric conditions, and the affected employee does not concur, a second physician selected by the employee shall render a medical opinion on the nature and extent of the restriction or limitation, if any.
>
> If the recommendation of the second opinion differs from that of the examining (first) physician, and if the employer and employee are unable to agree on the nature and extent of the restriction or limitation, an opinion from a third physician selected by the first two physicians shall be obtained. The employer's determination of the dive team member's fitness shall be consistent with the medical opinion of the third physician unless the employer and employee reach an agreement which is otherwise consistent with the recommendation or opinion of at least two of the physicians involved.
>
> Nothing in this procedure shall be construed to prohibit either a dive team member from accepting, or an employer from offering, an assignment which is otherwise consistent with at least one medical opinion while a final determination on the employee's fitness is pending.

Certainly, it is acceptable to request that the examined diver seek consultation with other experts in the field of diving medicine. However, any employee can probably find a physician who will qualify him/her to dive. For example, it would not be at all difficult to find two "less-informed" physicians that would allow a pregnant woman to continue diving throughout most of the term of pregnancy. Yet, in the opinion of many authorities this constitutes an unacceptable risk to both the woman and the unborn child. Although this is probably not a problem for the commercial diving community, it is a definite consideration in other employments such as the scientific/educational diving community. Incidentally, we have included pregnancy as a temporary disqualification.

For more inforamtion on OSHA's position on diving medical requirements consult Appendix B.

General Operational Requirements

The general operational requirements of this report parallel those stated by OSHA with some modification. The following changes are noted:

(1) Inclusion of the requirement for maintaining a list of addresses and telephone numbers of all employees and appropriate relatives at the work location in the event that special medical consent is required in handling an injury.

(2) The need for a physician to approve every first aid kit used on a work location is impractical. Most text and company manuals have appropriate lists of first aid supplies.

(3) Mouth-to-mouth resuscitation is as good as the use of a resuscitation bag. It takes special training and practice to use the bag correctly and effectively.

(4) The requirement for an oxygen breathing unit was added. In the event of a shallow-water air embolism where a chamber is not required on site, oxygen can make the difference between probable recovery with minimum residual damage and serious permanent impairment.

(5) The OSHA regulation specifically states that the use of the international code flag "Alpha" is to be used as a warning signal. The State of Michigan requires the use of the American diver's flag. Most boaters will not know the significance of the "Alpha" flag.

(6) The requirements for overhead lifting operations, in-water welding and burning, underwater electrical equipment, hand-held power tools and equipment, and explosives have been supplemented with information from the Z-135 Committee standard.

(7) Liveboating has been placed under the in-water procedure section instead of being included as a separate section as in the OSHA standard.

(8) The flying after diving requirement is more rigid than the OSHA requirement.

Self-Contained Air Diving

Self-contained underwater breathing apparatus (scuba) receives only limited use in commercial diving. However, scuba is used extensively in scientific/educational diving. Since OSHA clearly intends to classify scientific/educational divers as commercial divers, scuba diving must be addressed in much more detail in these standards. For purposes of this standard only open-circuit scuba utilizing compressed air breathing medium is addressed at present. However, one must keep in mind that several types of recirculating pure oxygen and mixed-gas scuba are used in scientific/educational diving and will possibly be employed in some commercial diving operations in the near future. The topic of mixed gas scuba diving will require additional study and preparation of specific regulations beyond the scope of this standard.

The OSHA standard states a specific depth limit of 130 fsw for scuba diving. This is the limit generally recommended for recreational divers. The U.S. Navy (1973) also specifies 130 fsw as the maximum working limit for scuba. On the other hand, MTS/ANSI Z-135 Committee (January 1977) approved a maximum depth limit of 190 fsw for open-circuit air scuba diving. The University of Miami authorizes diving up to depths of 240 fsw on compressed air. In a letter to the Docket Officer, Technical Data Center (3 December 1976) Mr. Stuart McCormick and Dr. Warren Wisby state "that of the 4735 dives conducted in the past five years in depths ranging from 10 fsw to 240 fsw there have been only four diving accidents; three occurred 36 hours after decompression from a saturation dive, and one occurred after a non-decompression repetitive dive to 90 fsw. None of the accidents resulted in any residual injury. Of these 4735 dives, 1322 (27.8%) were decompression dives. There were no cases of decompression illness associated with any of the decompression dives, excluding saturation diving." The saturation dive depth in the above was, to my knowledge, approximately 50 fsw.

In December 1976 Dr. Glen Egstrom supplied me with data collected from 37 scientific and research agencies for the years 1965-1975. This work was completed under the auspices of the University of California, Los Angeles Sea Grant Diving Safety Research Project. Of 220,411 scientific/educational dives logged, 1891 (1.3%) were in excess of 130 fsw and 328 (0.16%) involved decompression. Only 4 pressure related accidents were reported which included 2 cases of decompression sickness, and 2 deaths. The deaths included one surface drowning and one diver with a possible congenital defect. The second death occurred on a "deep" cable survey at night (depth not specified).

Most, if not all, of the above mentioned dives were conducted using open-circuit air scuba. In light of these impressive figures one may subjectively conclude that "imposing a stringent depth limit on scientific/educational scuba diving" is unjustified. Naturally, these figures do not represent the sum total of all scientific/educational diving in the United States nor do they include all of the accidents. However, I feel they are representative. The UCLA data shows an incidence of 1.1 deaths per 100,000 exposures in scientific/educational diving. Depth does not appear to be a significant factor in scientific/educational diver mortality.

One must understand that the University of Miami, University of California, and many other universities and research agencies have imposed strict training, qualification, and procedural regulations on their divers for years. The programs and divers are well controlled.

The recommendation of the 190 fsw depth limit for specifically trained and authorized scientific/educational scuba divers must not be construed to include approval of recreational scuba diving beyond a depth of 130 fsw. Recreational scuba divers generally lack the training, rigid program control, supervision, and support facilities necessary for deep diving authorization. Under such conditions scuba diving beyond 130 fsw is considered an unacceptable risk.

The requirement for a more stringent depth limit for commercial scuba diving may well be justified. Commercial divers are in general not as competent and experienced in scuba diving as the scientific/educational diver. The commercial diver may also attempt to use scuba in an environmental or task situation or procedural manner that is completely inconsistent with the accepted practices in the scientific/educational diving community. As long as the OSHA standards include jurisdiction over scientific/educational divers, the limits for scuba must be extended.

The OSHA standard states that scuba diving shall not be conducted (1) against currents exceeding one knot unless line-tended or (2) in enclosed or physically confining spaces unless line-tended. In routine scuba diving line-tending is generally only associated with under-ice diving.

Scuba divers often "drift" dive in currents with a boat overhead, a pick-up boat downstream, or selected and separate entry and exit points. Working or swimming against a current in excess of one knot is not recommended. However, the "unattached" drift diving technique is a very useful and safe technique in research activities and select environments. If the diver(s) must return to the precise entry point, then line-tended techniques may well be indicated. One must keep in mind that line-tending techniques are not commonly associated with scuba diving and therefore indiscriminate application of such a regulation may actually constitute a hazard. In any case a number of factors control the selection of technique. The matter of line-tending should be left to the discretion of the person-in-charge.

Diving in enclosed confined spaces such as underwater caverns involves use of a lightweight safety line reeled out by the diver. The safety line is not designed to "pull the diver back" nor is it attached to the diver; it is a hand-held guide line. Conventional line-tended diving techniques are considered inadequate and, in some cases, extremely hazardous by cave diving authorities. The scuba cave diving line technique is also considered adequate for entry into wrecks and underwater structures.

The OSHA standard also is inadequate in the area of scuba equipment. Scuba and associated scuba diving equipment must meet certain minimum requirements in both mechanical function and maintenance. Within the recreational and scientific/educational diving communities a common standard of selection and care does exist. Failure to apply this standard to commercial diving would be unfortunate.

For example, there is apparently no federal regulation that requires the internal inspection of a scuba air cylinder on an annual basis. Yet this is a standard practice in the scuba diving community. Annual visual cylinder inspection is recommended in this standard.

Emergency floatation equipment is covered to some degree in the OSHA standard. However, that standard fails to address floatation capacity or inspection protocol.

The standard of performance of scuba diver depth gauges does differ from that of the pneumofathometer used in commercial diving. Realistic accuracy requirements are recommended in this standard.

Probably one of the most awkward areas of scuba diving procedures specified in the OSHA standard is the apparently unrestricted application of the line-tended scuba diver. Line-tending of scuba divers where a single diver is involved is for the most part an unacceptable and, in some situations, an extremely hazardous procedure. The OSHA standard apparently endorses line-tended scuba diving (single diver) up to their specified limit of 130 fsw.

The American National Standards Institute - Marine Technology Society Z-135 Committee on Safety in Commercial and Professional Diving Operations not only endorses line-tended scuba dives, apparently to the depth of 190 fsw, but also suggests that a single diver can operate to the same depth with no direct connection to the surface or accompanying diver as long as a wireless communications system and a "means of positive location" is used. Positive location means can be interpreted as "bubbles breaking the surface within visual sight of the diving station." Most scuba diving authorities consider such practices as unacceptable. Unfortunately, endorsement of such procedures in the OSHA and Z-135 standards could encourage both recreational divers and scientific/educational divers to adopt previously unacceptable diving techniques and procedures. A significant safety hazard would thus exist.

Both OSHA and Z-135 fails to address mid-water scuba dives and open-sea or open-lake scuba diving. These activities do require added precautions.

Surface-Supplied Air Diving

Surface-supplied diving is covered more extensively in this standard than in the OSHA standard. Many small company divers have traditionally used heavy gear in the Great Lakes and the modern equipment has only been introduced relatively recently. Consequently, it is considered that the Great Lakes diver and employer will need more guidelines than their offshore counterparts.

The limits have been extended for diving without a chamber. Most diving is shallow-water, no-decompression diving. However, occasionally inspection dives are required beyond 100 fsw and, in some cases, decompression is required. Historically, the incidence of decompression sickness among Great Lakes commercial divers has been relatively low. Very few companies own chambers in the Great Lakes area. It seems impractical to require a chamber on location for one or two deep inspection dives. On the other hand, the few companies that do deep diving on a routine basis do provide chambers for employee protection. We feel that some employer discretion must be exercised in this area of protection for employees. If the dive location is a considerable distance from a treatment facility, then a chamber should be available on the job location.

We do not feel it is necessary to discuss each element of the surface-supplied air diving requirements since they parallel those recommended by OSHA and/or the Z-135 Committee. Unlike scuba diving, our surface-supplied requirements are relatively consistant with current practices in the commercial diving community.

Decompression Chambers

A separate section has been prepared on decompression chambers. The decompression chamber is relatively uncommon in Great Lakes diving operations. We feel that both employers and employees need more comprehensive guidelines in this area. The requirements given in this standard are more or less in accord with those specified by OSHA and/or the Z-135 Committee.

Recordkeeping Requirements

The recordkeeping requirements are essentially the same as those required by OSHA.

OCCUPATIONAL SAFETY AND HEALTH STANDARDS FOR GREAT LAKES COMMERCIAL DIVING OPERATIONS

SECTION 1: Purpose, Scope and Application

1.1 Purpose

The purpose of this standard is to provide guidelines which shall be considered as minimum reasonable requirements of safety in shallow-water commercial and industrial diving. It is not intended that provisions in this standard are to supercede and governmental regulations, present or proposed.

1.2 Scope

1.2.1 This standard applies to every place of employment within the inland and territorial waters of the United States defined as the Great Lakes Basin where diving and related operations are carried out.

1.2.2 This standard applies to shallow-water diving operations in which the diver's working depth does not exceed 220 fsw and compressed air is the primary breathing gas.

1.2.3 This standard establishes minimum requirements for the safety of divers in commercial and industrial diving work and employments, including industry, construction, ship repair, shipbuilding, shipbreaking, and longshoring.

1.2.4 This standard does not apply to any diving operation:

1.2.4.1 Performed solely for instructional purposes, using open-circuit, compressed-air scuba and conducted within the no-decompression limits;

1.2.4.2 Performed solely for recreational purposes;

1.2.4.3 Performed solely for scientific/educational purposes;

1.2.4.4 Performed solely for search, rescue, or related public safety purposes by or under the control of a governmental agency; or

1.2.4.5 Governed by 45 CFT Part 46 (Protection of Human Subjects, U.S. Department of Health, Education, and Welfare) or equivalent rules or regulations established by another federal agency, which regulate research, development, or related purposes involving human subjects.

1.3 Applications 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:

1.3.1 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

1.3.2 Upon request from the Area Director, submits such information in writing.

SECTION 2: Definitions

As used in this standard, the listed terms are defined as follows:

Acute alcoholism: an episode of repeated or continuous excessive consumption of alcoholic beverages over a relatively short period of time.

Acute gastrointestinal syndrome: refers to nausea, vomiting, diarrhea, or any combination, with abrupt onset and persisting a few days or less.

Air diver: a diver who, while executing his diving duties, utilizes air as a breathing medium.

Air diving supervisor: an individual qualified to supervise air diving operations and a diving team functioning on an underwater project and who is currently, or has formerly been, a qualified diver.

Ascent time: the time interval between starting ascent and arriving at surface pressure.

ASME: refers to the American Society of Mechanical Engineers.

ATA: an abbreviation for atmospheres absolute, a unit of pressure equivalent to ambient gauge pressure in atmospheres plus 1 atmosphere.

ATM: an abbreviation for atmosphere, a unit of pressure equivalent to 760 millimeters of mercury (mm Hg) or 14.7 pounds per square inch (psi).

Bottom time: the time interval between leaving the surface and beginning ascent back to the surface.

Burst pressure: the pressure at which the containment vessel will structurally fail.

Chronic: existing for a prolonged period of time.

Chronic alcoholism: repeated or continuous excessive consumption of alcoholic beverages over a prolonged period of time.

Closed-circuit: a system by which the diver breathes a gas supply that is recirculated through a carbon dioxide absorbent with periodic manual or automatic replenishing of oxygen.

Commercial diving: diving which is performed as a part of general industry, construction, ship repairing, shipbuilding, shipbreaking, and longshoring.

Cystic: an adjective meaning an enclosed hollow space.

Decompression: the reduction of environmental or ambient pressure to atmospheric pressure.

Decompression dive: a dive during which the diver must stop at a given depth or depths in accordance with U.S. Navy Decompression Tables and cannot proceed directly to the surface at the prescribed rate.

Decompression schedule: a time-depth profile with a specific bottom time and depth, for which a specific pressure reduction or decompression time sequence has been calculated.

Decompression sickness: a physiological condition with a variety of symptoms which may result from the formation of gas or gas bubbles in the blood or body tissues of divers during or subsequent to ascent or other pressure reduction.

Decompression table: a set of decompression schedules computed on common parameters.

Demand system: a gas-supply system that supplies gas to the diver only when the diver inhales.

Diabetes: a physiological condition involving excess sugar in the blood.

Disconnect switch: a safety switch, located at the surface, by which power can be quickly removed from the underwater cutting/welding lead.

Diver: an employee engaged in work using underwater breathing apparatus which supplies compressed breathing gas at ambient pressure from a self-contained or remote source.

Diver/tender: an individual qualified to conduct limited underwater work under the supervision of a full qualified diving personnel and tend divers.

Diving bell (open): an open vessel designed for transporting the diver to and from the work site and not designed to be operated with an internal pressure differential.

Diving bell (pressurized): a closed pressure vessel designed for transporting the diver to and from the underwater work site and operated with an internal differential pressure at least as great as the pressure at the working depth.

Diving harness: a harness assembly which the diver wears to which his umbilical unit connects and by which he can be lifted, with the harness distributing the load.

Diving supervisor: the person responsible for planning the dive, instructing the crew, making certain all necessary equipment is available and functioning properly, taking all necessary precautions against foreseeable contingencies, and is responsible for safety of the operation.

DOT: refers to the Department of Transportation (formerly designated on cylinders as ICC).

Drug addiction: the inability, either physiologically or psychologically, to function without the use of a drug or medication.

Drug intoxication: ill or undesirable effects caused by excessive use of a drug or medication.

Dry suit (variable volume): a diving suit capable of being inflated for buoyancy or insulation which maintains the diver's body essentially dry.

Epileptiform disease: a disease characterized by convulsive seizures.

Field experience: field days (offshore, inland lakes, harbors, rivers) directly participating as a diver, supervising divers, operating diving equipment or surface tending divers engaged in underwater operations.

Filter: a device used in gas supply systems to remove moisture, oil, and particulate matter from the breathing gas.

Free-flow system: a gas supply system that supplies gas to the diver by continuous flow.

FSW: the abbreviation for feet of seawater, a unit of pressure generally defined as 1/33 of a standard atmosphere, which represents the pressure exerted by a foot of seawater having a specific gravity of 1.027, equal to approximately .445 pounds per square inch. This pressure unit is used in freshwater diving since most diver's gauges and decompression tables use fsw as the standard unit. In freshwater the pressure at 34 feet is equal to that at 33 feet in seawater.

Hard piping: rigid permanent or semi-permanent piping, as distinguised from temporary, flexible hoses.

Heart disease: any abnormal or morbid condition of the heart.

Heavy-gear diving: diving which employes the use of conventional deep sea dress, including helmet and breastplate, suit of rubberized canvas, and heavy weighted shoes.

Helmet: diving apparatus constructed of hard material which completely encloses the diver's head and keeps it dry.

High pressure air: air supplied at a pressure in excess of 500 psi.

Hyperbaric chamber (also recompression chamber or decompression chamber): a pressure vessel suitable for, and in used in, recompression-decompression of divers.

Hyperbaric conditions: refers to pressure conditions in excess of surface pressure.

Lead diver (diver in charge): a diver who by virtue of experience and proficiency is qualified and responsible for the conduct of a diving operation when a designated supervisor is not assigned or present.

Life-support equipment: equipment designed to provide the diver with an appropriate respirable atmosphere and other protection as required.

Live boating: refers to a diver working from a boat which is under power and not anchored. The diver may be under tow on a diver's plane or shot line or he may be followed by the boat to which he is tethered while swimming or walking on the bottom.

Low pressure air: air supplied at a pressure of less than 500 psi.

Mask: a breathing and protective apparatus which covers the diver's face and is secured to the diver's head by a strap or harness assembly.

Mixed gas: refers to a mixture of oxygen and an inert gas appropriate for diver breathing at a given depth range and with given apparatus. Unless otherwise specified all breathing gas referred to in this document shall be air.

Mixed-gas diver: a diver who, while executing his diving duties, utilizes mixed gas as a breathing medium.

Mixed-gas diving: a diving mode in which the diver is supplied with a gas mixture other than air.

Mixed-gas supervisor: an individual qualified to supervise mixed-gas diving operations and a diving team functioning on an underwater project and who is currently, or has formerly been, a qualified diver.

Neurological decompression sickness: decompression sickness involving the brain, spinal cord, or nerves.

No-decompression limit: the time-depth combination which indicates that a diver can safely ascend to the surface at a prescribed rate without stopping to decompress.

Non-return valve: a one-way check valve installed at the hose-helmet or -mask attachment point or elsewhere in the diving system, which is designed to prevent pressure loss should the hose be severed or the gas supply be interrupted.

Obesity: a conduct of excessive body weight and fat content, generally accepted as 20% over the recommended level for a given height, weight, age, body type, and sex.

Open circuit: a system by which the diver inhales breathing gas directly from the supply and exhales or exhausts directly into the surrounding water.

OSHA: refers to the Occupational Safety and Health Administration.

Oxygen cleaning: a special cleaning procedure to remove contamination in apparatus used in supplying oxygen under pressure. This is a precaution used to prevent oxygen related ignition or explosion.

Oxygen compatibility: the ability of a substance to come into contact with high-pressure oxygen without ignition.

Oxygen service equipment: equipment or components which store or convey a gas having an oxygen concentration of 40% or greater.

Oxygen toxicity: the adverse physiological response to excessive partial pressure of oxygen.

P.A. Projections: a standard x-ray technique wherein the x-rays are emitted from behind the individual toward the front.

Partial pressure: that portion of the total gas pressure exerted by a particular constituent of the gas mixture.

Personnel lock: a chamber compartment through which personnel pass from air pressure environment to another.

Pneumofathometer: a depth measuring device indicating depth in fsw, consisting of an open-ended hose fixed to the diver or diving bell, with the other end connected to an air supply and pressure gauge at the surface.

Pressure: defined as force per unit area. In diving, pressure denotes an exposure greater than surface pressure (1 ATA).

PVHO: the abbreviation for "pressure vessel for human occupancy", a pressure vessel designed to contain human beings.

Qualified diver: a person medically fit for diving, trained or experienced in diving who possesses the mechanical skills and technical knowledge required for safe and satisfactory completion of a given underwater task. The diver must be able to show satisfactory proof of training and/or experience. He shall possess a diving logbook with recorded diving experience and/or letters from past employers or instructors attesting to his diving proficiency and experience. He must comply with the certification requirements given in this standard.

Rack/console operator: an individual qualified to operate a gas rack/console.

Receiver: a pressure vessel designed for the storage of gas. In conventional diving this is generally a low-pressure reserve tank located between the breathing gas source and the diver's hose connection.

Safety factor: the ratio of burst pressure to working pressure when used in reference to pressure vessels, piping, hose, and other pressure containing apparatus common to diving.

Saturation dive: refers to a dive during which the personnel have been exposed to a given pressure for a sufficient amount of time for a state of equilibrium to be established between the body and the breathing atmosphere.

Saturation habitat: a fixed or movable system of single or multiple PVHO's in which divers live under saturation conditions on the sea floor and from which they make working excursions.

SCUBA: a self-contained underwater breathing apparatus.

Self-contained diving (or scuba diving): a diving mode which allows the diver to carry his own breathing gas supply and be independent of the surface with regard to breathing gas.

Semi-closed circuit: a system by which the diver breathes a gas partially from the supply and recirculated gas from a breathing bag or canister after it has passed through a carbon dioxide absorbent.

Standby diver: a qualified diver who is suited up and prepared with proper equipment for the dive involved to enter the water immediately in the event of an emergency or upon orders of the diving supervisor.

Surface decompression: a special diver decompression procedure conducted in a deck decompression chamber in accordance with procedures given in the U.S. Navy Manual.

Surface supplied: refers to a system by which the diver is supplied with breathing gas through a hose from the surface.

Tender: a person possessing the mechanical skills and technical knowledge of setting up and operating the diver's gas supply (compressor and/or gas storage unit) and all other diving equipment. He shall be conversant with the use of appropriate decompression and repetitive dive tables and familiar with various diving injuries and appropriate first aid. He shall be skilled in tending the diver's hose assembly while the diver is submerged and sending and receiving hand (line) signals.

Timekeeper: a person responsible for keeping the diver's time and completing the information required for the diving record.

Treatment table: a time-pressure-gas profile which is calculated to eliminate the symptoms of decompression sickness.

Umbilical assembly(life-support hose bundle): a composite of hoses/cables or separate cables extending from the surface to the diver or diving bell which supplies breathing gas, power, heat, depth measurement, safety line and/or communications, as necessary.

Weight belt: a belt worn by the diver to which weights are attached to adjust buoyancy or provide negative buoyancy.

Working pressure: the normal maximum operating pressure exerted by a medium such as a breathing mixture.

Work site: a vessel or surface structure from which dives are supported and/or the underwater location where work is performed.

SECTION 3: Personnel Qualifications

3.1 General

3.1.1 Each dive team member shall have the training and/or experience necessary to perform tasks assigned in a safe and proper manner.

3.1.2 Each dive team member shall have training and/or experience in the following:

3.1.2.1 Techniques of the assigned diving mode;

3.1.2.2 The use of equipment, systems, and tools relevant to the assigned task; and

3.1.2.3 Diving operations and emergency procedures.

3.1.3 All dive team members shall be trained in cardio-pulmonary resuscitation and first aid.

3.1.4 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.

3.2 Assignments

3.2.1 Each dive team member shall be assigned tasks in accordance with the employee's experience and/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.

3.2.2 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.

3.2.3 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.

3.3 Designated person-in-charge

3.3.1 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.

3.3.2 The designated person-in-charge shall have the experience and training in the conduct of the assigned diving operation.

3.4 Employee responsibility

3.4.1 It shall be the individual diver's responsibility to maintain himself/herself in good physical condition and at a high level of diving proficiency.

3.4.2 Each diver has the responsibility and privilege to refuse to dive if, in his/her judgement:

3.4.2.1 Conditions are unfavorable;

3.4.2.2 He/she is not in proper physical or mental condition for diving;

3.4.2.3 He/she would violate the dictates of proper diving safety procedures or this standard.

3.4.3 The employee is responsible for reporting immediately to the designated person-in-charge any equipment malfunction or discrepancy in safety procedures.

3.5 Diving after illness or injury

3.5.1 No diver shall be allowed to dive following decompression sickness exhibiting CNS or vestibular symptoms or following a pulmonary barotrauma unless he/she has received medical clearance for diving from a physician recognized as qualified by the employer.

3.5.2 No diver shall be allowed to dive following extended hospitalization or illness unless he/she has received medical clearance for diving from a physician.

SECTION 4: Medical Requirements

4.1 General

4.1.1 The employer shall determine that dive team members who are, or are likely to be, exposed to hyperbaric conditions are medically fit to perform assigned tasks in a safe and healthful manner.

4.1.2 The employer shall verify that each dive team member who is, or is likely to be, exposed to hyperbaric conditions has complied with all medical examinations required by this standard.

4.1.3 All medical examinations required by this standard shall be performed by, or under the direction of, a qualified physician.

4.1.4 The medical examination requirements of this standard shall be provided for in the following manner:

4.1.4.1 The employer shall provide each dive team member who is, or is likely to be, exposed to hyperbaric conditions with all medical examinations required by this standard at no cost to the employee; or

4.1.4.2 The employee shall provide a current certified or notarized copy of his/her current annual medical examination report as required by this standard before exposure to hyperbaric conditions.

4.1.5 The employer and the employees or their designated representatives shall determine the policy for medical examination payment.

4.1.6 The employer shall bear the cost of any test specified by the employer which is beyond the requirements of this standard.

4.2 Physician qualifications

4.2.1 Examining physicians shall be familiar with the physical requirements and medical aspects of diving.

4.3 Frequency of medical examinations

4.3.1 Medical examinations shall be provided:

4.3.1.1 Prior to initial hyperbaric exposure with the employer, unless an equivalent medical examination has been given within the preceding 12 months and the employer has obtained the results of the examination and an opinion from the examining physician of the employee's medical fitness to dive or to be otherwise exposed to hyperbaric conditions;

4.3.1.2 At one year intervals from the date of initial examination or last equivalent examination;

4.3.1.3 After an injury or illness requiring hospitalization of more than twenty-four (24) hours;

4.3.1.4 Following decompression sickness with vestibular or central nervous system involvement or pulmonary barotrauma; or

4.3.1.5 If the employer has doubts as to the employee's medical qualification to continue diving.

4.4 Information provided to examining physician:

4.4.1 A copy of the medical requirements of this standard; and

4.4.2 A summary of the nature and extent of hyperbaric conditions to which the dive team member will be exposed, including diving modes and types of work to be assisgned.

4.4.3 A summary of the examiner's diving-related work history; and

4.4.4 A medical history provided by the diver.

4.5 Content of medical examination:

4.5.1 Medical examinations conducted initially and annually shall consist of the following:

4.5.1.1 Medical history;

4.5.1.2 Diving-related work history;

4.5.1.3 Basic diver's physical examination;

4.5.1.4 The test required in Table I;

4.5.1.5 Any additional tests or requirements imposed by the employer as dictated by specific activities and

4.5.1.6 Any additional tests that the physician considers necessary.

4.5.2 Medical examinations conducted after an injury or illness requiring hospitalization of more than 24 hours shall be appropriate to the nature and extent of the injury or illness as determined by the examining physician.

4.6 Physician's written report

4.6.1 After any medical examination required by this standard, the employer shall obtain a written report prepared by the examining physician containing:

4.6.1.1 The date and location of the medical examination;

4.6.1.2 The results of the medical examination; and

4.6.1.3 The examining physician's opinion of the employee's fitness to be exposed to hyperbaric conditions, including any recommended restrictions or limitations to such exposure (see Appendix A).

4.6.2 The employer shall provide the employee with a copy of the physician's written report.

4.7 Determination of employee fitness

4.7.1 The employer shall determine the extent and nature of the dive team member's fitness to engage in diving or be otherwise exposed to hyperbaric conditions consistent with the recommendations of the examining physician's report.

TABLE I. - Tests for diving medical examinations

Test	Initial Examination	Annual Examination
Chest X-ray (PA projection)	X	X
Visual acuity	X	
Color blindness	X	
Audiogram (Hearing Test)	X	X
Pulmonary Function (VC and FEV_1)	(1)	(1)
EKG (Standard 12 L)	X	X (2) (3)
EKG (Stress)	(1)	(1)
Hematocrit or hemoglobin	X	X
Sickle cell index	X	
White blood count	X	X
Urinalysis	X	X
Bone and joint x-ray series	(4)	(2) (4)

(1) If medically indicated; at physician's discretion.

(2) Required at 3 year intervals.

(3) Annually over the age of 35.

(4) If required by employer for specific diving activities.

SECTION 5: General Operations Requirements

5.1 Safe Practices Manual

5.1.1 The employer shall develop and maintain a safe practices manual which shall be made available at the dive location to each dive team member.

5.1.2 Contents

5.1.2.1 The safe practices manual shall contain a copy of this standard and the employer's policies for implementing the requirements of this standard.

5.1.2.2 For each diving mode engaged in, the safe practices manual shall include:

5.1.2.2.1 Safety procedures for diving operations;

5.1.2.2.2 Equipment procedures;

5.1.2.2.3 Assignments and responsibilities of diving team members;

5.1.2.2.4 Emergency procedures for fire, equipment failure, adverse environmental conditions, illness and injury.

5.2 Pre-Dive Procedures

5.2.1 The employer shall comply with the following requirements prior to each diving operation, unless otherwise specified.

5.2.2 A competent designated person-in-charge (lead diver or diving supervisor) shall be delegated the authority to take charge of each diving operation at the dive location.

5.2.2.1 The designated person-in-charge shall:

5.2.2.1.1 Maintain the provisions of this standard;

5.2.2.1.2 Maintain additional safety provisions specifically established by the employer;

5.2.2.1.3 Assure that all diving is conducted in accordance with accepted procedures and practices; and

5.2.2.1.4 Under no circumstances tolerate violation of these standards or other designated/accepted diving safety practices.

5.2.3 Emergency Aid

5.2.3.1 A list shall be maintained at the dive location of the telephone or call the number and location of the following:

5.2.3.2 Primary and alternate decompression chambers (if not at the diving location);

5.2.3.3 Accessible hospitals;

5.2.3.4 Available physicians;

5.2.3.5 Available means of transporation;

5.2.3.6 The nearest U.S. Coast Guard Rescue Coordination Center and facilities;

5.2.3.7 Employer offices;

5.2.3.8 Name, location, and telephone number of nearest relative of each employee; and

5.2.3.9 Other emergency facilities in area of operation.

5.2.4 First aid supplies:

5.2.5.1 A first aid kit appropriate for the diving operation and location shall be avialable at the dive location.

5.2.4.2 When used in a decompression chamber, the first aid kit shall be suitable for use under hyperbaric conditions.

5.2.4.3 An American Red Cross Standard First Aid Manual or equivalent and a manual or specific instructions on first aid for diving accidents shall be available at the dive location.

5.2.4.4 An emergency oxygen breathing unit shall be available at all dive locations.

5.2.5 Planning and assessment;

5.2.5.1 Planning of a diving operation shall include an assessment of the safety and health aspects of the following:

5.2.5.1.1 Diving mode;

5.2.5.1.2 Surface and underwater conditions and anticipated hazards;

5.2.5.1.3 Breathing gas supply including source, purity, quantity, and reserves;

5.2.5.1.4 Thermal protection requirements;

5.2.5.1.5 Diving equipment and system;

5.2.5.1.6 Dive team assignments and physical status of dive team members;

5.2.5.1.7 Repetitive dive designation or residual inert gas status of dive team members;

5.2.5.1.8 Decompression and treatment procedures (including altitude corrections); and

5.2.5.1.9 Emergency procedures.

5.2.5.2 The designated person-in-charge shall inform the vessel's master, work site foreman, and/or designated personnel of all diving operations to be conducted from the vessel or structure, emphasizing pertinent safety factors and coordination with other activities.

5.2.6 Hazard activities.

5.2.6.1 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 opeeration.

5.2.7 Employee briefing.

5.2.7.1 Dive team members shall be briefed on:

5.2.7.1.1 The task to be undertaken;

5.2.7.1.2 Safety procedures for the diving mode;

5.2.7.1.3 Any unusual hazards or environmental conditions likely to affect the safety of the diving operation;

5.2.7.1.4 Emergency aid procedures; and

5.2.7.1.5 Any modification to operating procedures necessitated by the specific diving operation.

5.2.7.2 Prior to making individual dive team member assignments, the employer or designated person-in-charge shall inquire into the diving team member's current state of physical fitness, restrict diving activities of individuals suffering from obvious illness or abnormal physical conditions contraindicated in diving.

5.2.7.3 Dive team members shall be informed of the procedures for reporting physical problems or adverse physiological effects during and after the dive.

5.2.8 Equipment.

5.2.8.1 Equipment to be used must meet the specifications set forth in this standard.

5.2.8.2 All life-support and associated equipment including mask, helmets, umbilical assemblies, thermal protection, scuba, floatation units, and compressors shall be inspected and determined to be in proper operating condition prior to each dive.

5.2.8.3 An adequate and appropriate primary and contingency air supply shall be available for the diving operation.

5.2.8.4 All hoses supplying the diver's life support equipment shall be protected against probable damage.

5.2.8.5 Except when heavy gear is worn or in scuba diving (not line tended), each diver shall wear a safety harness.

5.2.8.6 Adequate thermal protection provisions shall be made to minimize body heat loss or gain during the dive.

5.2.8.7 A multi-lock decompression chamber capable of recompressing a diver at the surface to a minimum depth of 165 fsw shall be available at the dive location or within 2 hours travel time from the dive location for:

5.2.8.7.1 Surface-supplied or scuba air dives to depths deeper than 130 fsw; and

5.2.8.7.2 Dives beyond the no-decompression limit.

5.2.8.7.3 If stage decompression in excess of 30 minutes is required, a decompression chamber must be available and ready for use at the work site.

5.2.8.8 Protective clothing shall be worn by divers whenever marine life, sharp objects, or abrasive surfaces present a potential hazard.

5.2.8.9 Surface personnel shall wear approved personal floatation equipment, safety hats, and safety shoes whenever the nature of the operation demands.

5.2.8.10 A sharp knife shall be carried by the diver either closed or in an appropriate scabbard at all times while in the water.

5.2.8.11 A safe means of entering and exiting the water appropriate to the dive platform, environmental conditions, and nature of the dive shall be provided.

5.2.9 Warning signal.

5.2.9.1 An appropriate warning shall be displayed at the dive location in a manner which allows all-round visibility, and it shall be illuminated at night when divers are operating in areas capable of supporting marine traffic.

5.2.10 Diving station.

5.2.10.1 Adequate diving stations from which safe diving operations can be conducted shall be provided at the entry/exit location on all platforms, structures, or vessels used for diving operations.

5.2.10.2 Platforms, structures, or vessels used for diving operations shall be determined as adequate and safe by the designated person-in-charge.

5.3 Procedures during dive

5.3.1 The employer shall comply with the following requirements which are applicable to each diving operation unless otherwise specified.

5.3.2 Water entry and exit.

5.3.2.1 A means capable of supporting the diver shall be provided for entering and exiting the water.

5.3.2.2 The means provided for exiting the water shall extend below the water surface.

5.3.2.3 A means shall be provided to assist an injured diver from the water.

5.3.3 Communications.

5.3.3.1 An operational diver - surface voice communications system shall be used for all surface-supplied dives.

5.3.3.2 An operational, two-way communication system shall be available at the dive location to obtain emergency assistance.

5.3.4 Overhead work and lifting operations.

5.3.4.1 For all lifting operations conducted while a diver is in the water, a workable communications system must be established between the dive team and the crane or winch operator.

5.3.4.2 The crane or winch operator shall accept instructions only from a designated person.

5.3.4.3 The diver in the water shall be advised prior to any movement of the load.

5.3.4.4 For all crane operations in which the diving team member giving instructions to the diver in the water is out of visual contact with the crane operator, and on all cranes of 100 tons or more capacity, an audio communications system shall be established between the two parties.

5.3.4.5 Under normal conditions, divers will not be required to dive if work is being performed by other personnel directly over the diver unless the dive team is satisfied that the overhead work does not pose a hazard.

5.3.5 In-water welding and burning.

5.3.5.1 Personnel designated to operate welding and burning equipment shall be properly instructed and familiar with all precautions necessary for safe in-water welding and burning.

5.3.5.2 A positive operating current supply switch to interrupt the current flow to the welding or burning electrode shall be:

5.3.5.2.1 Tended by a dive team member in voice communication with the diver performing the welding or burning; and

5.3.5.2.2 Kept in the open position except when the diver is welding or burning;

5.3.5.2.3 Of adequate capacity to handle the maximum electrical current of the power supply and be enclosed to prevent electric shock to the operator.

5.3.5.3 The welding machine shall be grounded and a ground wire shall connect the machine directly to the work.

5.3.5.4 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.

5.3.5.5 Precautions shall be taken to prevent contact between power supply cables and welding cables in such a way as to create a potential short.

5.3.5.6 A.C. power supplies of less than 500 Hz output shall not be used for welding or burning.

5.3.5.7 Rubber gloves or other insulated gloves shall be used by divers performing welding and burning operations.

5.3.5.8 Welding and burning gas supplies.

5.3.5.8.1 Compressed gas cylinders shall be handled in accordance with accepted safety procedures and properly secured to prevent damage to cylinders and valves or injury to personnel.

5.3.5.8.2 Regulators shall be used only for the gas for which they were intended.

5.3.5.8.3 Regulators shall be maintained and tested by qualified personnel.

5.3.5.9 Prior to welding or burning on closed compartments, structures, or pipes which may contain a flammable or unknown 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, except for hot tap operations.

5.3.6 Underwater electrical equipment.

5.3.6.1 When electrical apparatus is employed underwater which requires operating potential in excess of 36 volts, ground fault interrupters shall be installed, where practical, on the electrical supply circuit.

5.3.6.2 When technical considerations preclude the use of ground fault interrupters on underwater electrical circuits in excess of 36 volts, isolation transformers shall be installed on the electrical supply circuit.

5.3.7 Hand-held power tools and equipment.

5.3.7.1 Hand-held electrical tools and equipment shall be de-energized before being placed into or retrieved from the water.

5.3.7.2 Hand-held power tools shall not be supplied with power from the dive station until requested by the diver.

5.3.8 Explosives.

5.3.8.1 Explosives shall be handled only by specially qualified and appropriately licensed personnel.

5.3.8.2 Explosives shall be transported, stored, and used in accordance with this section and the applicable provisions of sections 1910.109 and 1926.912 of Title 2.9 of the Code of Federal Regulations.

5.3.8.3 Blasting caps shall not be connected to the primacord until the diver is out of the water.

5.3.8.4 Electrical continuity of explosive circuits shall not be tested until the diver is out of the water.

5.3.8.5 Explosives shall not be detonated while the diver is in the water.

5.3.9 Decompression tables.

5.3.9.1 Decompression, repetitive, and no-decompression dive tables (as appropriate) shall be available at the dive station.

5.3.10 Dive profiles.

5.3.10.1 A depth-time profile, including when appropriate, any breathing gas changes, shall be maintained for each diver during the dive including decompression.

5.3.11 Liveboating.

5.3.11.1 Employers engaged in diving operations involving liveboating shall comply with the following requirements:

5.3.11.1.1 Limits.

5.3.11.1.1.1 Diving operations involving liveboating shall not be conducted:

5.3.11.1.1.2 With an in-water decompression time of greater than 120 minutes;

5.3.11.1.1.3 In rough seas (beyond sea state 3);

5.3.11.1.1.4 In other than daylight hours; or

5.3.11.1.1.5 From a vessel of insufficient maneuverability.

5.3.11.1.2 Procedures.

5.3.11.1.2.1 The propeller of the vessel shall be stopped before the diver enters or exits the water.

5.3.11.1.2.2 A device shall be used which minimizes the possibility of entanglement of the diver's hose in the propeller of the vessel.

5.3.11.1.2.3 Precautions shall be taken to properly lead the diver's hose away from the vicinity of the vessel's propellers and to prevent loss of the depth control in the event of loss of vessel control.

5.3.11.1.2.4 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.

5.3.11.1.2.5 The tender shall be specifically qualified in liveboating tending.

5.3.11.1.2.6 A standby diver shall be available while a diver is in the water.

5.3.11.1.2.7 A self-contained emergency breathing air supply shall be carried by each diver engaging in liveboating operations.

5.3.11.1.2.8 The vessel operator shall be qualified to the satisifaction of the designated person-in-charge.

5.4 Post-dive procedures

5.4.1 The employer shall comply with the following requirements which are applicable after each diving operation, unless otherwise specified.

5.4.2 Precautions.

5.4.2.1 After the completion of any dive, the employer shall:

5.4.2.1.1 Check the physical condition of the diver;

5.4.2.1.2 Instruct the diver to report any physical problems or adverse physiological effects including symptoms of decompression sickness;

5.4.2.1.3 Advise the diver of the location of a decompression chamber which is ready for use; and

5.4.2.1.4 Alert the diver to the potential hazards of flying after diving.

5.4.2.2 A diver shall remain awake for at least one hour after completion of any dive.

5.4.2.3 For any dive beyond the no-decompression limits or deeper than 100 fsw, the employer shall instruct the diver to remain within access of a decompression chamber and competent operator for at least two hours following completion of the dive.

5.4.2.4 Flying after diving shall be limited to:

5.4.2.4.1 No flying for a minimum of two hours following a no-decompression dive providing that all dives performed in the previous 12 hours were also no-decompression dives.

5.4.2.4.2 A maximum of 800 feet altitude during the first 12 hours following a no-decompression dive.

5.4.2.4.3 No flying for a minimum of 24 hours following a decompression dive.

5.4.3 Record of dive.

5.4.3.1 The following information shall be recorded and maintained for each diving operation pressure exposure by both the employer and the employee:

5.4.3.1.1 Name of dive team member including designated person-in-charge and member assignments;

5.4.3.1.2 Date, time, and location;

5.4.3.1.3 Diving modes and equipment used;

5.4.3.1.4 General nature of work performed;

5.4.3.1.5 Estimated underwater and surface conditions (visibility, water temperature, sea state, current, and atmospheric temperature and conditions);

5.4.3.1.6 Maximum depth and bottom time for each diver;

5.4.3.1.7 Repetitive dive group designations or time of last pressure exposure;

5.4.3.1.8 Any unusual conditions;

5.4.3.1.9 Signature of designated person-in-charge; and

5.4.3.1.10 Employer's name and address.

5.4.3.2 For each dive beyond the no-decompression limit or deeper than 100 fsw, the following additional information shall be recorded and maintained:

5.4.3.2.1 Depth-time and breathing gas profiles;

5.4.3.2.2 Decompression tables designation (including modification, if any); and

5.4.3.2.3 Elapsed time since last pressure less than 24 hours or repetitive dive group designation for each diver.

5.4.3.3 For each dive in which decompression sickness is suspected or symptoms are evident, the following additional information will be recorded and maintained:

5.4.3.3.1 Description of decompression sickness symptoms (including depth and time of onset); and

5.4.3.3.2 Description and results of treatment.

5.4.4 Decompression procedure assessment.

5.4.4.1 The employer shall:

5.4.4.1.1 Investigate and evaluate each incident of decompression sickness based on the recorded information, consideration of the past performance of the decompression schedule used, and individual susceptibility;

5.4.4.1.2 Take appropriate corrective action to reduce the probability of recurrence of decompression sickness; and

5.4.4.1.3 Prepare a written evaluation of the decompression procedure assessment, including any corrective action taken, within 45 days of the incident of decompression sickness.

SECTION 6: Self-Contained Air Diving

6.1 Requirements

6.1.1 Employees engaged in scuba diving using compressed air breathing medium shall comply with the following requirements, unless otherwise specified.

6.2 Limits

6.2.1 Scuba diving shall not be conducted:

6.2.2 At depths greater than 190 fsw;

6.2.3 At depths greater than 130 fsw or beyond the no-decompression limits unless a decompression chamber is available and ready for use within 2 hours travel time from the diving location; or

6.2.4 If stage decompression in excess of 30 minutes is required unless a decompression chamber is available and ready for use at the work location.

6.3 Equipment

6.3.1 Scuba regulators shall comply with the following requirements:

6.3.1.1 All demand regulator components shall be of sufficient design and construction to operate at the maximum pressure of the cylinder unit on which the regulator is used.

6.3.1.2 All scuba regulators shall be inspected and designated satisfactory annually by an approved/qualified person, or more frequently if the regulator is used for deep or unusual diving operations or exhibits signs of malfunction.

6.3.2 All scuba shall be equipped with a submersible pressure readout gauge. The submersible pressure gauge shall comply with the following requirements:

6.3.2.1 Be within ± 5% of full scale accuracy over the entire gauge pressure range;

6.3.2.2 Be equipped with a means of relieving internal case over pressure without explosively ejecting the gauge lens or bursting the case; and

6.3.2.3 The pressure hose shall not show signs of cuts or abrasions extending to the hose reinforcing braid and not leak air through the braid fiber.

6.3.3 All scuba shall include a low-pressure warning device or reserve breathing gas supply consisting of:

6.3.3.1 A manually activated reserve;

6.3.3.2 A submersible pressure gauge;

6.3.3.3 An independent reserve cylinder with separate regulator or connected to the breathing apparatus; or

6.3.3.4 An audible low-pressure warning mechanism; and

6.3.3.5 If the scuba is equipped with an integral low-pressure warning mechanism, the mechanism shall activate at a cylinder pressure of not less than 250 psig.

6.3.4 High-pressure cylinders used for scuba shall comply with the following:

6.3.4.1 Cylinders shall be designed, constructed, maintained, and stamped in accordance with the requirements of the U.S. Department of Transportation for transportable high-pressure cylinders (applicable provisions of 29 CFR, Sections 1910.166-171.

6.3.4.2 Scuba cylinders shall have safety relief devices in accordance with applicable Department of Labor and/or Department of Transportation specified safety codes.

6.3.4.3 Scuba cylinders shall be inspected internally and externally for rust, corrosion, and damage annually in accordance with C.G.A. Pamphlet C-6, and hydrostatically tested in accordance with DOT specifications every five years or more frequently if subjected to damage or signs of significant rust or corrosion are evident.

6.3.4.4 Scuba cylinders shall be inspected/tested by an approved/qualified person.

6.3.4.5 Scuba cylinders shall be stored in a ventilated area and protected from excessive heat.

6.3.4.6 Scuba cylinders shall be secured from falling.

6.3.5 An approved emergency gas inflatable, floatation device or buoyancy compensator shall be required for all scuba dives. Emergency floatation units shall comply with the following requirements:

6.3.5.1 Provide a minimum buoyancy of 25 lbs. when fully inflated at the surface;

6.3.5.2 Be gas tight and capable of holding a pressure of 2 psig for 2 hours when the over-pressure relief valve is blocked;

6.3.5.3 Be equipped with a device for manual inflation from a compressed gas supply and an oral inflation-deflation tube;

6.3.5.4 Be equipped with an over-pressure relief valve capable of relieving a fully inflated unit when released by itself from 33 fsw without sustaining structural damage to the unit;

6.3.5.5 Be so designed that it will turn an unconscious diver into a face-up position and support the head out of the water;

6.3.5.6 Be equipped with an inflation source separate from the breathing gas supply;

6.3.5.7 Be inflated by manual activation of the inflation system at least once every 6 months or 30 dives, whichever comes first, and must hold full inflation for 2 hours.

6.3.6 All depth gauges used for scuba shall be selected so that the maximum scale depth is at least 30 fsw in excess of the intended use depth. The depth indicator shall comply with the following requirements:

6.3.6.1 Each depth gauge shall comply with an accuracy of $\pm$ 1 percent of full scale depth at 20 fsw and not exceed $\pm$ 3 percent of full scale the maximum at maximum depth;

6.3.6.2 Each depth gauge shall be calibrated against a master reference gauge of $\pm$ .25% accuracy when new, every six months thereafter, and when there is a discrepancy greater than 2% of full scale between any two equivalent gauges.

6.3.7 All scuba used for dives in excess of 100 fsw, in enclosed or physically confining spaces, or around nets shall be equipped with an auxiliary breathing unit.

6.3.8 All scuba harnesses and weight belts shall be equipped with a quick release device which allows the scuba or weights to be rapidly jettisoned with either hand in an emergency, unless otherwise specified.

6.3.9 Scuba divers shall have a knife in their possession at all times while diving. The knife shall be carried in a suitable scabbard or in a closed position when not in use.

6.3.10 Air compressors and supply systems for charging scuba cylinders shall have:

6.3.10.1 Operation and maintainance in accordance with the manufacturer's instructions and specifications unless such instructions or specifications shall result in infraction of the purity standards for breathable compressed air.

6.3.10.2 An operation and maintenance record maintained for all compressors and including operating time, repairs, type and number of filters used, oil consumption and changes, filter replacements, air analysis and other pertinent details.

6.3.10.3 Air pressure fittings, hoses, plumbing, and pressure system components with a maximum burst pressure rating specified as four times the maximum intended working pressure.

6.3.10.4 The air intake to the compressor so located as to prevent contamination of the air by noxious gases or materials.

6.3.10.5 Filters and separators incorporated into the diver air supply system to remove moisture, oil-mist, particulates, and noxious orders.

6.3.10.6 Respired air supplied to a diver shall not contain:

6.3.10.6.1 A level of carbon monoxide (CO) in excess of 20 ppm;

6.3.10.6.2 A level of carbon dioxide (CO_2) in excess of 1000 ppm;

6.3.10.6.3 A level of oil mist in excess of 5 milligrams per cubic meter;

6.3.10.6.4 Detectable gross moisture, dust, or particulates; and

6.3.10.6.5 A noxious or pronounced order.

6.3.10.7 The output of air compressor systems shall be tested for carbon monoxide, odor, and oil droplets every six months or 25 hours of operation, whichever comes first, 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.

6.3.10.8 Compressed gas cylinders shall:

6.3.10.8.1 Be designed, constructed and maintained in accordance with the appropriate provisions of 29 CFR, Sections 1910.166-171;

6.3.10.8.2 Be stored in ventilated area and protected from excessive heat;

6.3.10.8.3 Be secured from falling; and

6.3.10.8.4 Have shut-off valves recessed into the cylinder or protected by a cap, except when in use or manifolded (scuba diving cylinders excluded).

6.4 Procedures

6.4.1 Self-contained divers shall use only open-circuit scuba and air or equivalent breathing media.

6.4.2 A scuba diver shall be accompanied by another diver in the water in continuous visual contact during the diving operation except as provided for below:

6.4.2.1 When visibility is limited and continuous visual contact is impossible, the divers shall be linked together by a short line; and

6.4.2.2 A single scuba diver may dive to a depth of 15 fsw using a surface-tended line providing that the water is clear enough for the diver to be seen from the surface at all times.

6.4.3 Surface tended scuba divers shall wear a safety harness with:

6.4.3.1 A positive buckling device; and

6.4.3.2 An attachment point for the surface tended line.

6.4.4 A depth indicator and watch/timeing device shall be required for all scuba dives to depths exceeding 50 fsw.

6.4.5 The scuba cylinder pressure shall be determined immediately before each dive.

6.4.6 The planned time of a scuba dive (including decompression) shall not exceed the gas supply duration of the apparatus in use, exclusive of reserves.

6.4.7 For any mid-water scuba dives where the bottom depth exceeds 130 feet, the diver must be equipped with a buoyancy compensator and a depth gauge and a marked line shall be suspended from a boat or surface float.

6.4.8 During open-sea or open-lake scuba dives (beyond normal swimmer distance from shore), a small boat shall tend the divers.

SECTION 7: Surface-Supplied Air Diving

7.1 General

7.1.1 Employers engaged in surface-supplied air diving shall comply with the following requirements, unless otherwise specified.

7.2 Limits

7.2.1 Surface-supplied air diving shall not be conducted:

7.2.1.1 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;

7.2.1.2 At depths greater than 130 fsw or beyond the no-decompression limits unless a decompression chamber is available and ready for use within two hours travel time from the diving location; Or

7.2.1.3 If stage decompression in excess of 30 minutes is required unless a decompression chamber is available and ready for use at the work location.

7.3 Equipment

7.3.1 Air compressor and supply systems.

7.3.1.1 Compressors used to supply air to the diver must be independent of any other operation, unless an adequate contingency air supply is maintained under direct control of the diver's tenders.

7.3.1.2 The air supply system shall be of sufficient design and capacity to provide a minimum supply of 4.5 cfm measured at the diver's working depth.

7.3.1.3 The system shall supply air at a hose pressure of at least 50 psi over ambient pressure for dives to less than 100 fsw and 100 psi over ambient pressure for depths in excess of 100 fsw.

7.3.1.4 A compressor used to supply divers air shall be equipped with an air receiver or volume tank.

7.3.1.5 The air receiver or volume tank shall be equipped with a check valve on the inlet line, a pressure gauge, a pressure relief valve, and a drain valve.

7.3.1.6 Air receivers and volume tanks and safety relief devices used with compressed air systems shall conform to ASME and/or other required and applicable codes and certifications; they shall conform to U.S. Coast Guard specifications and be so certified when used on job sites within U.S.C.G. jurisdiction.

7.3.1.7 All pressure fittings, hoses, plumbing, and pressure system components shall comply with a maximum burst pressure rating specified as four times the maximum intended working pressure.

7.3.1.8 Air compressors shall be operated and maintained in accordance with the manufacturer's instructions and specifications unless such instructions or specifications shall result in infraction of the purity standards for breathable compressed air.

7.3.1.9 An operation and maintenance record shall be maintained for all compressors and shall include operating time, repairs, type and number of filters used, oil consumption and changes, filter replacements, air analysis and other pertinent details.

7.3.1.10 The air intake to the compressor shall be so located as to prevent contamination of the air by noxious gases or materials.

7.3.1.11 Filters and separators shall be incorporated into the diver air supply system to remove moisture, oil-mist, particulates, and noxious odors.

7.3.1.12 Respired air supplied to a diver shall not contain:

7.3.1.12.1 A level of carbon monoxide (CO) in excess of 20 ppm;

7.3.1.12.2 A level of carbon dioxide (CO_2) in excess of 1000 ppm;

7.3.1.12.3 A level of oil mist in excess of 5 milligrams per cubic meter;

7.3.1.12.4 Detectable gross moisture, dust, or particulates; And

7.3.1.12.5 A noxious or pronounced odor.

7.3.1.13 The output of air compressor systems shall be tested for carbon monoxide, odor, and oil droplets every six months or 50 hours of operation, whichever comes first, 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.

7.3.1.14 When air for surface-supplied diving is supplied from a high-pressure cylinder system, the volume of air contained must be sufficient to complete the dive with a minimum of 30% safety factor without requiring recharge.

7.3.1.15 For any surface-supplied dive, a secondary supply of sufficient capacity to complete the diver's decompression must be available at the surface to be used in event of the failure of the primary supply.

7.3.1.16 Compressed gas cylinders shall:

7.3.1.16.1 Be designed, constructed and maintained in accordance with the appropriate provisions of 29 CFR, Sections 1910.166-171;

7.3.1.16.2 Be stored in a ventilated area and protected from excessive heat;

7.3.1.16.3 Be secured from falling; and

7.3.1.16.4 Have shut-off valves recessed into the cylinder or protected by a cap, except when in use or manifolded (scuba diving cylinders excluded).

7.3.2 Helmets and masks shall comply with the following requirements:

7.3.2.1 Helmets and masks shall be used in accordance with the limitations specified by the manufacturer of the equipment unless the equipment is tested under new conditions in a manner equal to or more rigid than performed by the manufacturer.

7.3.2.2 Helmets and masks shall be equipped with non-return valves made of materials resistant to corrosion in sea water between the air supply hose and the helmet or mask to prevent sudden loss of air pressure if the hose is severed.

7.3.2.3 All control, non-return, and exhaust valves in the diving unit when properly supplied and used in accordance with the manufacturer's specifications shall be capable of passing air at a rate of 4.5 acfm.

7.3.2.4 Helmets and masks except for oral-nasal masks, shall have a minimum ventilation rate capability of 4.5 acfm at any depth at which they are operated.

7.3.2.5 Helmets and masks attached directly to "dry-type" diving dress shall be equipped with manually operated exhaust valves to facilitate rapid discharge of air in order to minimize the possibility of blow-up.

7.3.2.6 All modifications which may affect the performance of the helmet or mask must be approved by the employer or the manufacturer of the equipment prior to use and verified by tests equal to or more rigid than those performed by the manufacturer.

7.3.2.7 Helmets and masks shall be equipped with reliable surface-diver oral communications equipment.

7.3.3 Dive air supply hoses and umbilical assembly.

7.3.3.1 Breathing air hoses shall:

7.3.3.1.1 Have a bursting pressure at least equal to four times the working pressure;

7.3.3.1.2 Have a minimum working pressure of 100 psig plus the maximum ambient pressure at the depth of the dive;

7.3.3.1.3 Be of a size capable of the required flow rates for the system or equipment used;

7.3.3.1.4 Be kink resistant;

7.3.3.1.5 Be marked with a serial number for record purposes;

7.3.3.1.6 Be taped, capped, or plugged when not in use to eliminate the possibility of foreign material entering the hose.

7.3.3.2 Hose fittings shall:

7.3.3.2.1 Be constructed of sea water corrosion resistant materials;

7.3.3.2.2 Have connections of a type that are resistant to accidental disengagement from the compressor or air source;

7.3.3.2.3 Be attached to the hose with clamps or devices that are constructed of sea water resistant materials and that cannot be accidentally loosened;

7.3.3.2.4 Be capable of sustaining a 200 lb tensile load on the hose attached to the fitting without showing signs of slippage; and

7.3.3.2.5 Have a working pressure at least equal to the working pressure of the hose to which they are attached.

7.3.3.3 Umbilical assemblies shall:

7.3.3.3.1 Be marked at ten foot intervals to a length of 100 feet beginning at the diver's end and at 50 foot intervals thereafter;

7.3.3.3.2 Be constructed of kink-resistant components;

7.3.3.3.3 Include a pneumofathometer hose when used for diving in excess of 30 fsw;

7.3.3.3.4 Be fitted with a device for attaching the assembly to the diver's harness.

7.3.3.4 Umbilical assembly inspection and testing shall include:

7.3.3.4.1 Visual inspection for abrasion of the outer cover, exposed reinforcement, fitting slippage or misalignment, fitting damage, fitting corrosion shall be performed prior to each diving day and following exposure to unusual stresses or abuse.

7.3.3.4.2 Pressure testing of breathing air hoses at least once annually to the rated working pressure.

7.3.4 Gauges and timekeeping devices.

7.3.4.1 Gauges indicating diver depth which can be read at the dive station shall be used for all dives greater than 30 fsw.

7.3.4.2 All gauges used to determine diver's depth shall have at least a ± 1% of full scale accuracy.

7.3.4.3 Each depth gauge shall be dead weight tested or calibrated against a master reference gauge every six months or when there is a discrepancy greater than 2% of full scale between any two equivalent gauges.

7.3.4.4 A timekeeping device shall be available at each dive station.

7.3.5 Weights and harness.

7.3.5.1 Except when heavy gear (deep sea diving outfit) is worn, divers shall be equipped with a weight belt or assembly capable of quick release designed to prevent accidental release.

7.3.5.2 Except when heavy gear (deep sea diving outfit) is worn, each diver shall wear a safety harness with:

7.3.5.2.1 A positive buckling device;

7.3.5.2.2 An attachment point for the umbilical assembly to prevent strain on the mask or helmet;

7.3.5.2.3 A lifting point to distribute the pull force of the line over the diver's body.

7.3.5.2.4 Capability to withstand a minimum of 500 lbs. linear pull.

7.3.6 Buoyancy control equipment.

7.3.6.1 A dry suit or other buoyancy changing equipment not directly connected to the helmet or mask shall be equipped with an exhaust valve.

7.3.6.2 Exhaust valves used on buoyancy control equipment must be capable of exhausting the full volume of the suit or vest plus 10% during an ascent rate of 60 fpm.

7.3.7 Self-contained emergency air supply systems.

7.3.7.1 Self-contained emergency air supply systems shall be of a capacity sufficient to provide at least five minutes at working depth and must function independently of surface control or surface reserve supply.

7.3.7.2 The first stage of regulators attached to on-off valves on masks or helmets shall be equipped with an over-pressure relief valve.

7.4 Procedures

7.4.1 The minimum personnel requirements for surface-supplied air diving are as follows, unless otherwise specified:

7.4.1.1 One diver and one tender shall be required for dives to 100 fsw or less.

7.4.1.2 A standby diver and tender shall be required for dives to depths greater than 100 fsw or beyond the no-decompression limits.

7.4.2 A diver shall be stationed at the underwater entry point when diving is conducted in enclosed or physically confining spaces.

7.4.3 For dives deeper than 60 fsw or beyond the no-decompression limits:

7.4.3.1 A secondary surface air reserve shall be provided which will insure the diver of a minimum of five minutes continuous operation at working depth in the event of primary supply failure.

7.4.3.2 The diver shall be equipped with a self-contained reserve air supply which will provide five minutes of air at working depth, except when heavy gear is worn.

7.4.4 Except when heavy gear is worn, a self-contained air supply shall be carried by the diver whenever the configuration of the dive prevents ascending directly to the surface.

7.4.4.1 The self-contained air supply shall be of sufficient capacity to permit exit from the structure and completion of decompression.

7.4.5 For heavy gear diving deeper than 100 fsw or beyond the no-decompression limits:

7.4.5.1 An extra breathing air hose capable of supplying air to the diver in the water shall be available to the standby diver.

7.4.5.2 An in-water stage shall be provided to divers in the water.

7.4.6 Satisfactory surface-diver voice communications shall be provided for all surface-supplied dives.

7.4.6.1 A standby communication system shall be available for dives deeper than 100 fsw or beyond the no-decompression limits.

7.4.7 A protective hard-hat type safety helmet shall be worn by divers using a mask where overhead hazards or obstructions are evident.

SECTION 8: Decompression Chambers

8.1 Decompression chamber design and construction

8.1.1 Decompression chambers manufactured after the effective date of this standard shall be constructed in accordance with applicable ASME Unfired Pressure Vessel Codes.

8.1.2 Decompression chambers used on vessels and structures within the U.S. Coast Guard jurisdiction shall be U.S.C.G. certified and shall be tested and inspected as required by the jurisdictional authority.

8.1.3 Except for small portable emergency chambers a decompression chamber shall:

8.1.3.1 Have a minimum inside diameter of 48 inches except existing chambers with a minimum diameter of 40 inches may be used until 1982;

8.1.3.2 Have at least two compartments or locks designed so as to permit transfer of personnel and supplies to the outside while the main compartment remains pressurized;

8.1.3.3 Accommodate more than one person; and

8.1.3.4 Be capable of recompressing the diver at the surface to a minimum depth equivalent of 165 fsw.

8.1.4 Piping, tubing, and fittings shall comply to the following unless otherwise specified:

8.1.4.1 All permanently installed piping or tubing shall have a design bursting pressure of at least four times the working pressure.

8.1.4.2 Each chamber compartment shall be equipped with appropriate valves to enable the outside attendant to control the supply and discharge of compressed air and oxygen.

8.1.4.3 Chamber piping and valves shall be so located as to provide adequate ventilation and eliminate dead air spaces.

8.1.4.4 The inner compartment or working compartment of the chamber shall be fitted with an emergency safety pressure relief device which may be activated by the compartment occupants in event of overpressurization or disability of the outside attendants. The uses of automatic pressure relief devices is optional.

8.1.4.5 The inner compartment or working compartment of the chamber shall be fitted with an emergency safety pressure relief device to prevent damage from over pressurization.

8.1.4.6 Internal exhaust outlets shall be fitted with an antisuction device or positioned to prevent suction of hands or materials into the exhaust system.

8.1.4.7 Air pressurization line outlets inside the chamber and exhaust lines inside and outside the chamber shall be equipped with noise muffling devices.

8.1.5 Oxygen piping and fittings.

8.1.5.1 Oxygen piping and fittings shall conform to the following requirements unless otherwise specified:

8.1.5.1.1 Equipment used with oxygen or mixtures containing more than 40% oxygen by volume shall be designed for oxygen service.

8.1.5.1.2 Components exposed to oxygen or mixtures containing more than 40% oxygen by volume shall be cleaned of flammable materials before use.

8.1.5.1.3 Hard piping, fittings, and tubing in oxygen service shall be of corrosion resistant materials.

8.1.5.1.4 Oxygen systems over 125 psig shall have slow-opening type on-off valves.

8.1.6 Decompression chamber equipment.

8.1.6.1 Each decompression chamber shall be equipped with:

8.1.6.1.1 A view port at least four inches in diameter located in such a position so as to permit observation of all occupants of each habitable compartment from the outside.

8.1.6.1.2 An externally mounted depth indicator (gauge) for each habitable compartment visible at the operating station.

8.1.6.1.3 An inner or working compartment depth indicator (gauge) for each habitable compartment visible to the occupants.

8.1.6.1.4 An effective means of oral communication between the outside attendant and the occupants of the chamber.

8.1.6.1.5 A means to maintain the atmosphere below a level of 25% oxygen by volume.

8.1.6.1.6 A built-in breathing system with a minimum of one mask per occupant.

8.1.6.1.7 Illumination capability to light the interior.

8.1.6.1.8 A means for extinguishing fire.

8.1.7 Fire prevention.

8.1.7.1 Fire prevention measures shall include:

8.1.7.1.1 Equipment, fixtures and furnishings used inside hyperbaric chambers constructed of non-combustible materials whenever possible.

8.1.7.1.2 Chamber lighting equipment designed to eliminate possibility of electrical malfunction leading to ignition of components or chamber atmosphere contamination.

8.1.7.1.3 Only fire retarding paint used on the interior of the chamber.

8.1.7.1.4 Combustible accessory equipment used in decompression chambers being kept to an absolute minimum.

8.2 Decompression chamber pressurization and ventilation system

8.2.1 The primary pressurization system for a hyperbaric chamber shall be of sufficient capacity to allow pressurization to a depth of 33 fsw within one minute under actual working conditions.

8.2.2 The system shall be capable of ventilation at a rate of four acfm per occupant at depth in an air breathing atmosphere.

8.2.3 A chamber used for pressurizing personnel shall have two independent and separate sources of air. One air source shall be independent of primary electrical power. The secondary source may consist of a low pressure air compressor powered by an internal combustion engine or generator system or a high pressure air storage system.

8.2.4 An emergency or secondary system shall be of sufficient capacity to pressurize the chamber to 165 fsw and ventilate the chamber for one hour in accordance with the specified minimum ventilation rates for one patient and one attendant.

8.2.5 The emergency or secondary air supply system shall be periodically activated to insure workability of the equipment in an emergency. The pressure of the high pressure storage system shall be periodically checked and must be retained within 10% of the total capacity of the system.

8.2.6 The air intake of compressors used for pressurizing and ventilating hyperbaric systems shall be maintained in the same fashion prescribed for diving compressors.

8.2.7 Hyperbaric chamber air supplies shall be periodically analyzed to insure that the air is within the limits designated for diving in this standard and a record shall be maintained of all tests.

8.3 Decompression chamber maintenance

8.3.1 Hyperbaric chambers shall be maintained free of refuse, discarded materials, grease, dirt and unnecessary equipment at all times.

8.3.2 Chamber depth indicators (gauges) shall be dead weight tested or calibrated against a master reference gauge every six months, whenever the chamber is moved, or whenever a malfunction is suspected. Calibration sheets shall be maintained on file and correction tags or labels attached to the gauge.

8.4 Chamber references and supplies

8.4.1 Treatment tables, treatment gas appropriate to the diving mode, appropriate first aid supplies and timekeeping devices shall be available at the chamber station.

SECTION 9: Recordkeeping Requirements

9.1 Personnel records

9.1.1 Personnel records shall be maintained by the employer.

9.1.1.1 Personnel records shall contain the following information:

9.1.1.2 Complete personal and employment history of all divers and diving support personnel.

9.1.1.3 Technical training records including:

9.1.1.3.1 Federal service qualification certificates;

9.1.1.3.2 Diving school certificate of completion; and/or

9.1.1.3.3 Employer training program completion statements or equivalent of proof of competency.

9.1.1.4 Field experience records including:

9.1.1.4.1 Employment records;

9.1.1.4.2 Written statements from other employers;

9.1.1.4.3 Written statements from commanding officers or diving officers;

9.1.1.4.4 Field operation records; and/or

9.1.1.4.5 Individual personal diving records.

9.1.1.5 Proficiency dive records including:

9.1.1.5.1 Company field operations records; and/or

9.1.1.5.2 Federal service operations records.

9.1.2 Personnel records shall be retained for a minimum period of five years after termination of employment.

9.2 Medical records

9.2.1 The examining physician shall provide a complete report of the medical examination and associated tests to the employer.

9.2.2 The medical records shall be retained by the employer for a minimum of five years.

9.3 Diving record retention

9.3.1 Diving records (Section 5.4.3) shall be retained by the employer for a minimum of one year, except five years where there has been an incident of decompression sickness.

9.4 Decompression procedure assessment evaluation retention

9.4.1 Decompression procedure assessment evaluations shall be retained by the employer for five years.

9.5 Diving equipment records

9.5.1 Diving equipment inspection, testing, maintenance, and repair records shall be retained in accordance with the following unless otherwise specified:

9.5.2 Helmets and masks shall have:

9.5.2.1 Specifications and test procedures supplied by the manufacturer on file for each unit.

9.5.2.2 A record of all test, modifications, and maintenance for each unit.

9.5.3 Pressure test records shall be maintained for all breathing air hoses and fittings (Section 7.3.3.4.2).

9.5.4 Records shall be maintained on all compressors maintenance and repairs (Section 7.3.1.9).

9.5.5 Records shall be maintained on all gauge calibrations and correction tags attached to the gauge (Section 7.3.4.3 and 6.3.6.2).

9.5.6 Records of all decompression chamber pressurizations, maintenance, tests and repairs shall be maintained for a minimum of five years.

9.6 Accident recording and reporting

9.6.1 The employer shall record and report occupational injuries and illnesses in accordance with requirements of 29 CFR Part 1904.

9.6.2 The employer shall record the occurrence of any diving related 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 the injuries or illnesses.

9.6.3 Records of hospitalizations shall be retained for five years.

9.7 Availability of records

9.7.1 Upon the request of the Assistant Secretary of Labor for Occupational Safety and Health, or the Director, National Institute for Occupational Safety and Health, Education and Welfare or their designees, the employer shall make available for inspection and copying any record or document required by this standard.

9.7.2 Upon request of any employee, former employee or authorized representative, the employer shall make available for inspection and copying any record or document required by this standard which pertains to the individual employee or former employee.

9.7.3 After the expiration of the retention period of any record required to be kept for five years, the employer shall forward such records to the National Institute for Occupational Safety and Health, Department of Health, Education, and Welfare.

9.7.4 In the event the employer ceases to do business:

9.7.4.1 The successor employer shall receive and retain all dive and employee medical records required by this standard; or

9.7.4.2 If there is no successor employer, dive and employee medical records shall be forwarded to the National Institute for Occupational Safety and Health, Department of Health, Education and Welfare.

APPENDIX A

CONDITIONS WHICH RESTRICT OR DISQUALIFY AN INDIVIDUAL FOR DIVING AND EXPOSURE TO HYPERBARIC CONDITIONS

The following disorders are considered as a basis for absolute disqualification for occupational exposure to diving or hyperbaric conditions:

- Epileptiform disease.
- Chronic inability to equalize sinus and/or middle ear spaces.
- Cystic, obstructive, cavitary, or restrictive disease of the lungs.
- Seriously impaired pulmonary function.
- Significant central nervous system disease.
- 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).
- Malignancies (active) unless treated and without recurrence for five years.
- Psychotic disorders.
- Chronic alcoholism.
- Drug addiction.
- Significant hemoglobinopathies

The following conditions or disorders may restrict, limit, or disqualify an individual for occupational exposure to hyperbaric conditions depending upon severity, presence of residual effects, response to therapy, number of occurrences, diving mode, or degree or duration of isolation:

- Diabetes.
- Obesity.
- History of serious neurological decompression sickness.
- Conditions requiring continuous medication for control.
- Frequent fainting spells.
- Peptic ulcer disease.
- Visual acuity deficits.
- History of seizure disorder other than early febrile convulsions.
- Pregnancy.

The following conditions or disorders may be a basis for temporary restriction or disqualification from occupational diving or exposure to hyperbaric conditions:

Acute alcoholism and/or drug intoxication.

Acute gastrointestinal syndrome.

Acute infections (e.g. skin, upper respiratory, ear).

Recent incident of decompression sickness or pulmonary barotrauma.

Perforated typmpanic membrane.

APPENDIX B

COMMERCIAL DIVING OPERATIONS
OCCUPATIONAL SAFETY AND HEALTH REQUIREMENTS
PART 1910 of Title 29 of
the Code of Federal Regulations,
Subpart T

federal register

FRIDAY, JULY 22, 1977
PART III

DEPARTMENT OF LABOR

Occupational Safety and Health Administration

■

COMMERCIAL DIVING OPERATIONS

Occupational Safety and Health Requirements

Title 29—Labor

CHAPTER XVII—OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION, DEPARTMENT OF LABOR

COMMERCIAL DIVING OPERATIONS

Occupational Safety and Health Requirements

AGENCY: Occupational Safety and Health Administration, Department of Labor.

ACTION: Final standard.

SUMMARY: This final standard establishes mandatory occupational safety and health requirements for commercial diving operations. It reflects OSHA's determination, based on evidence that has been placed in the public record of this rulemaking proceeding, that commercial diving operations involve significant hazards to employees necessitating Federal regulation. By this final standard the Occupational Safety and Health Administration has established safety and health standards for personnel and medical requirements, operations procedures, equipment procedures and requirements, and recordkeeping.

EFFECTIVE DATE: October 20, 1977.

FOR FURTHER INFORMATION CONTACT:

Mr. Joseph J. LaRocca, Office of Standards Development, OSHA, Third Street and Constitution Avenue NW., Room N-3716, Washington, D.C. 20210 (202-523-7085).

SUPPLEMENTARY INFORMATION:

I. Procedural History

On August 8, 1975, a petition by the United Brotherhood of Carpenters and Joiners of America, AFL-CIO, was presented to the Secretary of Labor, stating the petitioner's belief that a situation of grave danger existed within the diving industry and urging that an emergency temporary standard (ETC) be issued with respect to diving operations to protect exposed employees. An informal fact-finding hearing was convened by OSHA in Washington, D.C., November 11-14, 1975. Based on the evidence gathered and evaluated by OSHA, with the assistance of an inter-agency federal task force and several independent experts, the Assistant Secretary of Labor for Occupational Safety and Health determined, in accordance with section 6(c) of the Act, that an ETS was appropriate to protect employees engaged in commercial diving from occupational exposure to grave danger.

On June 15, 1976, the Assistant Secretary issued an ETS for Diving Operations (41 FR 24272) as Subpart T of 29 CFR Part 1910, § 1910.401 et seq., pursuant to sections 6(c) and 8(c) of the Act, Secretary of Labor's Order No. 8-76, and 29 CFR Part 1911. The evidence and findings supporting issuance of the ETS and a discussion of its provisions are set forth at 41 FR 24272-24285.

The ETS was to have been effective on July 15, 1976. However, following a temporary stay, the U.S. Court of Appeals for the Fifth Circuit issued an indefinite stay of the ETS on August 11 pending a final decision on a suit filed by several diving contractors challenging the validity of the agency's action, *Taylor Diving and Salvage Co., Inc. et al.* v. *U.S. Department of Labor*, Civil Action No. 76-2886 (CA 5, 1976). Pursuant to the Court's order, the ETS was not enforced by OSHA. For the reasons stated in the Federal Register notice published on November 5, 1976 (41 FR 48742), the ETS was withdrawn. As a result, the Court dismissed the suit on the grounds that the issues raised by the case were moot.

In formulating the proposed permanent standard, OSHA reevaluated the underlying evidence and the substantive provisions of the ETS in conjunction with information made available to the agency subsequent to publication of the ETS. In this task, technical support was provided by individuals from the U.S. Coast Guard, the U.S. Navy, the National Institute for Occupational Safety and Health (NIOSH) of the Department of Health, Education, and Welfare, the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, and the Smithsonian Institution.

Inasmuch as many diving operations are closely associated with, or related to, construction activities, OSHA considered it appropriate prior to formulation of a proposed permanent standard to seek the advice and recommendations of the agency's Advisory Committee on Construction Safety and Health (the Advisory Committee), established under the Construction Safety Act. This action was taken pursuant to 29 CFR 1911.10 and 29 CFR 1912.3. All available materials were presented to the Advisory Committee. In August 1976, the Advisory Committee met to discuss materials and information relating to the occupational safety and health aspects of commercial diving operations. On August 9 and 10, the Advisory Committee considered the provisions of the ETS and the background materials contemplated for inclusion in the new proposal. On August 26 and 27, the Advisory Committee reconvened to consider an OSHA draft technical proposal which was prepared in advance for the Advisory Committee and simultaneously made available to the public. The Advisory Committee made its recommendations to OSHA at that time. In developing the proposed permanent standard, OSHA considered all the recommendations of the Advisory Committee in addition to public comments presented during its proceedings.

The proposed permanent standard and notice of hearings was published in the Federal Register on November 5, 1976 (41 FR 48950), with necessary corrections made on November 12, 1976 (41 FR 50008). A similar notice of hearing was issued by the U.S. Coast Guard on the same date (41 FR 48969). Public hearings on the proposal were held with the joint participation of the Coast Guard in New Orleans, La., on December 16-21, 1976, and January 10-14, 1977. A total of eighty-one individuals appeared at the hearings as witnesses. Among the witnesses were offshore and shallow water diving contractors, large corporate and small business employers, representatives from the affected workforce including divers, supervisors, and surface support personnel, diving instructors, marine scientists, experts in hyperbaric medicine, diving physiologists, equipment specialists, and other interested parties. Public participation was representative of virtually the entire diving community. The verbatim transcript of the hearings, as well as numerous comments and exhibits submitted to OSHA before, during, and after the hearings, were made part of the rulemaking record. The hearing record was originally scheduled to close on January 31, 1977, but at the request of several parties, it was kept open to February 28, 1977. Before the close of the record, OSHA met with each of the major parties represented at the hearings for the purpose of suggesting issues to be addressed in their respective written post-hearing comments.

This final standard is based on a careful consideration of the entire record in this preceeding, including materials submitted for the fact-finding hearing, materials relied on in the ETS, information submitted to and recommendations of the Advisory Committee, materials referenced in the proposal, and the record of the informal rulemaking hearing including the transcript exhibits and pre-hearing and post hearing written comments. Copies of the official list of hearing exhibits, comments, and notices of intent to appear at the hearings can be obtained from the Docket Office, Rm. S-6212, U.S. Department of Labor, Third and Constitution Avenue NW., Washington, D.C. 20210 (202-523-7894). References to exhibit or comment numbers which appear in this preamble are based on the numbering system in that list. Reference to transcript pages which appears in the preamble are based on the pagination of the certified transcript of the informal public hearings on the proposed standard for commercial diving operations.

II. Nature of the Diving Industry

Commercial divers perform a variety of underwater tasks and are engaged in diving throughout the country's coastal waters, the Outer Continental Shelf, in many of the nations' rivers and inland lakes, as well as in artificial and industrial waters. A March 1975 analysis made by NOAA indicated that there were approximately 2,300 commercial divers in the United States as of January 1973. The NOAA study estimated the diver population in the Gulf of Mexico alone to be 905 full-time and 450 part-time divers (ETS Ex. 12).

The structure of the commercial diving industry is such that approximately 90 percent of all offshore operations are conducted by 23 contractors who employ over half of the country's commercial divers. In addition, there are approximately 400 small and medium size diving companies, whose work is principally confined to relatively shallow waters in harbors and inland waterways.

Prior to 1960 almost all commercial diving in the United States was con-

ducted in harbors and inland waterways, and consisted mainly of construction, repair and salvage work. However, within the past fifteen years, in conjunction with the national search for energy and mineral resources, new areas located in coastal waters and further offshore areas have been opened for exploration and development. Divers are utilized extensively in all phases of the offshore oil industry—exploration, construction, and production.

While the majority of inland and harbor diving occurs at depths less than 100 feet of seawater (fsw), the offshore diver works at depths which range from very shallow to 300 fsw or more, and occasionally to 500–1000 fsw. Technology is sufficiently advanced to enable diving to depths exceeding 1,000 fsw. Based on the current trend in offshore oil exploration, deeper and longer working dives can be anticipated.

III. The Diver's Work Environment

Divers are called upon to use their skills in activities such as construction, repair, salvage, scientific observation, inspection, pipe laying, and rescue operations.

Commercial diving involves exposure to a high degree of risk. The diver's work environment is inherently hazardous. Many divers are subjected to the dangers commonly associated with maritime and construction work. Their work often involves such operations as welding and the manipulation of heavy objects. In addition, many times they work in isolation for relatively long periods of time and are exposed to decompression-related injuries and illnesses.

In diving, several techniques and modes are utilized. Their appropriateness for any particular situation depends on a number of factors, including depth, time, nature of the operation to be performed, and the experience and technical capabilities of the persons involved. Each has unique operational advantages and poses special hazards.

SCUBA diving, where the divers carry their own breathing gas supply, is used primarily for inspection and search activities. Diver inwater mobility and ease of operation are its principal assets. However, the possibility of the diver's getting lost in relation to the dive location (i.e., the vessel or surface from which the dive is conducted), the limited breathing gas supply, and the usual absence of voice communications limit the usefulness of SCUBA in commercial activities and pose hazards which can largely be avoided by using the surface-supplied mode.

Surface-supplied diving is more common than SCUBA diving for commercial operations. This method involves supplying the working diver with the breathing gas, either air or mixed gas, through a hose, from a source located at the dive location. This method of supplying the diver with life support allows monitoring of the diver, who is tethered and in communication with dive location. A major safety limitation of this mode is the duration of inwater exposure. The diver working in the water is continuously subjected to temperatures, currents and other adverse factors of the work environment. In addition, if a diver is decompressed in the water, these factors are intensified by the additional exposure required by this procedure.

When a dive is particularly deep or lengthy, these inherent hazards make the use of a diving bell appropriate. A diving bell is a device which allows the diver to be transported to and from the underwater worksite in an enclosed, dry compartment. It may be pressurized (closed), or it may be unpressurized (open). With a bell, the diver, when tethered to the bell, has a shorter umbilical or life support bundle than if surface supplied, is closer to a place of refuge, and can be decompressed in the relative safety of an enclosed environment.

Mixed-gas diving is carried out with mixtures of oxygen and gases such as helium and/or nitrogen; an oxygen-helium (heliox) mixture is most commonly used. Mixed gas replaces air as the breathing mixture when the increased partial pressure of nitrogen in the compressed air becomes narcotic. Consequently, mixed gas is used during deeper and sometimes during longer dives. Mixed gas is used commercially in conjunction with surface-supplied, bell and saturation diving.

Saturation diving, in which the body tissues become saturated with inert gas, is used in situations where the diver will be exposed to hyperbaric (or high pressure) underwater conditions for long periods of time. For example, for diving depths exceeding 400 fsw with working times over two hours, saturation diving is commonly used. The advantage of saturation is that once the diver's body tissues become essentially saturated with inert gas at any given depth, no additional decompression time is needed regardless of the length of time the diver stays at that depth, because additional time spent at pressure results in little additional gas uptake. However, the saturation mode usually involves very long periods of decompression and isolation for the affected divers. This can be physiologically and, in some cases, psychologically wearing.

Liveboating is a technique in which a surface-supplied diver is supported from a vessel which is underway. This gives the diver greater mobility on the bottom for tasks such as pipeline inspection than would be possible if the diver were tethered to a fixed vessel or surface structure. Because the vessel is underway, however, liveboating poses the potential hazard of hose entanglement in the turning propellers.

Whatever the diving technique or mode used, divers must rely completely on external life-support systems while working under severe performance limitations to perform their tasks. Factors such as environmental, psychological and physiological stress, makeshift or poorly designed tools and inadequate training can further impede the diver's efforts. A close working relationship between the diver and surface support personnel must be established, and an experienced, trained person must be present and in charge of each diving operation. The dive team must be trained or experienced in the diving mode to which it is assigned and the use of the tools necessary to perform its tasks. This is especially true of divers, because many of the work tasks they perform underwater, such as burning, welding, and using explosives, are themselves hazardous. In addition, divers and others who are likely to be exposed to hyperbaric conditions and underwater exposure must by physically fit. It is essential, therefore, that a high level of training, experience, fitness, and supervision prevail for each diving operation.

In addition to having qualified personnel who are medically fit, a dive team must follow sound operating procedures to promote the diving operation's safety and efficiency. Advanced planning is essential to the proper selection of techniques and equipment which will achieve maximum safety under anticipated conditions, especially when the exact conditions to be encountered are not fully known in advance. Effective planning requires a thorough evaluation of what the diver must do to complete the job as well as anticipation of present or developing hazards. Environmental conditions often affect the choice of diving procedures and frequently determine whether diving can be carried out safely. Sea state, sea and air temperatures, weather conditions, underwater visibility and currents, and the nature of the bottom all have significant influence on diving safety, and these factors need to be evaluated prior to and throughout any diving operation.

Proper planning for emergencies and development of appropriate contingency plans are essential to the safety of all diving activities. In an emergency many forms of outside aid may be required. Careful consideration must be given to potential emergencies before any operation is undertaken, so that necessary aid may be obtained as quickly as possible. Moreover, means for emergency transportation must be considered and made available. Because the dive team's isolation can transform any accident or injury into a serious medical emergency, there is also a need for first aid training and careful advanced planning so that personnel may respond to such emergencies in a manner which reduces the likelihood of aggravated injury and illness.

Other safety precautions must be routinely incorporated into the diving operation. Examples of precautions which are necessary under certain conditions, are maintaining the diver in thermal balance, having sufficient breathing gas reserves in case of failure or depletion of the primary source of supply, and providing a standby diver to aid the working diver promptly when inwater assistance is necessary. Similarly, whenever diving outside the no-decompression time-depth limits is planned, appropriate decompression tables designed to return the diver to the surface safely must be followed. In the event that decompression sickness does develop, a decompression chamber, oxygen or treatment gas mixtures, and treatment tables and instructions must

be readily available to treat this condition effectively.

The contribution of comprehensive instruction and effective communication to safety is not limited to emergency or contingency situations; many types of communications are vital to safe diving. Whether used to warn other vessels in the area that a diving operation is underway, to summon emergency aid, or to coordinate operations between the diver and the dive location or bell, reliable two-way communication is essential.

The equipment used in a diving operation is also critical. It must be in proper operating condition and carefully inspected prior to use in diving operations. For example, compressors must be well maintained and located away from sources of contamination locations. The safety implications of equipment failure or misuse for the diver warrant the greatest attention to equipment condition and suitability.

IV. Physiological Hazards

Divers are particularly, and in some cases uniquely, exposed to certain kinds of physiological hazards. On any dive, a diver is exposed to such potentially harmful physical agents as pressure, breathing gas, and water. One pervasive variable is the element of depth. Increased depth means an increase in the pressure exerted on the diver's body, 1 atmosphere (14.7 pounds per square inch) for every 33 feet of depth. While every increase in pressure does not necessarily create a proportionately greater physiological risk, many diving hazards are inherently pressure-related.

In a hyperbaric environment, the increased pressure of the breathing gas forces more gas to be dissolved in the body than is the case at atmospheric pressure. Subsequent ascent to a lesser ambient pressure can cause much of this absorbed gas to come out of solution in the form of bubbles, which are the cause of decompression sickness and other diving-related disorders, either directly or indirectly. The probability of these disorders is minimized by controlling the ascent rate of the diver.

The term decompression sickness is applied to a disease which may occur as the result of a reduction in ambient pressure. The symptoms vary from mild local pain or itching of the skin to neurological effects or collapse with unconsciousness. Decompression sickness symptoms usually occur shortly after completion of a dive or other pressure exposure, or before reaching the surface from deeper dives.

Serious decompression sickness may involve permanent or residual damage to the central nervous system (CNS) or to the audio-vestibular system. Decompression sickness involving the audio-vestibular system may be manifested as partial or total hearing loss, a ringing of the ears, or a sudden severe dizziness and nausea. This type of decompression sickness occurs more often during decompression from very deep dives. Among the symptoms indicating possible CNS involvement are numbness, dizziness, nausea and vomiting, weakness, abdominal pain, visual disturbances, speech difficulty, shock and unconsciousness.

Research using ultrasonic monitoring during decompression has produced convincing evidence that some bubbles may exist during most decompressions, even in the absence of overt symptoms of decompression sickness. These bubbles may damage the linings of the blood vessels and cause changes in the blood itself. Eventually, they may also cause other subtle physiological effects on various organs of the body.

Divers as a class are also subjected to increased risk of skeletal damage. There is evidence that this damage, known as dysbaric osteonecrosis, is decompression-related, the result of gas bubbles trapped in bone tissue which cause the death of such tissue. Dysbaric osteonecrosis may appear as a benign lesion of a long bone, but a lesion situated critically at or near a joint may cause structural failure, which results in painful limitation of movement and eventual loss of joint function. At the present time, ways to prevent dysbaric osteonecrosis entirely are unknown, and it is also not possible to relate the occurrence of osteonecrosis to any particular diving exposure with certainty.

Divers are subject to other decompression-related medical problems. An example is gas embolism, the result of gas being forced into the bloodstream, which is usually caused by a diver holding the breath while ascending. This gas acts as an obstruction, or embolus, which blocks the proper flow of blood to the brain or spinal cord. Embolism causes such serious symptoms as weakness, disorientation, visual and hearing disturbances, dizziness, nausea, shock or unconsciousness; it may be fatal or result in permanent damage unless recompression is accomplished immediately. Similarly, gas may also leak into the pleural cavity or flow under the skin and collect around the heart or in the chest, and may cause collapse of a lung.

Other problems may arise if the pressure in the rigid cavities of the body are not equalized. This condition is known as barotrauma or squeeze. If the pressure imbalance is great enough, ruptured blood vessels or other tissue damage may result. This form of barotrauma most commonly affects the middle ear, but may also occur in the sinuses, teeth, or lungs. Similar effects can result from unequal pressure between the ambient environment and spaces enclosed by the mask or folds of the suit.

In addition to the hazards caused, directly or indirectly, by the increased pressure divers are also exposed to a number of hazards because they breathe compressed air or artificial gas mixtures and must rely on special equipment to furnish the gas (compressors, pressure, vessels, valves, hoses, masks, regulators, and helmets). Among the potential dangers, those associated with oxygen present the greatest hazard in diving. If the partial pressure of oxygen in the breathing mixture is too low, oxygen deficiency (hypoxia) will result; this condition can produce unconsciousness without warning, and can be fatal if not corrected. Excessive oxygen in the inspired breathing gas can cause convulsions resembling those of epilepsy; prolonged exposure to somewhat lower levels of oxygen may cause lung irritation which increases if exposure continues. In addition, excessive nitrogen in the inspired breathed gas can produce narcotic or anesthetic effects which impair the diver's cognitive function.

The possible presence of contaminants in the breathing gas is another hazard associated with diving. Several potentially harmful contaminants have been found in air supplied to divers from engine-driven air compressors. These contaminants can be picked up by a compressor intake or be produced by the compressor itself. The most significant one is carbon monoxide, which combines with the blood's hemoglobin and interferes with oxygen transport to the tissues. This can result in reduced cognitive function; if the level of carbon monoxide is high enough, death can result. Carbon dioxide, while a normal metabolite and not toxic at low levels, can cause unconsciousness and convulsion if it accumlates in a breathing system, especially during exertion. Oil mist causes coughing and nausea, and if it reaches a lung, can damage its sensitive lining and lead to the development of lung edema.

In addition, divers are exposed to the hazards inherently associated with water as a work environment, as well as those which accompany other physically demanding and stressful occupations. The normal hazards of such work are compounded by the fact that the diver is in the water, limited in mobility and visibility, working with heavy objects and sometimes restricted to a physically confining space. The possibility of serious traumatic injury is therefore always present.

V. Summary and Explanation of the Standard

The standard applies to all diving operations conducted in connection with all types of work and employment within OSHA's jurisdiction unless specifically exempted. Because of the interrelated nature of every diving operation, it has been necessary to include requirements which address personnel qualifications and assignments, medical fitness, operational procedures, both generally and by diving mode, equipment, and recordkeeping. The approach taken has been to develop a standard which, based on the full record of this proceeding, promotes employee safety and health by providing for safe and healthful working conditions so far as possible, is technically correct, and is technologically and economically feasible. The major issues raised in the proceedings as well as the purpose and rationale of each requirement of the standard is addressed in the section-by-section discussion which follows this introduction.

No serious question has been raised covering the technological feasibility of the standard. The techniques, equipment and procedures mandated by the stand-

ard are known to and used by substantial portions of the commercial diving industry today. To the extent that there will be any difficulty in complying with the standard by the effective date, the difficulty will stem from short-term shortages of some types of equipment and not from any infeasibility of the standard. To a great extent, these possible short-term supply problems have been remedied by providing delayed effective dates in the standard for some of the equipment requirements. Based on evidence in the record and in consideration of the time period that has already elapsed since the notice of proposed rulemaking and the hearings, the standard accordingly requires employers to comply as soon as possible but in no case later than 6 months after the effective date (9 months after the publication date) with provisions where decompression chambers or bells are required and such equipment is not yet available (Tr. 174–6; Ex. 43). To the extent that even after this period all employers may not have been able to obtain the necessary equipment, the provisions for temporary variances in section 6(b)(6)(A) of the Act are appropriate and adequate to provide the relief necessary.

In considering the economic impact of the standard, OSHA has relied on its Inflationary Impact Assessment (IIA) (Ex. 27) and evidence in the record presented by professional economists, individual employers and others connected with the industry. Prior to the proposal, OSHA prepared within the time and resources available to it an IIA in accordance with Executive Order No. 11821 (39 FR 41501, November 29, 1974), OMB Circular A–107 (January 28, 1975), Secretary's Order No. 15–75 (40 FR 54484, November 24, 1975), and the U.S. Department of Labor Temporary Directive No. 1 (November 17, 1975). Based on the data collected in the IIA, OSHA was able to conclude that the proposed standard was not a "major" action which would necessitate further inflationary impact evaluation, because the threshold criteria established by the enabling orders were not exceeded.

The proposal invited information, data and comments concerning economic feasibility and inflationary impact for presentation at the hearings; and testimony was heard on the subject. A panel which was sponsored by the major industry group and which had been contracted by them to conduct a cost impact survey presented testimony challenging the methodology and conclusions of the IIA and introducing their own cost estimates of the impact of the proposed standard (Tr. 1854–1917). After the hearings, OSHA had Arthur Young & Co., its economic consultant in this matter, review this critique and a similar one by the Council on Wage and Price Stability (Ex. 127); this review was entered into the record (Ex. 128). The industry economic panel then commented upon the analysis of the OSHA economic consultant (Ex. 182). Based on the analysis of its consultant, OSHA has determined that the IIA adequately addressed the specific threshold criteria and properly concluded that they were not exceeded.

A finding of a non-major inflationary impact is not necessarily equivalent to a finding of economic feasibility, particularly when a relatively small industry is involved. OSHA has therefore considered the economic impact of this standard on the regulated industry. In assessing economic impact, only the incremental impact of the standard vis a vis current and projected industry practice is relevant; that is, only costs imposed on employers which would not otherwise be incurred can be considered. In making this determination, the agency must rely on whatever data on costs, revenues, profits, and market structure exists in the record, as well as its knowledge of current and expected industry practices. In approaching the data that has been presented, OSHA recognizes that at the time the data was collected, many of the employers surveyed either by OSHA or the industry contractor, and particularly the small business employers, had an inaccurate and often exaggerated conception of what the proposal would require (Tr. 1883, 1912); and, secondly, there was insufficient appreciation of the extent to which diving companies would already be in compliance with the standard given their standard operating procedures (Tr. 1901–12).

The IIA estimated an annualized yearly cost of $22 million for the entire industry, an estimate which was, if anything, intentionally biased on the high side because it did not take into account a report by a major contractor that there would be no significant economic impact (Ex. 27, p. III–4). This figure can be compared to the estimated total domestic revenues of less than $100 million. The industry-sponsored statistician was of the opinion that, because of the sample size used, there was a 25 percent chance that the IIA cost estimates were over or understated by as much as 30 per cent. (TR. 1861, 1889), which would place the annualized yearly cost in a range of approximately $14.7 million to $29.3 million; while the analysis of the OSHA economic consultant, after review of a survey presented by the major industry group of its membership (ETS Post-Hearing Comment 13), indicates that the IIA estimate of total domestic revenues appears warranted.

By contrast, the industry economic panel estimated the total annual cost of compliance to be $34.3 million to $40.2 million (TR. 1885). It presented no precise estimate of total revenues for the industry as a whole, but indicated that they certainly exceeded $100 million in domestic sales and $200 million in worldwide sales (TR. 1872, 1884; Ex. 182). Unfortunately, the background information for the companies it surveyed and upon which its estimates were based was not entered into the record, so that careful analysis of the conclusions presented is not possible. In addition, several individual employers who classified themselves as small businessmen performing mostly shallow-water diving testified in general terms that the economic impact of the standard would be significant on their individual firms (TR. 592, 626–31, 722–3, 1262, 1274, 1277, 1414, 1416–7, 1421–4, 1689, 1693–6), but none provided an itemized breakdown of costs or was willing to divulge revenue or profit information (Tr. 1423–4), and none was in a position to project cost impact for the industry as a whole or any particular sector. No evidence was presented on profits within the industry, either individually or industry-wide; and given the lack of publicly held corporations in the industry, no such evidence was independently available. The information provided by the industry, and over which it was uniquely in control, was therefore of limited usefulness.

Much of the substantive testimony at the hearings and in the record concerned actual industry practice and indicated that it did not differ significantly from much of the proposal; reference to such testimony is made when appropriate in the section-by-section discussion of the standard. Examination of the most common industry manual (ETS Ex. 4), which is endorsed and used by approximately half the industry and nearly all the offshore contractors, confirms this to be true.

In considering cost impact, it should also be recognized that there are differences between this standard and the proposal. For example, costs associated with first aid training and supplies, medical examinations, compressor systems, and recordkeeping should generally be lower than was true of the proposal; while there may be some increased costs with regard to standby divers, reserve breathing supplies, and decompression chambers. On the whole, however, the cost impact of the standard has probably been reduced because care has been taken to eliminate those items of the proposal identified as "liability traps;" other requirements have been modified or deleted to accord with evidence presented in the record; whenever possible to do so without compromising the safety and health of employees, it is left to the employer to seek the most cost-effective means of achieving a particular performance requirement; and close attention has been paid to recommendations from individuals with practical experience in the industry and particularly to evidence of current industry practice. Moreover, there should be no disproportionate impact on market structure, because the nature of the standard is such that the greatest cost impact of the standard will be felt by the portion of the industry best able to bear the cost, namely the larger offshore contractors who do mostly deep diving in conjunction with the oil industry and should be able to pass on much of the cost to their client industry (Ex. 128); while the cost impact on the smaller contractors who do almost exclusively shallow-water work will be correspondingly less. Finally, to the extent that temporary supply bottlenecks can be anticipated due to the initial start-up costs of compliance with

certain capital cost requirements of the standard, the extended effective dates for these requirements should eliminate that potential short-term problem. Accordingly, OSHA is able to determine that the standard is both technically and economically feasible.

In so concluding, OSHA has, of course, also considered the benefits which will accrue from compliance with the standard in the reduction of injuries, illnesses, and fatalities and the accompanying reduction in tangible and intangible social costs. Evidence that deaths, injuries, and illnesses have occurred as a result of the hazards associated with diving is found throughout the records (ETS Exs. 34, 41, 42, 44, 45, 47, 48, 49, 50, 52; ETS Post Hearing Comments 13, 14; Exs. 17, 62, 76, 100; Comments P, Y, MM); much of the statistical information presented has been compiled in a single document by OSHA (Ex. 44B). While no dollar figure is possible, OSHA believes that the benefit to be derived from the standard is significant and serves the legislative mandate of the Act.

In addition, OSHA is able to reaffirm its determination (41 FR 48959) that the standard is not a major Federal action significantly affecting the quality of the human environment and that an environmental impact statement is therefore not required. The only potential impact that has been raised relates to its effect on the offshore oil industry. The IIA found that there would be virtually no impact on either the nation's energy supply or demand, and no impact on supplies of critical materials as a result of the standard (Ex. 27, IV-7). There was testimony by the industry economic panel that the standard could result in some marginal oil wells becoming economically infeasible and an increase in the mobilization time for the diving industry which would cause pipelines and wells needing repairs to be shut down for longer periods of time (Tr. 1869, 1871; Ex. 182). However, this assumption fails to take into account the fact that the increased costs to the diving industry compared to the economic costs of lost production, particularly when considered in light of demand for oil and the ability of the oil industry to absorb an increase in the cost of diving services, is such that no significant impact on energy supplies, and hence on the environment, can reasonably be anticipated (Ex. 128). It is also noted that the standard permits deviation from its requirements, in emergency situations, to the extent necessary to prevent major environmental damage.

1. *Scope and application* (§ *1910.401*). The standard applies wherever OSHA has statutory jurisdiction. Consequently, unless specifically excluded from the standard, diving in any natural or artificial inland body of water, as well as diving along the coasts of the United States and possessions listed in Section 4(a) of the Act, 29 U.S. 655, or within the Outer Continental Shelf surrounding them, is covered. Diving outside of the Outer Continental Shelf is not covered by this standard.

The standard applies to diving and related support operations conducted in connection with all types of work and employments over which OSHA has jurisdiction, except in cases where exclusion from the standard has been explicitly provided. For this reason, and to avoid any possible ambiguity, the standard is not only adopted as a subpart of Part 1910 of 29 CFR (general industry), but is also incorporated into Parts 1915 (ship repairing), 1916 (shipbuilding), 1917 (shipbreaking), 1918 (longshoring), and 1926 (construction). Sections 803 and 804 of 29 CFR Part 1926, which apply to compressed air and decompression in construction work, do not apply to diving operations in view of the specific provisions in Subpart T which deal with these subjects as they pertain to diving. Nor does the standard apply to agricultural operations within the meaning of Part 1928 (agriculture).

Pursuant to Section 4(b)(1) of the Act, the standard does not apply to working conditions over which other Federal agencies exercise statutory authority to prescribe or enforce standards or regulations affecting occupational safety and health. OSHA has been advised of the U.S. Coast Guard's intention to publish proposed regulations, within its area of jurisdiction, on commercial diving operations.

Specific exclusions have been provided where the nature of the diving operations is such that inclusion in this standard would be inappropriate, or where the safety and health of divers is governed by rules or regulations of another Federal agency. The three exclusions are: (1) Instructional diving utilizing only open-circuit compressed air SCUBA within the no-decompression limits; (2) search, rescue and related public safety diving by or under the control of a governmental agency; and (3) diving governed by to the Protection of Human Subjects regulations of the Department of Health, Education and Welfare (HEW) or equally effective rules or regulations of another Federal agency.

In addition, pursuant to Section 3(5) of the Act, employees of Federal agencies of the United States government are excluded from the jurisdiction of the standard. Instead, such employees would be protected in accordance with Section 19 of the Act under which it is the responsibility of each agency which engages in diving operations to establish and maintain an effective and comprehensive safety and health program which is consistent with this standard. Because of the nature of this standard, OSHA recognizes that certain Federal agencies such as the U.S. Coast Guard and those within the Department of Defense have unique activities and obligations which may require adjustments to this standard consistent with their diving operations.

Several parties, and the Construction Advisory Committee, have argued against any exclusions from the standards, and particularly against those which appeared in the proposal for instructional and scientific/educational divers whose operations utilized open-circuit compressed air SCUBA and were conducted within the no-decompression depth-time limits. Their reasoning was essentially that no valid distinction can be drawn between commercial diving and that performed by the excluded groups, because divers in both groups are employees, both work in the same marine environment, and both are subject to some of the same inherent hazards and physiological effects of diving. It has also been stated that SCUBA diving is at least as hazardous as surface-supplied diving (Tr. 779, 797, 1391; Ex. 35, 178 p. 81).

OSHA has concluded, however, that a valid distinction can be made between the class of SCUBA instructors and that of commercial divers, and that exclusion of SCUBA instructors, in the circumstances indicated, is warranted. The comments presented by the sport and recreational diving instruction groups provide a convincing rationale for such a distinction (Ex. 148). The diving instructor, who is an employee, is student oriented, not task oriented. The dive site is not determined by the location of a particular job as it is in commercial applications, where operations must of necessity be conducted under environmental conditions which are often adverse. The SCUBA instructor, by contrast, selects a location which is usually clear, shallow, and warm. Indeed, a swimming pool is the dive site for most SCUBA instruction. Such dives are discontinued if the slightest difficulty occurs. SCUBA instructors do not utilize construction tools, handle explosives, or use welding or burning tools. As a result of these factors, SCUBA instructors are rarely exposed to adverse sea states, temperature extremes, great depths poor visibility, or heavy work loads, some or all of which are common to the great majority of commercial diving operations.

However, OSHA recognizes that some diving techniques or conditions pose greater potential hazards than others, regardless of the purpose of the dive. Thus, this exclusion for instructional diving has been ilimited to a restricted diving range, a particular specific mode, and equipment. The exclusion from the standard applies only to instructional diving which uses open-circuit compressed air SCUBA and is conducted within the no-decompression limits. The standard defines no-decompression limits as the depth-time limits of the "no-decompression limits and repetitive dive group designation table for no-decompression air dives" of the U.S. Navy Diving Manual, or equivalent limits which the employer can demonstrate to be equally effective. No distinction per se is made between instructors of prospective sport and recreational divers and instructors of prospective commercial divers. However, by its very nature, the training for commercial divers involves diving that is surface-supplied, uses mixed gas as a breathing gas, or requires decompression; each of these factors potentially increases the hazard

of the operation. Once the instructional environment exceeds the specified limits, the standard applies. Coverage of instructors who work outside these limits protects the instructors' own health and safety, and also serves to introduce proper compliance with the standard at the formal training level.

In addition, it should be noted that individuals engaged in recreational or sport diving for their own personal enjoyment, and not otherwise related to their respective employments, are not within the jurisdiction of the Act, and therefore are outside the scope of this standard. On the other hand, SCUBA diving for a commercial rather than instructional purpose is covered by the standard, regardless of equipment or depth-time range.

The second category to be excluded from the standard is diving operations performed solely for search, rescue, or related public safety purposes by or under the control of a governmental agency. Although not in a class explicitly excluded by the proposal, OSHA has received a number of comments from persons engaged in diving which is incidental to police and public safety functions, who have urged the specific exclusion of this group from the standard (Comments J, W, AA, FF) and OSHA has concluded that such an exclusion is appropriate. The "by or under control of" language is intended to make the exclusion applicable to all divers whose purpose is to provide search, rescue, or public safety diving services under the direction and control of a governmental agency (e.g., local, state or federal government) regardless of whether or not such divers are, strictly speaking, government employees. Diving contractors who occasionally perform such services privately on an emergency basis, and who are not under the control of a governmental agency engaging their services, do not come under this exclusion. This may, however, be covered by the provision concerning application of the standard in an emergency, which is discussed below. In exempting these search and rescue operations, OSHA has determined that safety and health regulation of the police and related functions are best carried out by the individual States or their political subdivisions.

In contrast to the proposal, the category of scientific/educational diving is treated separately in the standard from SCUBA instructors because the record does not adequately support a conclusion that the work conditions and risk exposure of scientific divers differ measurably from those of commercial diving (Tr. 1769–80). They are therefore generally covered by the standard. A portion of the scientific diving community is, however, excluded from this standard. Diving operations which are governed by 45 CFR Part 46 do not come within the scope of this standard; such operations involve research and development or related scientific activities requiring human subjects and receive HEW grants or contracts. Compliance with the HEW regulations is mandatory for such employers or contractors, and the regulations are designed to promote safety and health. Similarly, any other Federal agency which adopts rules or regulations that are equally effective, i.e., similar in design, purpose, and effect to those of HEW, will come under this exemption. The exclusion is appropriate and supported in the record on the grounds that it would permit continued scientific research designed to extend the safe limits of diving physiology and technology (Tr. 1318, 1335–7). The long-term safety and health interests of divers are best served by the continuation of this research, and such diving cannot reasonably be expected to comply in every respect with a standard which is designed to reflect current operational practice.

OSHA has received numerous comments from employers whose operations are predominantly or exclusively confined to relatively shallow waters, requesting that their operations be excluded from the standard or at least be treated separately by a two-tiered standard. OSHA has determined that this would not be appropriate. First, the record indicates that shallow water divers are often subjected to many of the same hazards as the deeper water divers, and occasionally to the increased hazards of repetitive diving (Tr. 105, 748–9, 923–4, 9440–1, 1109; Ex. 178, pp. 13–16). Second, the standard is designed to reflect good operating practice, which is equally relevant to shallow water diving operations. Nevertheless, while a separate set of provisions has not been created for the shallow water diving sector, OSHA has been sensitive to the need to promulgate suitable requirements for this segment of the industry and has endeavored to provide appropriate distinctions wherever it could be done without compromising employee safety or health.

In addition to the exclusions discussed above, the emergency provision has been included in the standard because of the unique situations in which the diving industry is at times placed. Contractor comments urged "that the designated person in charge be given the discretion to take whatever action he deems necessary to cope with emergency situations requiring immediate action, so long as he takes the proper precautions to provide for safety under unusual conditions" (Ex. 178, p. 7). OSHA agrees that in such emergencies the overriding consideration should be the preservation of life and the protection of the environment. The emergency provision, which reflects these concerns, is restricted to permitting deviations from the requirements of the standard in those situations where death, serious physical harm, or major environmental damage is likely, but only to the extent that such action is immediately necessary to prevent or minimize the harm. No exemption is provided for situations where purely economic or property damage is likely, nor is the emergency waiver intended to substitute for the statutory variance procedures (sections 6(b)(6)(A), 6(b)(6)(C), 6(d), and 16 of the Act). This emergency provision anticipates the unique circumstances for which diving services are sometimes needed and thus obviates the need for a continuous OSHA variance capability to make ad hoc determinations in emergency situations, as has been recommended (Ex. 178, p. 5). Although temporarily exempt from inappropriate substantive portions of the standard in such emergency situations, the employer is required to notify the OSHA Area Office within 48 hours and, upon request of the Area Director, to submit a record of the notification, with an indication and explanation of what deviations from the standard were taken as a result of the emergency. This requirement will enable OSHA to monitor the use of this exemption.

As in all OSHA standards, the responsibility for compliance with its requirements is placed upon the employer. Throughout the proceedings, several individuals questioned why some legal responsibility could not also be placed directly upon employees, because the diver must exercise a large measure of individual responsibility and, while underwater, is to a large extent beyond the direct control of the employer/supervisor (TR. 143–4, 178, 1250–1, 1747–52). However, while the Act directs each employee to "comply with occupational safety and health standards * * * which are applicable to his own activities and conduct" (§ 5(b)), there is no mechanism under the Act by which such standards can be enforced against an employee. The legislative history (S. Rep. No. 91–1282, 91st Cong., 2d Sess. 10–11 (1970)) and case law (*Atlantic & Gulf Stevedores v. OSHRC*, 534 F.2d 541 (3rd Cir. 1976)) are clear that "final responsibility for compliance with the requirements of this act remain (sic) with the employer" and Congress did not intend to confer on the Secretary [of Labor] or the [Occupational Safety and Health] Commission the power to sanction employees, because the OSHA Act provides for "an enforcement scheme directed solely at employers."

While placing legal responsibility for compliance solely upon the employer, OSHA has carefully endeavored throughout the standard to take the realities of the diving environment into account and to make the substantive requirements, and hence the responsibility for compliance, consistent with the degree of control the employer has over particular aspects of a diving operation. Moreover, performance of particular functions for which the standard makes the employer responsible may in fact be delegated to the employer's designated person-in-charge or to other employees; however, such delegation does not dilute the employee's legal responsibility for compliance with this standard.

2. *Definitions* (§ *1910.402*). The list of definitions in the standard has been greatly reduced from that which appeared in the proposal. The purpose in providing definitions for key terms is to clarify the intent of these terms as used

in substantive provisions of the standard. For instance, "dive location" refers only to the vessel or surface from which the diving operation is conducted, and never to the underwater site of the dive. Certain definitions which appeared in the proposal have been deleted because they were considered identical to their common, unambiguous meanings (e.g., "decompression," "exhaust valve"); others have been deleted because they no longer appear anywhere in the standard (e.g., "ascent time," "hot tapping," "PVHO"). Of the definitions which remain, many have been modified in the interest of precision and in accordance with testimony and comments received in connection with the hearings on the proposal (Tr 149–152, 188–90, 1721–3, 1936–9, 1979–85, 2096–7; Exs. 154, p. 6–9, 165, 178, p. 17–22).

3. *Personnel qualifications (§ 1910.410).* In the diving industry, employee qualifications are critical to safety and health since lack of adequate training and experience has been one of the most frequent contributing causes to diving accidents and injuries (Tr. 781–3, 843, 921–23, 1814, 2208; Ex. 17, 44, 62, 76, 77). Employee safety and health can be maximized by establishing basic criteria for experience and training of participants in diving operations (Tr. 781, 783, 1366).

The standard specifies that all dive team members, i.e., divers and support employees involved in diving operations, including the designated person-in-charge, must have experience or training in the use of tools, equipment, systems, techniques, operations and emergency procedures which pertain to their assigned tasks and diving modes, i.e., SCUBA, surface-supplied air, or mixed gas. These required elements of experience or training are essentially unchanged from the proposal and is supported by testimony (Tr. 134). In addition, dive team members who are exposed to or control the exposure of others, to hyperbaric conditions (e.g., a chamber operator) must be trained in diving-related physics and physiology. Training in diving-related physics was specifically included at the recommendation of a hearing witness who noted that an understanding of the effects of pressure on gases is as essential to a basic understanding of diving as is knowledge of the physiological effects of diving (Tr. 134). However, under the standard's formulation, for example, a beginning tender or other dive team member who is not exposed to hyperbaric conditions nor responsible for the exposure of others will not be required to have this training.

The level of experience or training required by the standard depends upon the particular function an employee fulfills on a dive team and the diving mode to which the employee is assigned. For example, a tender employed in shallow air diving would be required to have a basic understanding of the breathing air system and the operating and emergency procedures which pertain to this mode and the equipment associated with it. A mixed-gas diver, by contrast, would be required to have a greater degree of understanding, including a working knowledge of mixed-gas equipment, such as a decompression chamber, bell and mixed-gas breathing gas supply system, the operations and emergency procedures associated with this diving mode and the equipment used with it, and an understanding of the physics and physiology of mixed gases. By allowing employee qualifications in these areas to be achieved through either field experience or classroom training, or a combination of both, the standard acknowledges industry practice, which is to train dive team members on the job, including those who are graduates of formal diving courses. Most divers begin as tenders and advance to diving status after a year or more of field experience (Tr. 606; Ex. 64Aii, Ex. 154, p. 10–19).

In addition, each dive team member must be trained in cardiopulmonary resuscitation and standard first aid. This requirement replaces the proposal's requirement that there be one person trained in advanced first aid at every dive location, and a diving paramedic (Emergency Medical Technician/Diving) at the location of certain remote or particularly deep dives. While the need for first aid training is widely recognized, there has been considerable testimony and comment that a diving paramedic (EMT/D) requirement is both inappropriate and infeasible at this time (Tr. 77, 314, 645–6, 649, 1542–45, 1792–3, 1926–7, 2060–1; Comments B, 90; Ex. 178, p. 52–5) although some testimony supported the concept in principle (Tr. 900, 901, 981–5, 1027–31). OSHA has determined that requiring all dive team members to be trained to handle basic trauma and breathing emergencies offers the broadest possible protection to the greatest number of personnel (Tr. 77, 314, 645–6, 649, 717, 901, 1158–9, 1272–3, 1545, 1654, 1733, 2113, 2214–17; Ex. 178, p. 51–2; Ocean Systems letter—3–17–77, late submission 3). An American Red Cross standard course (14 hours) or equivalent training is specified because the combination of both field experience and formal instruction, is considered the best method of gaining necessary first aid knowledge and skills. First aid and cardiopulmonary resuscitation courses of instruction meeting the requirement in the standard are offered throughout the country.

The requirement of the standard concerning job assignments is similar to that for "employee training" in the proposal. It is intended to assure that job assignments are consonant with an employee's experience and training. Dive team members may receive such training on the job when under the direct supervision of an employee already experienced in the task to be performed (Tr. 605–6, 924–5).

The requirement that no employee be exposed to hyperbaric conditions against the employee's will derives from similar provisions in the proposal (§ 1910.421(d)(2) and (e)) and is consistent with traditional and well-understood industry practice (Tr. 2107–8; Ex. 64Aiv,1.2a.2). However, notwithstanding an individual's desires, the standard anticipate that it may become necessary to prolong the diver's hyperbaric exposure to complete a decompression or treatment procedure to avoid serious or fatal consequences (Tr. 137–8, 1748–52; Ex. 178, p. 58–9).

The requirement that a dive team member not be permitted to dive or be otherwise exposed to hyperbaric conditions for the duration of any physical impairment or condition known to the employer and likely to affect adversely the safety or health of a dive team member derives from the "temporary impairment or condition" section of the proposal. Exposure with such as impairment or condition could be detrimental to the employee's health and possibly jeopardize others. However, the "known to the employer" language reflects the requirement that an employer must inquire into, and make an assessment of, the physical fitness of the dive team member before each dive. The list of specific impairments from the proposal has been deleted because these were intended to be merely illustrative, rather than all inclusive (Tr. 2186).

The standard maintains the proposal's requirement that the employer designate a person to be in charge of all aspects of the diving operation affecting the safety and health of dive team members. This requirement was supported by hearing testimony which emphasized the importance of such a person to operational safety (Tr. 143–4, 178, 1748–52, 1768–9; Ex. 178, p. 26–7). The person who fulfills this function may be either the employer or an employee who has had experience and training in the conduct of the assigned diving operation. Depending on the size of the diving operation, the designated person-in-charge may either act as a full-time supervisor or may carry out this role in conjunction with other duties at the dive location. The "affecting the safety and health of dive team members" phrase has been added to clarify that the requirement is not directed to functions which are unrelated to safety or health, such as payroll, contracting, and other management responsibilities. The standard's requirement that the designated person-in-charge be experienced and trained in the conduct of the assigned diving operation derives from testimony that such prior experience is crucial to the safety of the operation and that lack of such experience has resulted in accidents and fatalities in the past (Tr. 843–8). The proposal would have required that the designated person-in-charge be currently or formerly qualified as a commercial or military diver. This was supported by some evidence at the hearings (Tr. 819–20, 1264, 1429, 2105). However, this requirement has been deleted in favor of the general experience requirement because of testimony that it is not necessary in all cases to have been a diver to be an effective supervisor, but it is essential that the person must be experienced and familiar with the operational aspects of the work (Tr. 94–5, 207–8, 435; Ex. 178, p. 27–8).

4. *Medical requirements (1910.411).* The medical requirements of this standard are premised on the fact that diving

is basically a high-stress occupation performed under difficult environmental conditions, and that the safety of the diver and other dive team members can depend on the health of the individual diver. For this reason, OSHA considers it appropriate to require mandatory medical examinations for employees in this occupation who are, or are likely to be, exposed to hyperbaric conditions. In addition, the requirement for medical examinations implements the purposes of section 6(b)(7) of the Act to determine whether the health of such employee is adversely affected by this occupational exposure.

As in the proposal, the employer is ultimately responsible for determining whether affected dive team members are medically fit to perform assigned tasks in a safe and healthful manner. However, the decision is to be based on the best available medical opinion.

For the employer to have sufficient information on which to base that determination, the standard requires the employer to provide dive team members who are, or are likely to be, exposed to hyperbaric conditions with medical examinations at no cost to the employee. The proposal required examinations for "employees engaged as divers or otherwise subjected to hyperbaric conditions." It has been recommended to OSHA that only divers be provided with the required examinations, a recommendation which would exclude all non-diving support employees from the medical requirements (Ex. 178, pp. 23–4, 30–1). However, the standard as written reflects the view, expressed by a commercial diving physician at the hearings (Tr. 71), that any dive team member who is to be exposed to hyperbaric conditions should be medically fit beforehand. Being subjected to pressure and undergoing decompression are stresses which warrant inclusion of this group of employees in the medical requirements of the standard. For the purposes of the standard, "are, or is likely to be exposed" applies to any employee who is expected to dive, enter a decompression chamber, or be otherwise exposed to increased pressure. In addition to divers, this requirement would apply, for example, to dive team members such as tenders or designated persons-in-charge who might reasonably be expected to enter a decompression chamber to treat, or aid in the treatment of, a diver suffering from decompression sickness.

Objection has been raised to the requirement that employers bear the cost of the examinations, particularly with regard to the issue of providing an examination for transient divers hired on a temporary basis for specific jobs. Nevertheless any employer exposing employees to hyperbaric conditions, except in emergency situations, would be obligated to pay for their medical examinations unless it could be demonstrated that an equivalent medical examination were taken within the preceding 12 months. (Tr. 716–7, 926; Ex. 178, p. 30). The cost of medical examinations being borne by the employer is mandated by statute (§ 6(b)(7) of the Act) and reflects a purpose that the medical fitness of all employees is the responsibility of the employer.

There was considerable testimony about the importance of the physician's familiarity and knowledge of diving medicine (Tr. 125, 378, 1011, 1391, 1456), and OSHA believes such concerns are justified. Accordingly, it is expected that employers will seek out and engage the services of physicians who are knowledgeable in the physiological effects of hyperbaric conditions. Such an understanding is important to enable a physician to examine diving employees and to render an informed opinion as to the fitness of an employee based on an employer's indication of likely hyperbaric exposure and types of assigned work. However, no specific qualifications for the training of physicians performing the required medical examinations are prescribed, because there is no formally recognized sub-specialty of hyperbaric medicine at this time.

The requirement that medical examinations be provided at one-year intervals from the date of the initial or last equivalent examination reflects standard medical practice (Tr. 70). Since there will be a 90 day effective date for the standard, OSHA believes there will be adequate time to provide the required examinations (Comment Y). Employees hired after the effective date of this standard must be provided the examination before being assigned to tasks requiring hyperbaric exposure so that the determination of fitness can be made before exposure. As in the proposal, the standard permits an employee who has had an examination within the preceding year which is equivalent to the one required by the standard to meet the examination requirement. This will avoid unnecessary medical examinations.

The reexamination requirement after an injury or illness appeared in the proposal, but the criterion for when such a reexamination is necessary has been modified in accordance with testimony of diving physicians (Tr. 57–8, 73, 1649). The testimony recommended that hospitalization in excess of 24 hours would be proper and adequate, since it reflects current medical practice which requires patients to be hospitalized for observation for a 24-hour period in cases where the seriousness of symptoms or signs is undetermined. After the observation period, those patients whose conditions warrant hospital treatment are admitted, while those whose injuries or illnesses have resolved or are clearly minor in nature are discharged. The standard therefore requires reexamination only for that group of employees whose conditions are medically judged to warrant such hospital admittance, and further provides that the nature and extent of such reexamination be determined by the examining physician. After such a reexamination, an employee cannot be reassigned until the employer determines that the employee is fit to return to the assigned work based upon the physician's report.

The requirement that the employer provide the physician with certain basic information derives from a similar provision in the proposal, as modified by testimony (Tr. 71); this is consistent with general OSHA policy. The examining physician must be supplied with a copy of the medical requirements of the standard. In addition, the employer must provide the physician with a summary statement of the nature and extent of the hyperbaric conditions to which the dive team member will be exposed. For instance, such a statement might indicate that a chamber attendant will be exposed to a pressure equivalent to 165 fsw (6ATA), but would not be exposed to the underwater work environment. The physician must also be told by the employer what modes of diving and what types of work a diver will be performing; such a description might note that the employee will be diving in the saturation mode, which requires prolonged exposure to stressful and isolated hyperbaric conditions, or is expected to perform heavy construction work.

Each initial and annual examination must include a medical history, a diving-related work history, a basic physical examination, the tests required by Table I, and any additional tests the physician considers necessary. In contrast to the proposal, the required work history is limited to diving-related matters, because other details of work history would not be relevant except to the extent they have become a part of the medical history (Tr. 72). The proposal's requirement for "any tests deemed necessary to establish the presence or absence of any * * * disqualifying conditions" has been deleted. This was done because the intent of that provision has been met in the standard by leaving the physician the discretion to administer other tests deemed necessary by sound medical practice, because the absence of a condition cannot be definitively established, and because the specific disqualifying conditions of the proposal are no longer a mandatory part of the standard (Tr. 72, 1650; Ex. 178, p. 35–6).

The required medical tests which appear in Table I are basic examination requirements and are somewhat modified from those which appeared in the proposal. The EKG (Standard 12L) identifies certain cardiac abnormalities not detectable by auscultation (Tr. 85). A hearing test is essential because hearing degradation is common in diving and hearing is essential if the critical voice communication requirements specified in the standard are to be used effectively (Tr. 85). A visual acuity test is necessary to the extent vision may be relevant to job performance. A color blindness test is necessary because color coding is commonly used for piping and hose markings; appropriate work assignments or adjustments should be made if there is a problem in this area (Tr. 86). Blood and urine tests are important because some conditions (anemia, diabetes) can only be detected this way. Diabetes could produce unconsciousness; anemia reduces work capacity and therefore fa-

tigue and exhaustion (Tr. 86). A white blood count is an indication of acute infection. The sickle test index tests for hemoglobinopathies. Abnormal hemoglobins produce sickling under conditions of hypoxia, which causes blockage of blood vessels throughout the body and injury to many organs and tissues (Tr. 52–3 1205); exposure to low oxygen partial pressure might precipitate a sickling crisis, which would be incapacitating underwater. The chest X-ray detects restrictive or obstructive lung disease, which is hazardous for a diver whose pulmonary function is less than normal because of stress imposed by breathing under pressure; certain chest disorders cannot be detected without an X-ray (Tr. 84). In addition, because the physiological effects of the normal aging process begin to be detectable at about age 35, a single routine (12 lead) EKG is required at age 35 or over to establish a base-line record of heart function.

Medical tests which were required only "when medically indicated" have been deleted from the tables, since these and other relevant medical tests and procedures may be required at the discretion of the physician after consideration of the employee's work and medical history and the results of any other required tests. The requirement that all divers involved in decompression dives undergo a triennial long-bone and joint X-ray survey has been deleted from the standard because testimony on this issue was contradictory (Tr. 89–98, 72–3, 643–5, 1059–65, 1204, 106–7, 1397–9, 1651–3), and because of a reluctance to mandate a periodic X-ray procedure as a diagnostic technique where no established relationship between the procedure and effective treatment is clearly established. Similarly, the chest X-ray is required only initially; whether to require it at the annual reexamination is left to the discretion of the physician.

The report written by the examining physician has been modified from that required by the proposal to include the overall results of the examination only, rather than the test results, because they would be difficult for the employer to decipher and revealing such results could perhaps be an infringement of the employee's privacy (Tr. 1764–6). In addition to the examination results, the report must include the physician's opinion of the employee's fitness to be exposed to hyperbaric conditions, including any recommended restrictions or limitations to such exposure. The intent of this provision is that a medical condition should be disqualifying only to the extent dictated by sound medical judgment. For example, the physician might recommend that a diver with an ulcer could dive without jeopardizing the individual's or another dive team member's health or safety so long as the diver only participates in shallow air diving in a harbor or lake, where medical aid is readily accessible and the diver's decompression obligation is minimal. On the other hand, a physician would probably insist that a mixed-gas or saturation diver be in excellent medical condition before declaring such a diver fit to work in such circumstances.

The employer's decision on diving assignments must be consistent with medical opinion. Therefore, the function of the physician's medical report is to serve as a basis of the employer's determination. If the physician's opinion is that an employee is medically fit, the employer should be able to rely on that opinion and assign the employee to any task for which the employee is otherwise qualified. On the other hand, if the physician recommends a restriction or limitation on the employee's hyperbaric exposure, OSHA recognizes that both the employer and employee are put in a difficult position by the standard's requirement that employees who are medically unfit, as determined by the employer based on a mandatory medical examination, not be permitted further hyperbaric exposure. By its nature, diving demands that employees whose assignments require hyperbaric exposure be medically fit. It is recognized that certain medical conditions may be incompatible with diving; persons with these conditions who continue to be exposed jeopardize not only their own lives but may risk the lives of others as well. OSHA must also be cognizant of the employees' countervailing rights to be protected in their choice of occupation. The agency must endeavor not to create, through a health and safety standard, a situation which restricts entry into a profession or allows employees to be dismissed for a cause which is less than substantial.

The proposal provided a procedure to be used if an adverse medical opinion, based on certain mandatory disqualifying conditions, led to an employer's determination to withdraw an employee from further hyperbaric exposure. This decision gave the employee the right to obtain a second opinion from a physician chosen by the employee. If the two medical opinions rendered were in disagreement, the proposal's procedure would have required that a binding third opinion by a physician agreed upon by the first two physicians be obtained. This procedure for the determination of medical fitness was endorsed by employee interests, who believe that it provided a necessary safeguard against unwarranted disqualification. On the other hand, several objections to this procedure were raised at the hearings. First, it was said that it would result in the employment or retention of divers who were marginally fit (Tr. 58–9, 1322–4, 1698–1701; Ex. 178, p. 43). Second, it was argued that the employer, who bears the ultimate responsibility and potential liability for diver safety, should not be required to bear the cost and be bound by the opinion of a physician whom he has not consulted and in whom he may place little confidence. (Tr. 76, 1322–4, 1438, 1642, 1675–6, 16999, Ex. 178, p. 44). Third, it was argued that the first examination would often be conducted by the physician who knows the employee and the particular diving and medical background better than any other physician, so that, if anything, the first opinion should carry more weight than later ones (Tr. 76–7, 1642, 1675; Ex. 178, p. 44). Finally, it was claimed that the procedure implied an unwarranted distrust of physicians and medical ethics (Tr. 75, 1700, Ex. 178, p. 45). However, these arguments do not reach the fundamental policy balance between the need for a mandatory medical examination and the employee's right to a thorough medical assessment.

A second opinion by a physician selected by the employee, provides a firmer and broader basis on which to make a determination of medical fitness. This second opinion will benefit both the employer and the employee in planning future action. Moreover, it will help protect the employee from being barred or dismissed from employment or certain job assignments on the basis of a single medical opinion which may be incomplete or inaccurate. In addition, peer review may result in the first physician reconsidering the original opinion after comparing the findings of the second physician. This requirement for a second opinion is in fact not significantly different from current medical practice, since testimony indicated that physicians often consult with other physicians whenever a difficult medical diagnosis or a critical opinion is made (Tr. 1707–8, Ex. 178, p. 44), and patients often seek a second opinion on their own. If there is a concurrence between the medical opinions, the employer must act consistent with the medical opinions.

Where there is a difference between the first and second medical opinions, it is essential to provide a third determinative medical opinion in order to balance the requirement for a mandatory medical examination with the employee's corollary right to a thorough medical assessment of potentially disqualifying, limiting or restricting conditions. The employer's assignment shall be consistent with the third physician's opinion. However, the employer and the employee are free to agree on an assignment which is consistent with any two physicians' opinions. All medical examinations are to be provided at the cost of the employer.

The proposal's list of disqualifying conditions is now included in an appendix, entitled "example of conditions which may restrict or limit exposure to hyperbaric conditions" (Appendix A) which is intended to be advisory in nature. The physician is alerted that the conditions listed may be restricting or limiting depending on severity, presence of residual effects, response to therapy, number of occurrences, and the diving mode, or degree and duration of isolation. This is in accord with testimony (Tr. 76, 685–8, 1466). The conditions listed are essentially the same as those which appeared as mandatory disqualifying conditions in the proposal. However, the appendix is not intended to be binding or exclusive, and the absence of a particular condition from the list should not be construed to mean that the physician should rec-

commend restriction or limitation for a particular condition or inhibit the physician from recommending that a particular physical condition not included in the appendix should be cause for prohibiting or limiting further hyperbaric exposure by the employee. The standard requires that the recommended restrictions or limitations be reasonably related to the nature and extent of exposure to hyperbaric conditions.

5. *Safe practices manual (§ 1910.420).* The requirement that the employer develop and maintain a safe practices manual is similar to a comparable provision in the proposal. Testimony supported the importance of such a document to operational diving safety (Tr. 134–5, 178, 196–97, 760–1), and indicated that it is general industry practice to have one available (Tr. 178, 196–7, 604, 1718–9, 1789–70). The requirement does reflect, however, testimony which recommended that the manual would be more manageable and useful if made specific to the particular diving modes used by the employer (Tr. 1470, 1499–1501, 1729–30; Ex. 178, p. 46–7). The requirement is also more specific as to what topics the manual must include and makes clear that the purpose of the manual is to contain the employer's policies for implementing the requirements of the OSHA standard. For this reason, a copy of the standard must be included in every safe practices manual. For each diving mode engaged in, the employer's manual shall include safety procedures and checklists for diving operations, dive team assignments and responsibilities, equipment procedures, and emergency procedures, with appropriate checklists to be used to inspect equipment and brief employees before and after each operation. The required safe practices manual is to be distinguished from an employer's operations manual in that the standard mandates inclusion only of items and procedures relating to safety and health, and not to other company policies or business matters; an employer may, however, combine operational and safety procedures in a single document.

6. *Pre-dive procedures (§ 1910.421).* This section corresponds with, but is generally a reordering and reworking of, several sections of the proposal which appeared under the "general operations procedures" section of the proposal (§ 1910.421) and were formerly designated: (b) Emergency aid; (d) hazards to diving operations; (f) inspection of tools, equipment and operational systems; (g) diving plan; (k) diving at altitude; (l) thermal exposure; (m) underwater hazardous conditions; (o) warning display; and (s) positioning. It contains those provisions of general applicability, i.e., not specific to a particular diving mode, which must be considered and complied with before the diver enters the water.

The emergency aid requirement of the standard is essentially the same as the one in the proposal. There was broad support at the hearing for the need to maintain a list of sources of emergency aid at the dive location (Tr. 135, 904–6, 1644), as well as testimony that this is already industry practice (Tr. 1716–7). The category of "air transportation" has been replaced by "available means of transportation" in response to testimony that air transportation may not always be the most appropriate means to transport an injured diver to a medical treatment facility (Tr. 179).

The requirement for first aid supplies approved by a physician at each dive location is similar to the one in the proposal. When used in a decompression chamber or bell, the first aid kit must be suitable for use under hyperbaric conditions because certain items in a standard kit (e.g., bottles of liquids, mercury thermometers, ammonia capsules) create a hazard when subjected to high pressure use in a decompression chamber or bell (Tr. 1939, Ex. 178, p. 49). The requirement that an American Red Cross standard first aid handbook or equivalent be available is related to the level of first aid training required of dive team members, who will be able to use this as a basic and necessary reference source. The bag-type manual resuscitator with transparent mask and tubing is specified because such equipment would not always be included in a standard industrial first aid kit, but could be a life-saving aid in some breathing emergencies (Tr. 59). Unlike other types of resuscitators, the bag-type manual resuscitator, without oxygen flasks, minimizes the danger of overpressurizing the lungs and the hazard associated with the use of oxygen in chambers (Ex. 178, p. 51). A transparent mask and tubing enables the operator to determine whether the passages are clear.

The requirement for planning and assessment of the diving operation derives from the proposal's "diving plan" requirement. Task assessment and planning are closely related to the safety of a dive and central to the role of the designated person-in-charge. From the standpoint of safety and health, task assessment must include consideration of at least the factors listed in the standard. These factors are directly related to other affirmative requirements of the standard.

Examples of surface and underwater conditions which may appropriately be evaluated include not only natural conditions such as weather, water temperature, current, and bottom conditions, but surface conditions which may pose a hazard to the operation; they also include underwater hazards such as mechanical devices in the vicinity of the dive which are capable of creating strong water currents, or high intensity sonar, or electric fields created by cathodic protection. Although it is recognized that it may not always be possible to shut such devices off completely (Tr. 674–9; Comment GG), evaluation should include consideration of appropriate precautions which can be taken to inactivate the device or otherwise minimize or avoid the hazard.

The one resource essential to any diver on any dive is air or other breathing gas. Both the proposal and the standard require a reserve breathing gas supply; the planning called for in the standard should include consideration of such factors as depth and duration of dive, work load, anticipated bottom time, breathing equipment, and gas handling and reclamation capability.

Consideration of thermal protection includes protective clothing and other measures which may be necessary to keep the diver's body temperature in relative thermal balance. Both hypothermia and hyperthermia can be problems in diving. At the hearing, there was testimony that specific thermal protection requirements should be included in the standard (Tr. 86, 140, 155, 739, 755; Comments R, Y; Ex. 154, p. 27). However, because of the complexity of this subject and the indefinite state of the art, OSHA has determined that it is premature to regulate further in this area because there is no satisfactory way to specify what steps must be taken to achieve the goal of diver thermal balance in the widely varying conditions which prevail in diving operations, other than to require that thermal requirements be carefully considered before each dive (Tr. 2067–30; Ex. 177, 178, p. 68–9).

The repetitive dive designation or residual inert gas status of dive team members must be considered because each diver's residual gas obligation affects selection of the proper decompression table (Tr. 105, 748–9, 923–4, 940–1, 1109). Consideration of decompression procedures includes choosing a decompression table suited to the depth and bottom time, breathing mixture, work load, and water temperature. Altitude corrections must be applied to decompression tables, if appropriate. It is also appropriate to review all appropriate emergency procedures.

The requirement for employee briefing follows directly from the task assessment requirement and also derives from the "diving plan" requirement of the proposal. To perform their work safely, dive team members must be told in advance by the designated person-in-charge about the tasks to be undertaken, safety procedures for the diving mode, unusual hazards or environmental conditions, as well as any modifications to the safe practices manual necessitated by the specific diving operation. This is currently a widespread practice within the industry (Ex. 178, p. 62–3), and the need for pre-dive instruction of the dive team was testified to at the hearings (Tr. 138–9, 186). The dive team members must also be asked to disclose any current problems affecting physical fitness and be told the procedures for reporting physical problems or adverse physiological effects during the dive. That affirmative requirement follows from the requirement concerning temporary impairments or conditions in the personnel section of the standard. In response to other testimony, however, it is considered unnecessary and impractical to require that the briefing always be in writing (Tr. 1439–40, 1499–5101, 1735–7, 1749, 1967–8; Comment R). Rather, an oral briefing is considered sufficient to satisfy the goal served by this requirement, and

may in fact be preferable to a written dive plan in many cases because of the greater opportunity afforded for group discussion, coordination, and interchange. In conjuction with this requirement, the safe practices manual which is a written document and generally applicable to all diving operations is to be available to dive team members at the dive location.

The equipment inspection requirement prior to each dive derives from a comparable provision in the proposal and relates directly to the equipment checklist requirement in the safe practices manual, which was the subject of testimony (Tr. 138, 180–1). It specifies that the breathing supply system including reserve breathing gas supplies, masks, helmets, thermal protection, and bell handling mechanism (when appropriate) be inspected prior to each diving operation. Items singled out for pre-dive equipment inspection are those which are critical for the safety of the dive operation; however, this list is not intended to be all inclusive. It is expected that the items of equipment included in the check list which require visual inspection will vary depending on mode and individual company policies. An issue was raised at the hearings concerning employer-provided versus employee-owned equipment and whether the diver or designated person-in-charge should be responsible for the required pre-dive equipment inspection (Tr. 138, 181, 1127–9, 1394, 1734–5, 1798–9, 2193; Ex. 178, p. 60–2). However, the standard's inspection requirement recognizes no such distinction. The employer is responsible for overall compliance and a designated person is in charge of each diving operation; how particular functions required by this standard are apportioned or delegated is the employer's responsibility, so long as the performance required by the standard is met.

The standard requires the international code flag "A" to be displayed at the dive location on structures other than vessels which are situated in areas which support marine traffic. As of July 15, 1977, a similar warning display requirement applies to all diving operations supported from vessels, pursuant to Congressional ratification of the "International Regulations for Preventing Collisions at Sea 1972, Rule 27." The further requirement that the warning display be illuminated at night is responsive to testimony (Tr. 215–7; Comment N). Other warning displays such as the American dive flag may still be flown, but not in lieu of the international code flag "A".

The requirement that diving operations be coordinated with other activities in the vicinity which are likely to interfere with the diving operation corresponds to the "hazards to diving operations" requirement of the proposal, which was generally supported in the hearings (Tr. 136, 1733). The purpose of such coordination is to make appropriate arrangements to minimise hazards to the dive team. Nearby blasting, movement of surface vessels, or movement of materials directly over the dive location would be examples of such activities. In response to testimony, the requirement has been modified to require coordination only with those activities in the vicinity which are "likely" to interfere with the diving operation, and not with all operations that "may" interfere; the warning display should be sufficient notice to such other activities to stay clear of the diving operation (Tr. 2037–8).

7. *Procedures during dive (§ 1910.422).* The requirements in this section relate primarily to procedures which must be followed between the time the diver enters and the time the diver leaves the water.

The requirements for water entry and exit are similar to that of the proposal, although a greater measure of specificity has been introduced by requiring that the means provided be "capable of supporting the diver" and that they "extend below the water surface" when the diver is exiting (Tr. 739–41, 927, 1927). In conjunction with this modification the proposal's provision on "positioning" (formerly § 1910.421(s)) has been deleted since the concept of a stable work platform is embodied to a great extent in the final standard's requirement for a means of entry and exit which is capable of supporting the diver. In some situations, depending on sea state and other factors, a diver's entry into and exit from the water can be extremely hazardous, as evidenced from the hearing record (Tr. 849, 2203). Recommendations included requiring an open-bottom bell (Tr. 849) or a stage for all mixed-gas diving (Tr. 740). There was also testimony that the British require a skip, stage, or basket which is incapable of turning over (Tr. 2203). However, because there are a large number of possible alternatives for different operations under a variety of circumstances, precise means have not been specified (Ex. 178). As written, the requirement permits discretion, depending on sea state, diver dress, stress or fatigue, or any other factor which might affect the driver's ability to enter or exit the water safely, so long as the means provided are capable of supporting the diver. Such means might range from a stable work platform in the case of a SCUBA diver in calm water, to a ladder for a diver in a lightweight diving outfit, or a stage and winch for a diver in heavy gear who may be carrying several hundred pounds of suit and equipment and has greatly limited mobility. The latter situation relates closely to the standard's requirement for an inwater stage for heavy-gear diving as well as for mixed-gas diving, discussed below. Similarly, the provision requiring that the means for exiting the water extend below the water is a recognition that divers are often fatigued at the completion of a dive (Tr. 927). This fact, combined with the weight they carry, necessitates that whatever means are provided be easily accessible to the diver upon surfacing. This is even more critical in the case of an injured diver, for whom, the standard, like the proposal, requires a means to be provided for assistance from the water; for example, a hoist might be required to help a tender assist a disabled diver into a bell.

The requirement for an operational two-way voice communication system between each surface-supplied air or mixed-gas diver and a dive team member at the dive location or bell (when provided or required) is essentially the same as the proposal's requirement for communication between the diver and the tender, which was broadly supported at the hearings (Tr. 135, 141, 622, 719, 783, 200, 1739–40). The requirement for two-way voice communication between the bell and the dive location is also a particular application of the proposal's requirement and equally necessary to the safety of the operation. Pull signals are not considered an adequate substitute for voice communication; the only exception to this rule is SCUBA diving, where reliable voice communications are not generally an available or technologically feasible alternative (Tr. 783). The requirement for operational two-way communications at the dive location to obtain emergency assistance is essentially the same as that which appeared in the "emergency aid" requirement of the proposal. The need for this requirement was supported in the hearing record (Tr. 135, 720) and is in consonance with an existing Coast Guard requirement for vessels (Tr. 622, 720).

The requirements that appropriate decompression tables be at the dive location and a depth-time profile be made for each diver and maintained for the duration of the dive are basically the same requirements as those which appeared in the proposal's "pressure vessel for human occupancy (PVHO)" and "employer's record of dives" provisions. The tables are necessary to decompress the diver within prescribed limits or to assure that the diver remains within the no-decompression limits. Maintaining a record of the dive profile, including any breathing gas changes, enables the designated person-in-charge or the dive team member managing the decompression to determine if the diver is staying within the no-decompression limits, or is being decompressed or compressed in accordance with the planned decompression table (Tr. 1546–9). The proposal's requirement for automatic recording of time and depth for dives deeper than 190 fsw and for all mixed-gas dives has been deleted because testimony indicated that automatic recorders were unreliable for field use (Tr. 194, 1361–2, 1942–4; Ex. 178, p. 75), cannot be used to calculate a diver's decompression obligation (Tr. 1476–8, 1547; Ex. 178, p. 75), and would not increase the diver's safety (Tr. 653, 1547, 1760–1; Ex. 178, p. 75). Therefore, the required information may be recorded by whatever means and in whatever form the employer deems appropriate so long as the dive profile is maintained accurately.

The requirements for hand-held power tools are similar to those in the proposal. Requiring that hand-held electrical tools and equipment be de-energized before being placed into or retrieved from the water is a good safety

precaution against shock because a diver in the water is immersed in a conductive medium which diverts stray currents; when a tool is held out of the water by a partially immersed diver, the only path for leakage current is through the diver's body (Ex. 178, p. 92). The requirement for a constant pressure switch or control on the tool has been deleted in accordance with testimony (Ex. 178, p. 92). It is not always necessary that these tools be controlled from the dive location. There is a requirement however, that if power is supplied from the dive location, the tools not be energized until the diver requests that they be turned on. This provision assures that these tools or equipment will not be supplied with power when it is not wanted or the diver is not ready.

The welding and burning requirements are similar to those that appeared in the proposal. The requirement for a current supply switch to interrupt the current flow to the welding or burning electrode is necessary to control the power supplied to the welding equipment (Tr. 933). The tending requirement is intended to enable the tender or person-in-charge to operate the equipment and oversee the operation at all times; voice communication is essential to operations of this type because of the need for coordination between the power supply at the dive location and the diver working underwater (Ex. 12B, p. 66, 232). The switch has to be in the open position except during the actual welding so that power is not supplied to the welding or burning equipment at other times. The grounding requirement comes from the proposal and serves to protect against the hazard of shock to the diver (Ex. 12B p. 66, 232). The requirements for proper insulation and for equipment capable of carrying the maximum current are also addressed to the shock hazard (Tr. 919, 1743–4, 2019; Ex. 12B, p. 66, 231–2). Testimony supported the safety benefits of insulated gloves but it was also pointed out that employers cannot ensure that the diver underwater will wear them (Tr. 1745, 2018). The venting, flooding, or purging requirement derives from the proposal and is directed to the possibility of explosion in enclosed spaces containing flammable vapors or where such vapors may be generated by the application of hot-work and ignited (Tr. 2019; Ex. 154, p. 24; Ex. 178, p. 93–4). There have been serious accidents caused by explosives of this nature (Ex. 44B). Closed compartments, structures and pipelines already under flow, as in hot tapping operations, are flooded by definition and therefore meet this requirement.

The issue of whether or not the standard should prohibit the use of alternate current (AC) welding machines and direct current (DC) rectifiers in underwater welding was raised at the hearings. The NIOSH document (Ex. 12B, p. 231) and the National Academy of Sciences Marine Board Report, entitled Underwater Electrical Safety Practices, recommend prohibition of these machines because AC current (or AC leakage from DC rectifiers) is physiologically more hazardous than DC. However, testimony indicated that DC rectifiers and AC machines have been widely and safely used in underwater welding (Tr. 2044–9, Ex. 138, 178, p. 94–5). Post-hearing comments recommended that this issue should be investigated further because the Marine Board is at present reconsidering the matter (Ex. 46F; Comment R). OSHA has, therefore, determined that it would be premature to prohibit the use of alternating current and rectified direct current for underwater welding at this time.

The explosives requirements are similar to those in the proposal. No serious issues were raised concerning this section and consequently little testimony was presented on the subject. There was general testimony, however, concerning the hazardous nature of underwater demolition and the need for skill and knowledge in handling explosives (Tr. 903–4). The requirements of this section are addressed to the need for proper handling, storage, and use of explosives and the hazard of premature detonation when the diver is still in a position of risk.

The requirement concerning the termination of dives brings together several concepts which were explicit or implicit in the proposal. Termination refers only to the working interval of the dive; decompression procedures should not be omitted if this practice would add greatly to the diver's overall physical risk. Termination of a dive at the diver's request, restates the proposal's prohibition against making a diver dive unwillingly (Tr. 137, 2107–8); it is presumed that the diver would only request termination in the event of serious difficulty. If a diver fails to respond correctly to communications or signals, the dive should be terminated because of the likelihood that something is wrong with the diver, who may be unconscious, out of breathing gas, or otherwise disabled (Tr. 844–7, 853). Requiring that the working interval be terminated when communications are lost between the diver and a dive team member at the dive location or bell (either voice or line pull, as appropriate) is a corollary to the standard's two-way communication requirement, which requires such communication during the dive. Communication is essential to supporting the diver safely. Because of the high potential for hazards to the diver in liveboating operations, a similar termination provision is included when communication is lost between the designated person-in-charge and the person controlling the vessel in these operations. Finally, the dive must be terminated when the diver begins to use the diver-carried reserve or when the dive-location reserve breathing gas supply is reduced to an amount sufficient only to supply the divers during decompression. This follows from the proposal's reserve breathing gas supply requirements. Because the diver-carried reserve (bail-out bottle), the manual air reserve valve (J valve) of a SCUBA cylinder and the reserve supply available in heavy-gear dress are sufficient for only 3–5 minutes depending on depth, it is imperative that the diver stop work immediately and seek refuge or another source of breathing gas. Similarly, when the dive-location reserve supply is reduced to a level which will only support the divers during decompression, the working interval must cease and the diver must begin decompression.

8. *Post-dive procedures* (§ *1910.423*). This section is concerned with procedures which must be followed after the completion of a dive. The requirement concerning post-dive precautions is similar in most respects to that of the proposal. The steps to be taken must include checking the diver's physical condition and watching for signs and symptoms of decompression sickness. This requirement applies to all divers because of tesimony that there may be sufficient inert gas in the tissues of a no-decompression diver to warrant post-dive surveillance (Tr. 322). After completion of a decompression dive, the diver must also be instructed to report any physical problems or adverse physiological effects, including symptoms of decompression sickness. Similarly, the diver must be advised of the location of an available decompression chamber. Decompression sickness symptoms may not be apparent until several hours after the dive, at which time the dive team may no longer be at the dive location. In such a situation, the diver should know exactly what to do to obtain proper treatment. Instruction on the hazards of flying after decompression diving derives from the proposal and testimony in support of the provision (Tr. 906, 1208, 1737), although omission of a time or altitude limitation reflects evidence that the state of the art in this area is not sufficiently developed to prescribe specific restrictions (Tr. 322, 1323, Ex. 178, p. 76–8). In addition, for those dives which require the presence of a decompression chamber, the diver must be instructed to remain awake and in the vicinity of the chamber for at least one hour after the dive including decompression or, if appropriate, treatment (Tr. 1104, 1472–3). These requirements are comparable to similar provisions in the proposal, and reflect a recognition that delayed decompression effects can occur, and that sleep may conceal the onset of symptoms of decompression sickness.

The requirements for decompression chambers derives from the pressure vessel for human occupancy (PVHO) section of the proposal. The acronym PVHO is a general term encompassing any pressure vessel designed to be occupied by a human being. Because of the potential confusion in using a term which is currently not used in the industry, "PVHO" has been omitted from the standard (Tr. 1485–6; Ex. 178, p 64). Pressure vessels for human occupany other than decompression chambers (e.g., closed bells and personnel transfer capsules) are not specifically addressed in this standard except in respect to their recompression capability. As defined in the standard, the term decompression chamber is used to mean any pressure vessel, whether deck

chamber or bell/deep diving system, used for the purpose of treatment.

The standard requires a decompression chamber to be ready for use at the dive location for any dive which is outside the no-decompression limits or deeper than 100 fsw. Throughout the standard, the no-decompression limits and 100 fsw are used as a dividing line for the imposition of certain requirements which are made mandatory only outside these limits. For instance, the requirements concerning standby divers and diver-carried reserves, as well as the requirements for a decompression chamber, are based on these limits. This tiering of the standard reflects a determination that there is an increasing level of hazard associated with dives outside these limits. Decompression dives are deeper or longer than no-decompression dives, and they subject the diver to greater exposure times and increase the likelihood of diver fatigue and decompression sickness. These dives may also involve greater operational complexity. There is also a relationship between depth and increasing hazard. The diver is more frequently exposed to colder water on deep dives, and is constantly subjected to the added risks of greater pressure and pressure changes. All of these factors contribute to the increased stress associated with depth.

OSHA recognizes that decompression chambers involve relatively significant cost outlays and are sometimes cumbersome to transport, but their importance to diver safety is clear (Tr. 809, 817, 1272). Decompression chambers serve two primary functions. First they provide the only effective therapy—recompression—for decompression sickness and embolism. Second, decompression chambers are used for surface decompression, to reduce the amount of time the diver must be exposed underwater (Tr. 1272). Testimony on the issue of when to require a decompression chamber resulted in a number of alternative suggestions (Tr. 61, 181, 229–30, 239–40, 314–15, 397, 433, 598, 608–9, 720, 737, 747–8, 927–8, 969, 1645, 1941; Ex. 144, 145, 147, 154, p. 26 178, p. 65 Comment A). These ranged from a statement recognizing that a decompression chamber could be useful on all dive sites regardless of depth or conditions (Tr. 229), to a recommendation that it be required at 132 fsw if more than 30 minutes of ascent time is involved in the dive (Tr. 315). Other testimony supported the concept of a combination of time and depth as a determinant for decompression chamber availability (Tr. 61). Other specific depth-time combination recommendations included from any mixed gas dive, or dive deeper than 66 fsw decompression dive (Ex. 12B, p. 70), to 60 or 70 fsw and any decompression dive (Tr. 1941, 1972), to 120 fsw (Tr. 720). By setting a depth limit of 100 fsw in addition to the no-decompression/decompression cut-off, OSHA has attempted to weigh the conflicting evidence and has chosen the limit which had the widest support in the record (tr. 68, 181, 230, 608, 968; Ex. 154, p. 26; Comment V). By adding a depth limit to the decompression chamber requirement, the standard sets a specified depth at which all diving operations will require a chamber, eliminating the safety hazard inherent in operations which are planned below that depth to no-decompression limits without an on-site chamber, but which exceed those limits when the job is actually carried out (Ex. 178, p. 65). While it is difficult for a single rule to take into account all conditions where a decompression chamber might be needed, OSHA believes that this provision will result in recompression capability being available for the great majority of diving situations where the probability of its being needed is greatest.

Most, if not all, decompression chambers currently used in the field should already meet the 6 ATA requirement (Tr. 193). The requirement for a surface treatment capability to the maximum depth of the dive for dives exceeding 300 fsw can be met by a large-capacity deck decompression chamber, or a closed bell equipped for treatment, or a closed bell capable of mating with the chamber under pressure. A pressure capability of 6 ATA is sufficient for most decompression sickness treatment, but recompression capability to the depth of the dive is necessary for very deep dives because of the possibility of having to recompress a deep mixed-gas diver to the depth of the dive to carry out effective treatment (Tr. 192–3). If a bell or deep diving system is used as a decompression chamber, it must meet the other requirements for decompression chambers as well.

The treatment chamber must be dual-lock (two compartments) so that supplies and personnel may be transferred into and out of the main compartment (Tr. 950–1). Multiplace means that at least the main compartment must be large enough to accommodate and decompress two persons (a diver and an attendant) simultaneously (Ex. 178, p. 66). The requirement that the chamber be located within 5 minutes of the dive location is in consonance with the proposal's requirement that the chamber be "ready for use" and was supported in testimony (Tr. 738, 1091). The requirement that the chamber be located within 5 minutes of the dive location is necessary because the surface decompression tables are commonly designed to be used with equipment which meets this criterion (Tr. 193).

The requirement for a pressure gauge for each compartment capable of being pressurized follows from the dual-lock requirement and also derives from the depth gauge requirement of the proposal; it is comparable to the requirement that a depth gauge be used for each dive. A separate pressure gauge for each compartment is essential for dual-lock chambers to control pressure in each of two chambers if two divers are being treated in different locks, or if personnel have been transferred from outside and must be brought to the pressure of the inner lock (Tr. 170, 1069; Ex. 12B, 42, 178; Comment N).

The built-in-breathing-system requirement derives from the same section of the proposal, but has been made mandatory in response to testimony that all surface decompression and treatment tables in existence today are designed to use oxygen as an internal part of the decompression or treatment process (Tr. 181, 1069, 1073, 1272; Ex. 178, p. 110). The requirement for voice communication between chamber occupants and support personnel allows monitoring of a diver undergoing decompression or treatment, and is identical to the proposal's requirement. A viewport is essential so that chamber occupants can be observed when in the chamber; this provision also appeared in the proposal.

The requirement that the chambers be capable of illumination to permit observation of occupants and essential equipment is basic to the operation and tending of the chamber and its occupants from the outside (Tr. 1700, 1069).

The requirement that treatment tables, oxygen or other treatment gas, and sufficient breathing gas to pressurize the chamber during treatment be present when treatment is conducted reflects the need to treat divers with pressure-related illnesses or injuries and is based on testimony that proper and prompt treatment must be available to divers under such circumstances (Tr. 199, 1073, Ex. 178, p. 110). The requirement that a dive team member be available to operate the chamber for one hour after a dive derives from the proposal's requirement that a chamber operator be available to operate the chamber and that divers should remain in the vicinity of a chamber for one hour after completion of a dive. This provision reflects the fact that decompression sickness may occur within approximately an hour of surfacing; a chamber without a qualified operator would be of no help to a diver needing treatment and could itself pose a hazard (Tr. 1077–8).

The requirement to maintain a record of dives is similar to the one in the proposal. The hearing record indicates that keeping dive records is industry practice (Tr. 794–5, 801, 1549, 1575) and supports the need for accurate dive records (Tr. 1546–7). The main difference between this requirement and the proposal's is that certain items of information are required to be kept for all dives, and other information must be kept only for dives which are outside the no-decompression limits, deeper than 100 fsw or involve mixed gas, and others must be kept only for dives in which decompression sickness is suspected or its symptoms evidenced. Dive records are particularly relevant to accident reconstruction, determining individual diver sensitivities, and for making necessary operational adjustments in decompression procedures. The recordkeeping requirement for shallow water dives has been reduced, as recommended by evidence in the record (Comments A, B). In addition, the details of underwater and surface conditions have been modified and need only be approximate (Tr. 1757–8; Ex. 178 p. 73–4). The breathing gas profile and the residual inert gas obligation of each diver at the beginning of the dive,

in addition to the depth-time profile has been included in the list of required information for dives deeper than 100 fsw, outside the no-decompression limits, or using mixed gas to provide a complete record of the essential dive information (Tr. 1562). The approach which the standard takes toward reducing the incidence of decompression sickness is based on assessment of the past performance of tables and procedures, and consequently relies on the availability of records such as these.

Employers are required to keep accurate records of those decompression dives in which decompression sickness is suspected or symptoms are evidenced. These records are to include the depth and time of onset and description of decompression sickness symptoms, and the description and results of treatment. Many companies already keep such records (Tr. 1545–8, 1560–2) and the offshore diving industry where the impact of this provision is likely to be greatest generally recommends such a recordkeeping program (Ex. 178, p. 74–5). This requirement is in addition to the required investigation, evaluation and appropriate corrective action required in the decompression procedure assessment section.

The standard's requirements for decompression procedure assessment reflect the testimony and comments received in connection with the proposal's "decompression table assessment" section. The evidence presented by experts in the field of decompression indicated that the present state of decompression table development, performance, and verification is not sufficiently advanced to warrant inclusion of specific numerical field performance criteria of the type which appeared in the proposal (Tr. 300–303). However, the record does support a program of recordkeeping, investigation and evaluation of each incident of decompression sickness, with corrective action to be taken, after evaluation of the incident, to reduce the probability of recurrence of decompression sickness (Tr. 321, 886–7, Ex. 178, p. 89–91). The factors to be considered in the required investigation are the relevant information contained in the dive record, including such factors as work, temperature, diver's repetitive status, consideration of the past performance history of the decompression table in question, and the individual susceptibility of the diver, since these would be necessary to any investigation to determine what corrective action would be appropriate. The advantage of this approach compared to the criteria method of the proposal is that this approach requires every incident of decompression sickness to be assessed without waiting for the number of incidents to exceed a prescribed numerical ceiling (Tr. 309, 327). Because the performance criteria concept has been deleted, the need for a decompression assessment advisory committee, an idea which was explored by the panel of expert witnesses at the hearings (Tr. 328, 341), is not being pursued by OSHA at this time. However, after sufficient experience with the standard's decompression assesament provision has been gained, OSHA will seek to have the data reviewed and endeavor to reevaluate its regulatory approach in this area of concern.

The decompression procedure assessment section is designed to aid employers in the evaluation of the field performance of their decompression procedures (Tr. 311, 305). It is believed that such evaluation will lower the incidence of this occupational hazard, regardless of diving mode or current incidence, by eliminating or modifying those tables whose performance is not adequate and by revealing other procedures or conditions which may be causing decompression sickness (Tr. 307). OSHA anticipates that this requirement will result in continuing improvement in decompression tables and procedures so that divers in the field can be protected to the extent possible from the hazard of decompression sickness.

9. *SCUBA Diving* (*§ 1910.424*). The limits for SCUBA diving reflect testimony as to industry practice and procedure (Tr. 60–1, 779, 796–7, 851–2; Ex. 154, p. 30, 178, p. 80–1), and NIOSH and Navy recommendations (ETS Ex. 6, I-4-9, Ex. 12B, p. 79–82). Because the SCUBA diver has a limited breathing supply, does not generally have voice communication, and is often not monitored or controlled by surface support personnel, more stringent limits than those for surface-supplied air diving are considered appropriate to this mode (Tr. 1391, 1408). These factors have caused OSHA to limit commercial open-circuit SCUBA diving operations to depths shallower than 130 fsw. Although some testimony was presented to OSHA recommending an extension of the SCUBA depth limitation for divers using self-propulsion devices (Tr. 60; Ex. 154, p. 31, 178, p. 81), OSHA believes that the increased risks associated with the greater depths and a severely limited breathing gas supply do not justify this extension, particularly since most tasks can be more safely accomplished using other diving modes.

The standard requires a decompression chamber ready for use at depths deeper than 100 fsw or outside the no-decompression limits. No distinction between SCUBA and surface-supplied diving is made in this regard; and the reasons for the requirement are the same.

Untethered SCUBA diving, i.e., where the diver is not line-tended from the dive location, has been prohibited against currents greater than 1 knot, because divers in such situations must exert considerable effort to swim upstream, and the risk of disorientation and running out of breathing gas is a distinct hazard (Tr. 1391, 1408; ETS Ex. 6, I-4-9; Ex. 12B, p. 79–82). This requirement does not preclude work swimming with, rather than against, the current. Similarly, the requirement that a SCUBA diver not be allowed to perform work in enclosed and physically confining spaces unless line-tended has been included because of the danger of the diver's exhausting the breathing gas supply before reaching the surface in circumstances where the possible risk of temporary entrapment or disorientation is high (ETS Ex. 6, I-4-17; Ex. 62).

The procedures required for SCUBA diving include a standby diver available at the dive location while a diver is in the water. The purpose of a standby diver is to be ready to aid a diver who needs assistance in the water. This requirement for the SCUBA mode is based on a recommendation made by the diving contractors, who testified that SCUBA diving is generally not as safe as surface-supplied air diving, and that requiring a standby is an appropriate means of reducing the hazards associated with this mode (Ex. 178, p. 81).

The requirement that the diver be supported by either a diver in the water in continuous visual contact or a dive team member line-tending from the surface derives from the proposal's exception to the communications requirement for "buddy diving" in the SCUBA mode, and is a clarification of the intent of that provision. While line-tending the SCUBA diver from the dive location is considered preferable to buddy diving (Tr. 1391–2), it is recognized that the latter is an accepted practice and is relatively safe in clear and calm waters, such as should prevail when there are currents less than 1 knot. The "in continuous visual contact" restriction has been added because the safety advantage of having two divers in the water tending each other (buddy diving) is lost if this condition is not fulfilled; without visibility, divers cannot tend each other adequately (Tr. 796).

Stationing a diver at the underwater point of entry to an enclosed or confining space was a requirement of the proposal which was endorsed as industry practice in testimony, and is necessary because of the increased danger of entanglement or disorientation when diving in such circumstances (Tr. 140, 791, 822). The diver at the point of entry is required in addition to any standby diver at the dive location. Because of the configuration of many underwater structures, the diver in a physically confining space must be able to rely on immediate assistance in an emergency, particularly since in very narrow spaces, such a diver may not be able to carry an independent reserve breathing supply. This is a particularly important requirement for line-tended SCUBA diving in such circumstances because of the limited air supply.

The requirement that a diver-carried reserve breathing gas supply with either a manual reserve (J valve) or an independent reserve cylinder be provided for each diver allows alternative means of carrying a reserve breathing gas supply when diving in the SCUBA mode, such a supply is essential to the safety of the SCUBA diver (Ex. 178, p. 81). Requiring that the manual reserve valve or supply valve on the independent reserve cylinder be in the closed position prior to each dive is a safety precaution to assure that the air reserve will not be depleted inadvertently during the dive (ETS Ex. 6–5–1; Ex. 12B, p. 141).

10. *Surface-supplied air diving* (§ *1910.425*). The surface-supplied air diving limits are the same as those which appeared in the proposal; they were generally supported by testimony (Tr. 142, 689–92; Ex. 178, p. 82). Beyond these limits air diving is considered unsafe because of nitrogen narcosis.

The standard requires that a decompression chamber be available and ready for use at the dive location for any surface-supplied air dive outside the no-decompression limits or deeper than 100 fsw; the reasons for such a requirement are the same as those discussed in connection with the requirement for recompression capability. The standard also requires the use of a bell for any dive with an inwater decompression time greater than 120 minutes, except when heavy gear is worn or diving is conducted in physically confining spaces. The 120 minute limit for bell diving, which appeared in the proposal, is now specified as "inwater" decompression time because it is time actually spent in the water which most affects the diver (Tr. 1574, 1952; Ex. 154, p. 31, 176, p. 83). The exceptions to the bell requirements have been modified to conform with testimony in the record. Heavy-gear diving with an inwater decompression time in excess of 120 minutes is permitted without a bell because this type of gear affords the diver relatively greater protection (ETS Ex. 6, I–6–1), and is too cumbersome to be used safely in conjunction with an open-bottom bell. This modification accords with the NIOSH recommendation (Ex. 12B, p. 82, 256) and with testimony (Tr. 157, 190–1, 1969, 1978). Second, the proposal's exception for "structurally enclosed dives" has been reworded as "physically confining spaces" to make it clear that the exception relates to any space whose configuration is such that use of the bell is hazardous because of the likelihood of entanglement, or infeasible because of the smallness of the space (Tr. 646, 1298, 1951; Ex. 178, p. 83). An example of such a situation would be inspection or work inside the structure of an offshore platform. No depth requirements are established for the use of a closed bell in surface-supplied air diving, because such diving is not permitted at the depths at which the standard requires closed bells to be used. The depth limits for closed bells are therefore discussed in connection with mixed-gas diving.

The requirement for each diver to be continuously tended while in the water is a basic safety practice for surface-supplied air diving. The requirement for a diver to be stationed at the underwater point of entry of an enclosed or physically confining space is included for the same reasons as stated in the discussion of SCUBA diving. The requirements that there be a primary breathing gas supply recognizes the most essential component of surface-supplied air diving. The system which provides air to the surface-supplied diver must have the capability to support all divers for the duration of the planned dive including decompression. (Ex. 12B, p. 36, 160).

Because of the generally greater hazards and complexity associated with deeper or longer dives, the standard specifies that one member of the dive team shall tend each diver in the water for dives deeper than 100 fsw or outside the no-decompression limits, because the safety of the diver could easily be compromised if the tender were also responsible for tending a second diver. This provision is supported by testimony (Tr. 925; Ex. 154, p. 24).

The requirement for a standby diver for all dives deeper than 100 fsw and outside the no-decompression limits is similar to the proposal's. The inclusion of a depth factor in this provision is another recognition by OSHA of the increasing hazard associated with increasing depth. Testimony indicated that this practice is essential to diver safety. (Tr. 610, 720, 929).

The requirement for a diver-carried reserve breathing gas supply for surface-supplied air dives deeper than 100 fsw or outside the no-decompression limits derives from a comparable section in the proposal and has been amended to accord with testimony recommending that greater specificity in this requirement would increase diver safety (Tr. 80, 141, 157; Comment R). A diver-carried reserve breathing gas supply is also required if a diver is prevented by the configuration of the dive area from directly reaching the surface, because of the greater risk of diver entrapment (Tr. 1927; Ex. 154). The diver-carried reserve required by the standard must be 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. Heavy-gear diving is exempted from these provisions, because the gear itself carries its own reserve. There is also an exemption where the physical space of the dive area is such that a reserve supply cannot be carried safely.

The requirement for a dive-location reserve breathing gas supply at depths deeper than 100 fsw or outside the no-decompression limits derives from the reserve breathing gas supply section of the proposal. The supply is intended to function as a surface reserve supply. That this reserve system must be sufficient to support the divers during decompression follows from the fact that the working interval of the dive must be terminated as soon as the dive-location reserve is reduced to the amount needed to decompress any divers adequately. The working interval of a dive may continue, however, if this reserve is itself supplemented by an additional reserve supply. This requirement interrelates with the requirement for a diver-carried reserve sufficient to get the diver to a bell or other underwater place of refuge (which would have to be supplied by the dive-location system), the surface (where the diver may need a decompression chamber supplied by the dive-location system), or to support the diver while awaiting a standby diver (who must be supplied by the dive-location system) (Ex. 12B, p. 84, 259).

The requirements for an extra breathing gas hose capable of supplying breathing gas to the diver in the water and available to the standby diver at the dive location when heavy gear is worn for dives deeper than 100 fsw or outside the no-decompression limits is important because the established way to rescue the diver whose breathing gas supply has been lost is by sending a standby diver with a spare hose which is either attached to a secondary supply or contains an emergency air reserve. To be effective, the standby dive must also have the necessary tools to attach the spare hose (Tr. 668; Ex. 12B, p. 84). Similarly, an inwater stage is provided for heavy-gear diving outside these diving limits. This will limit the fatigue to which a heavy-gear diver is subject by providing a place when the diver can rest and from which a reserve breathing gas supply may be suspended (Tr. 157, 190–1, 850).

11. *Mixed-gas diving* (§ *1910.426*). Mixed gas must be used as the breathing gas for any dive which exceeds the depth and bottom time limits for surfaced-supplied air diving. This requirement is unchanged from the one in the proposal, and the need for mixed gas at least at these limits is generally recognized.

A decompression chamber is required for all mixed-gas dives because of the greater likelihood of decompression sickness associated with this diving mode (Tr. 283–4; Ex. 12B, p. 70, 238). In addition, diving bells are required for such diving below 220 fsw or if the inwater decompression time exceeds 120 minutes, and closed bells are required below 300 fsw, with exceptions made when heavy gear is worn in the 220–300 fsw and the over 120 minute inwater decompression ranges, and for diving in physically confining spaces. The basic depth limits for mixed-gas diving with a bell appeared in the proposal, and are supported in the record (Ex. 154, p. 31). There was also testimony that bells always enhance job safety (Tr. 695) and some suggestion that bells should become mandatory at depths as shallow as 165 fsw, as is required in Great Britain (ETS Ex. 7); but contrary testimony urged a limit of 350 fsw (Comment EE). While the Association of Diving Contractors manual parallels the bell limits provision in many respects, the depth-time combinations of the manual would on occasion lead to different results (Tr. 1764, 1713–14; ETS Ex. 4). Testimony in the record, however, was more concerned with discussing what appropriate exceptions to the bell requirements should be rather than taking issue with the prescribed depth limits (Ex. 178, p. 82–3). As in surface-supplied air diving, exceptions are made for heavy-gear diving and diving conducted in physically confining spaces. The exception for heavy-gear diving does not extend deeper than 300 fsw because the hazards associated with such depths are not offset by the relatively greater safety advantages of heavy gear.

It should be noted that the standard does not include the section from the proposal on limits for oxygen partial pressures, long-duration oxygen expo-

sure, and partial pressures of nitrogen. Testimony at the hearing was opposed to the proposal's limits because such limits were too conservative (Tr. 81, 647), have not yet been definitively established (Tr. 1332, 1348–9; Ex. 178, p. 87), might interfere rather than enhance diver safety (Tr. 316, 647, 1392), and would prohibit a number of safe and successful procedures (Tr. 317, 647, 1332, 1348–9).

The procedures required for mixed-gas diving are similar to those for surface-supplied air diving and the same rationale supports them, except that no depth or time distinctions are made with regard to the requirements for a separate dive team member to tend each diver, a standby diver, and a dive-location reserve breathing gas supply. This is because mixed-gas dives are inherently complex operations. Regardless of depth or time in the water, mixed-gas diving presents a relatively greater risk than does air diving. Also, because of the cumbersomeness of the gear and the fatigue to which mixed-gas divers are subject, an inwater stage is required to be provided for all mixed-gas dives deeper than 100 fsw or outside the no-decompression limits without access to a bell and for all heavy-gear dives regardless of time or depth (Tr. 927). As a practical matter, however, most mixed-gas dives are conducted for times or at depths at which the comparable requirements would be applied if the surface-supplied air diving mode were used.

In the case of mixed-gas diving, the requirements with regard to the amount of breathing gas that must be available is particularly significant because the mixed-gas supply is fixed in quantity and must be either mixed at the dive location or brought pre-mixed. Further, these dives are likely to be longer and deeper, and the likelihood of decompression sickness is consequently greater, thus necessitating relatively longer dependence on the available breathing supply. Moreover, because the decompression chamber is generally supplied with air even though the dive itself was on mixed gas, both primary and dive-location reserve systems must include sufficient air capacity in addition to the mixed-gas supply.

12. *Liveboating* (§ *1910.427*). Liveboating is defined as the practice of supporting a surface-supplied air or mixed-gas diver from a vessel which is underway. It is considered to be one of the more hazardous divings operations because the vessel is moving and the possibility exists of the diver's hose becoming entangled in the propeller (Tr. 741–2). As in the proposal, liveboating is limited by the surface-supplied air diving limits, although mixed-gas may also be used to 220 fsw. This represents a determination that liveboating is too hazardous for greater times or depths and corresponds with the minimum time and depth limits at which use of a diving bell is required (Tr. 751, 1432; Ex. 154, p. 32). Since liveboating cannot practically or safely be conducted with a bell (Tr. 751; Ex. 178, p. 184), it is not permitted beyond these depths. There are alternative methods of accomplishing the same work tasks performed by liveboating operations (Comment EE). The limit for decompression time has been changed to "inwater decompression time," in accordance with testimony, and for the reasons stated in the discussion of the diving bell limits. The requirement that liveboating not be conducted in rough seas has been made "rough seas which significantly impede diver mobility or work function" in response to suggestions that this be specified (Tr. 750, 1144–5; Ex. 154, p. 32), the determination of rough seas is therefore directly related to their affect on the safe conduct of the operation. The prohibition on diving in other than daylight hours remains because of the excessive hazard of liveboating in the dark, when the diver and hose cannot be adequately monitored.

The procedures required for liveboating apply in addition to those for surface-supplied air or mixed-gas diving, and are necessitated by the particular characteristics and relative hazards of this technique. The standard requires that the propellers of the vessel supporting liveboating be stopped before the diver leaves the last water stop (Tr. 742). This is a necessary precaution against hose entanglement. Second, a device must be used in all liveboating operations to protect the diver's hose from accidental entanglement with the vessel's propeller. Suggestions for the necessary device ranged from a propellor shroud (Tr. 742) to a weighted fair lead system (Tr. 930–2, 1703–4), to an air tugger with a heavy weight (Tr. 1430). Some of these devices are said to interfere significantly with the vessel maneuverability and thus to increase the hazard (Ex. 178), and other testimony indicates that using a weight off the bow is ineffective (Tr. Darr). Because of the conflicting testimony and the lack of firm data as to which is the preferred method, the standard does not specify which device must be used, so long as a device or apparatus is used to minimize the hazard of hose entanglement. Third, the proposal's requirement for two-way communication has been extended to include such equipment between the designated person-in-charge at the liveboating dive location and the person controlling the vessel from which the operation is supported (Tr. 1132, 1431). This provision allows the person-in-charge instant communication with the vessel captain should an emergency such as hose entanglement occur. Finally, a standby diver must be available and a diver-carried reserve breathing gas supply must be carried during all liveboating operations in recognition of the relatively greater hazard, particularly the risk of entanglement inherently associated with this diving technique. In addition, the working interval of a liveboating operation must be terminated if communication is lost between the diver and the dive location, or between the person-in-charge and the person controlling the vessel. The general personnel requirements that each dive team member must be assigned tasks in accordance with the individual's experience and training, and that the designated person-in-charge have experience and training in the conduct of the assigned diving operation, are of particular importance in liveboating (Tr. 741, 778–9, 1134, 1952).

13. *Equipment* (*1910.430*). The equipment section provides basic requirements for equipment essential to diving operations. The general requirement that work done on or to equipment used in diving operations be recorded is similar to the "equipment log" section of the proposal. Such recording is basic safety procedure; the failure to keep records concerning such operations as equipment modification, repair, testing, calibration or maintenance service could constitute a serious hazard to the health or safety of the diver (Tr. 142–3). The standard permits either tagging or logging of the recorded information, whichever the employer finds more useful or appropriate, in accordance with testimony (Tr. 2072, Ex. 178, p. 112). Requiring the recording of the date and nature of the work performed and the name or initials of the person performing the work should provide the basic information necessary to ascertain the conditions of the equipment in question and whether or not it is in need of maintenance, testing, or replacement. The record, i.e., log or tag, must be kept until replaced by a subsequent, up-to-date record or when the equipment to which the record refers is withdrawn from service, because that is the period in which the record will be useful to the employer and employees.

The air compressor system requirements are similar to the proposals. The standard specifies that compressors must be equipped with a volume tank. The volume tank requirement is essentially the same as in the proposal, except that a drain valve has been included in the list of required items, in accordance with testimony (Tr. 977; Ex. 12B, p. 37). The check valve prevents loss of air from the volume tank if the compressor fails; the pressure gauge tells how much pressure is available, and the relief valve prevents excessive pressure buildup in the vessel. The drain valve can be used to drain water from the volume tank. The requirement that air compressor intakes located in an area away from exhaust and other contaminants is a basic and undisputed requirement designed to protect the purity of the diver's breathing air.

The air purity standards of the proposal reflect a concern with the quality of breathing air in diving operations, which was testified to by several divers (Tr. 781, 898, 1054–5, 1087–9). The contaminant levels contained in the proposal have been revised, however, in accordance with testimony and the new U.S. Navy air purity standards for divers, which indicate that 20 ppm for carbon monoxide and 1000 ppm for carbon dioxide are acceptable exposure levels for divers (Tr. 83, 317–20, 567–87 1647, 1657–59; Ex. 178, p. 106–7, Ex. 181). The proposal's hydrocarbon limit of 5 milligrams per cubic meter has been defined as oil

mist, as recommended in testimony (Tr. 569–71; Ex. 178, p. 106–7). Where the air sample should be taken is an important factor in determining air purity (Tr. 194–5). Requiring sampling at the connection to the distribution system allows air to be monitored near where it enters the system, i.e., diver's hose or chamber. This provides a truer indication of what the diver is breathing. The exclusion from oil mist testing of air delivered by compressors which do not use oil for lubrication is in accordance with testimony that such testing is unnecessary, and the use of such non-oil lubricated compressors should be encouraged (Tr. 167; Ex. 12B, p. 161–2, Ex. 178, p. 107). The proposal's requirement that air purity be tested every 1000 hours has been deleted to respond to testimony that compressors which run frequently have fewer problems than those run intermittently (Tr. 168, 183–4, 571–2); the requirement for testing at least every six months remains and was supported by testimony (Tr. 167–8).

The requirements for breathing gas supply hoses, connections and umbilicals are similar to those in the proposal. The requirement that the hoses shall have a working pressure at least equal to the working pressure of the total breathing gas system derives from, but is more specific than, the proposal's requirement that such hoses "be capable of the required gas flow rates of the system used." The requirement for bursting pressure was in the proposal and is a basic engineering principle, while the pressure testing requirement has been reworded to better achieve the intent. (Tr. 611, 2014–5, 2075–7; Ex. 178, p. 104). A test of 1.5 times the working pressure, rather than the maximum allowable working pressure, is appropriate to determine hose strength but places less stress on the hose, since the pressure prescribed will be well within the designed pressure capability of the hose. Requiring the open ends of hoses to be taped, capped or plugged when not in use is essentially the same requirement as appeared in the proposal and is designed to prevent the entry of foreign matter into hoses. With regard to breathing gas supply hose connectors, the standard makes it clear that the connectors, like the hoses themselves, must have a working pressure at least equal to the working pressure of the hose to which they are attached. That they be "resistant to accidental disengagement" has been specified in accordance with testimony indicating that such wording establishes an achievable requirement (Tr. 163). The requirements for hose markings, kink-resistance, and calculation of working pressure in relation to depth apply specifically to breathing gas supply hoses (umbilicals) between the supply source (i.e., the drive location or a bell) and the diver, because they are not necessary for other hoses used on the surface. The requirement for markings at 10 ft. interval has been extended to 100 ft. because some decompression tables require steps deeper than 50 ft. While the hose markings should never be used as the primary means of depth measurement, they have sometimes been used as a back-up when the pneumofathometer is disconnected (Tr. 821–2, 934, 1185, 1483). The requirement for calculating the working pressure relative to the supply source is so stated because the calculation is different depending on whether the supply source is on the surface or a submerged bell under pressure. The determining factor is the pressure differential between the supply source and the diver (Tr. 162–3).

The buoyancy control requirement is similar to the proposal's "dry suits (variable volume)" requirement, but is modified in accordance with testimony (Tr. 2030–1; Ex. 178, p. 103). The purpose of requiring exhaust valves in connection with buoyancy control is to minimize the possibility of uncontrolled ascent by the diver. The requirement for a buoyancy compensator, if used in SCUBA diving, to have an inflation source separate from the breathing gas supply is related to the SCUBA reserve supply requirement and is necessary to prevent diversion of the primary or reserve supply to non-emergency use. The provision for an inflatable flotation device for SCUBA diving has been given design specifications because an improperly designed device can be a greater safety hazard than aid (ETS Ex. 6, I–4–9). Requiring the manually activated device allows for quick inflation while the oral inflation device provides for a back-up capability. The function of the exhaust valve is the same on an inflatable flotation device as on any buoyancy-changing equipment.

The requirements for compressed gas cylinders are similar to those in the proposal. Specific design, construction and maintenance criteria for such equipment are already included in an existing OSHA regulation (29 CFR §§ 1910.166–177), and the applicable provisions of that standard apply to diving operations as well. The protection cap requirement has been modified to make clear that a cap is not required when the cylinder is manifolded or when used for SCUBA diving (Tr. 2059; Ex. 178, p. 111). The requirements for protection from excessive heat and falling are designed to prevent accidental rupture of the cylinders.

Design and maintenance criteria have been included for decompression chambers in that the standard requires such chambers to be built in accordance with the ASME (American Society of Mechanical Engineers) Boiler and Pressure Vessel Code, Section VIII or an equivalent. There was testimony that other pressure vessel codes, such as Det Norske Veritas, Lloyds, and the American Bureau of Shipping, establish acceptable standards which are recognized within the industry (Tr. 320; Comment R). These would be considered equivalent codes under this standard. However, decompression chambers manufacturered prior to the effective date of the standard will be in compliance if they are maintained in conformance with the code requirements, to which they were built, or their equivalent.

The requirement for means of maintaining the oxygen concentration in the chamber atmosphere below a level of 25% by volume derives from the "installed oxygen breathing system" section of the proposal, which has been modified based on testimony (Tr. 1486–8, 1442, 1953–4). Some means to control the chamber's oxygen level is essential when oxygen is being administered by mask for treatment or in surface decompression, as a protection against fire, particularly since the mask can leak (Tr. 1791). The means employed may be a ventilation system or an overboard dump system. While no written records or oxygen analysis are required, OSHA would anticipate that the oxygen concentration would be periodically analyzed during oxygen administration (Ex. 178, p. 110–11).

The muffler requirement has been included in accordance with testimony (Tr. 170, 184, 203, 1104; Ex. 154, p. 40; Comment R). Noise suppression in the chamber is essential to protect against hearing loss and to permit communication (Ex. 12B, p. 55, 209). It is recognized, however, that noise mufflers can be a fire hazard because oil collects on them. Accordingly, they must be regularly inspected and maintained. The exhaust muffler protects hearing of personnel outside the chamber and also prevents the noise of decompression from excessive disruption of voice communications.

The requirements for guards on exhaust line openings and a means for extinguishing fire are essentially the same as appear in the proposal, and have not been the subject of comment. They are directed to the suction and fire hazards that can occur in chambers. The requirement to equip and maintain the chamber to minimize sources of ignition and combustible materials is directly addressed to the problem of chamber fires. It has been modified from the proposal in accordance with testimony that fire hazards can and must be minimized, but cannot always be eliminated entirely (Tr. 169).

The requirement of a depth gauge for all divers is essentially the same as in the proposal and follows from the need to monitor the diver's depth-time profile, which is a basic component in calculating decompression (Ex. 178, p. 75). This gauge must be readable at the dive location for all surface-supplied and mixed-gas dives, but, as in practice carried by the SCUBA diver. A pneumofathometer is not specifically required because a digital gauge may also be used. The requirement for deadweight testing or calibration against a master reference gauge every 6 months appeared in the proposal and is intended to achieve the necessary accuracy (Tr. 1545). The factor of 2% discrepancy is based on testimony (Tr. 320). A timekeeping device is also specified to effect the requirement for maintaining and recording the key times of each dive.

The requirements for masks or helmets are similar to those in the proposal. The non-return valve was specified in the proposal and is designed to prevent reverse flow of the breathing gas if the supply is cut off; this is a protection against diver squeeze. The exhaust valve

requirement is the helmet/mask equivalent to the proposal's dry suit exhaust valve; the valve is used to control buoyancy and reduce the risk of uncontrolled ascent to the surface. This is standard equipment (ETS Ex. 6, I–69, Ex. 64Aiii, 1.2e1, e2). The mask or helmet ventilation requirement for surface-supplied air diving is identical to the one appearing in the proposal, except that the standard adds a performance specification which would allow helmets or masks with lower ventilation rates to be used or developed, provided they meet the performance requirements. This modification is in accord with the testimony at the hearings (Tr. 160–2, 195–6, 204–6), and NIOSH (Ex. 12B, p. 32–33).

The requirements for oxygen safety procedures have systemwide application. The oxygen safety requirement addresses primarily the hazard of combustion, and derives from the "oxygen cleaning" and the "oxygen piping in PVHO's" requirements of the proposal. That equipment used with oxygen or mixtures containing over 40% by volume oxygen must be designed for oxygen service was testified to at the hearings (Tr. 1393). Examples of metals which are suited to oxygen service are copper, brass, and monel. Non-metal materials should have low flammability (Ex. 12B, p. 133). Structural factors such as avoiding sharp turns and edges and using slow-opening valves should also be considered in determining suitability for oxygen service. The requirement concerning cleaning for oxygen service generalizes the proposal's requirement by applying it to all components (except umbilicals) used in oxygen service, in accordance with testimony (Tr. 164). Umbilicals are excluded from the requirement because there is no agreement as to how they should be cleaned and this is not current industry practice (Tr. 164). The standard does not specify which cleaning agents should or should not be used, because of lack of a generally recognized preferred method, and because many effective agents can be used. It should be noted, however, that NIOSH recommends that trichloroethylene, a non-fluorinated chlorinated hydrocarbon, should not be used because of potentially toxic effects of the solvent and its breakdown products; tri-sodium phosphate, trichlorotrifluoroethane and non-ionic detergents are considered acceptable agents, while use of ultrasonic cleaning devices facilitates quick and effective cleaning (Ex. 12B, p. 63).

The requirement for slow-opening shut-off valves in high-pressure systems also addresses the hazard of combustion. It is intended to prohibit the use of a ball valve or other quick-opening valve because quick-opening valves allow a rapid buildup of pressure, and therefore heat, in the piping system. If any hydrocarbons are present in such a situation, combustion may result. It is not meant to apply to hull-stop valves, which are open under normal operating conditions. Compressed air systems over 500 psig are included in this requirement because a similar combustion hazard exists in high-pressure air systems.

The weights and harnesses requirements derive from similar provisions in the proposal. The weight belt or assembly requirement its intended to permit weight assemblies, such as weights carried in pockets, to be used; this is preferable to specifying only belts. In accordance with the proposal and testimony, the standard requires the weights to be quick release, but does not specify that the quick release must be "simple" (Tr. 141, 152, 423, 1949; Ex. 178, p. 80). The harness requirement exempts SCUBA diving in addition to heavy-gear diving, since harnesses are not used or needed in these situations. The harness requirement has been modified in accordance with testimony that the harness does not have to be "separate" (Ex. 178, p. 82). No testimony was presented against the positive buckling device requirement, which remains from the proposal. The attachment and lifting point requirements have been modified slightly to achieve the intent both of preventing strain on the mask or helmet and distributing the force over the diver's body.

14. *Recordkeeping requirement* (*§ 1910.440*). The recordkeeping requirements of the standard are consistent with general OSHA policy concerning the recording, reporting, and availability of records. Part 1904 of 29 CFR is the basic OSHA regulation on the recording and reporting of occupational injuries and illnesses. Reference to 29 CFR Part 1904 is included in the final standard, as in the proposal, to remove any uncertainty as to its applicability. In addition, employers are required to record the occurrence of any diving-related injury or illness which requires hospitalization of 24 hours or more. Because of the relatively small size of the diving population and of individual diving operations, reports of fatalities or five or more hospitalizations, as required by 29 CFR Part 1904, may leave unrecorded a substantial proprotion of diving accidents. Requiring a record of hospitalizations of 24 hours or more will preserve information which can provide a more complete indication of the incidence of disease and injuries in the diving industry. The 24-hour hospitalization period has been used for the same reasons that have been discussed in relation to the reexamination after injury or illness requirement; again, this represents a modification of the 72-hour hospitalization or 5 days' treatment by a doctor criteria which appeared in the proposal.

In addition to recording and reporting of occupational injuries and illnesses there are other documents or reports which the standard requires. These are:

(1) Notification of deviations from the standard in an emergency situation and a written submission of the same upon request of the Area Director (§ 1910.401 (c));

(2) Physician's written report to the employer (§ 1910.411(e));

(3) Safe practices manual (§ 1910.420 (b));

(4) List of emergency aid (§ 1910.421 (b));

(5) Record of each dive (§ 1910.423 (d));

(6) Written evaluation of the decompression procedures assessment (§ 1910.423(e)); and

(7) Tagging or logging of equipment procedures (§ 1910.430(a)). The rationale and record support for each of these documentation requirements have already been discussed in the order in which they appear in the standard.

The requirement to make records available to OSHA officials and to retain records required by the standard for varying periods depending on the type of record, remains from the proposal. Records which contain essential medical information, including dive team medical records, records of dives when there has been an incident of decompression sickness, decompression procedures assessment evaluations, and records of hospitalizations, are required to be kept for 5 years. This is consistent with the retention period for occupational illnesses and injuries reports required by 29 CFR Part 1904. The five year retention period is considered an appropriate time period in which employers must maintain the data from which the safety and health problem of diving can later be studied. After a record has been retained five years by the employer, the records must be forwarded to the National Institute for Occupational Safety and Health, which, under Section 20 and 22 of the Act, is authorized to conduct research, experiments, and demonstrations relating to occupational safety and health.

Depth-time profiles are required to be kept until completion of the recording of dive or, if appropriate, a decompression procedure assessment. A separate record of the profile information is not needed at that point. Records of dives, when there has been no incident of decompression sickness, must be retained for a year for OSHA enforcement purposes; they may also be used for research or study by NIOSH or OSHA. The safe practice manual and equipment records must be current because they serve only an operational function for which no historical record is necessary.

In addition, the standard provides for the availability of any record which pertains directly to the employee for inspection and copying by employees, former employees or their authorized representatives. This reflects a statutory provision in section 8(c)(3) of the Act that employees have a right to know their work exposures and medical status. A provision which requires successor employers to keep dive and employee medical records and the forwarding of records of the type required to be kept for 5 years to NIOSH in the event that an employer ceases to do business and there is no successor, has been included so that such records will be preserved for at least the required retention period.

In developing these requirements, OSHA has endeavored to require recordkeeping to the extent which is minimally necessary from the standpoint of safety

and health. On the whole, the requirements should be less burdensome for the shallow water employer, because the safe practices manual will be less complex, less information is required to be kept for each dive, and the need to assess an incident of decompression sickness should not arise in these operations.

Moreover, the recordkeeping requirements have been simplified in other respects from the proposal. First, as has been discussed, there is no requirement for automatic recording of time-depth profiles, and no need to maintain complicated statistical data in order to satisfy specified performance criteria for decompression sickness. Secondly, the requirement for a diver's log has been deleted. OSHA believes that since the log would, by its nature, have to be maintained by the employee, it would be difficult and unrealistic to enforce against the employer. Testimony at the hearings maintained that employers would not be willing to rely on the diver's log to verify an employee's diving-related work history or experience (Tr. 1522–7), that employer logkeeping placed an unnecessary burden on both employer and employee (Tr. 1478–81, 1711–2, 1753–6; Ex. 178, p. 78), and that such a log could not be used as a substitute for an accurate and complete diving-related medical history for each diver (Tr. 1478–81, 1522–7). OSHA encourages divers to maintain logs for their own personal use, but the agency has determined that the essential information required by this section of the proposal can best be obtained and maintained in the form of accurate dive and medical records, such as those required by the standard.

VI. Legal Authority

This standard is promulgated pursuant to sections 6(b), 6(c), and 8(c) of the Occupational Safety and Health Act of 1970 (the Act) (84 Stat. 1593, 1596, 1599; 29 U.S.C. 655, 657), Secretary of Labor's Order No. 8–76 (41 FR 25059), and Title 29, Code of Federal Regulations (CFR) Part 1911. By that authority, Part 1910 of 29 CFR is amended by adding a new permanent occupational safety and health standard for commercial diving operations as Subpart T, §§ 1910.401–1910.441. In addition, pursuant to the above authority and section 41 of the Longshoremen's and Harbor Workers' Compensation Act, as amended (44 Stat. 1444; 33 U.S.C. 941) and section 107 of the Contract Work Hours and Safety Standards Act (the Construction Safety Act) (83 Stat. 96; 40 U.S.C. 333), Parts 1915, 1916, 1917, 1918, and 1926 of 29 CFR are amended by adding to those Parts references to the new standard for commercial diving operations to clarify the applicability of this standard to diving operations conducted in the maritime and construction industries. A conforming amendment is also made to 29 CFR 1928.21(b), to include this Subpart T of Part 1910 among the general industry standards not applicable to agriculture.

This document was prepared under the direction of Eula Bingham, Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, 200 Constitution Avenue NW., Room S–2315, Washington, D.C. (202–523–9261).

Signed at Washington, D.C., this 15th day of July 1977.

Eula Bingham,
Assistant Secretary of Labor.

PART 1910—OCCUPATIONAL SAFETY AND HEALTH STANDARDS

Part 1910 of Title 29 of the Code of Federal Regulations is amended by adding a new subpart T to read as follows:

Subpart T—Commercial Diving Operations

Authority: Sec. 6, 8, 84 Stat. 1593, 1596, 1599 (29 U.S.C. 655, 657); Secretary of Labor's Order 8–76 (41 FR 25059); 29 CFR Part 1911; sec. 41, 44 Stat. (33 U.S.C. 941); sec. 107, 83 Stat. 96 (40 U.S.C. 333).

Subpart T—Commercial Diving Operations

General

§ 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, Education, and Welfare) or equivalent rules or regulations established by another federal agency, which regulate research, development, or related purposes involving human subjects.

(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.

§ 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 elapsed 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 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-worn 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).

"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.

Personnel Requirements

§ 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.

§ 1910.411 Medical requirements.

(a) *General.* (1) The employer shall determine that dive team members who are, or are likely to be, exposed to hyperbaric conditions are medically fit to perform assigned tasks in a safe and healthful manner.

(2) The employer shall provide each dive team member who is, or is likely to be, exposed to hyperbaric conditions with all medical examinations required by this standard.

(3) All medical examinations required by this standard shall be performed by, or under the direction of, a physician at no cost to the employee.

(b) *Frequency of medical examinations.* Medical examinations shall be provided:

(1) Prior to initial hyperbaric exposure with the employer, unless an equivalent medical examination has been given within the preceding 12 months and the employer has obtained the results of the examination and an opinion from the examining physician of the employee's medical fitness to dive or to be otherwise exposed to hyperbaric conditions;

(2) At one year intervals from the date of initial examination or last equivalent examination; and

(3) After an injury or illness requiring hospitalization of more than twenty-four (24) hours.

(c) *Information provided to examining physician.* The employer shall provide the following information to the examining physician:

(1) A copy of the medical requirements of this standard; and

(2) A summary of the nature and extent of hyperbaric conditions to which the dive team member will be exposed, including diving modes and types of work to be assigned.

(d) *Content of medical examinations.* (1) Medical examinations conducted initially and annually shall consist of the following:

(i) Medical history;

(ii) Diving-related work history;

(iii) Basic physical examination;

(iv) The tests required by Table 1; and

(v) Any additional tests the physician considers necessary.

(2) Medical examinations conducted after an injury or illness requiring hospitalization of more than 24 hours shall be appropriate to the nature and extent of the injury or illness as determined by the examining physician.

Table I.—*Tests for diving medical examination*

Test	Initial examination	Annual reexamination
Chest X-ray	X	
Visual acuity	X	X
Color blindness	X	
EKG: standard 12L[1]		
Hearing test	X	X
Hematocrit or hemoglobin	X	X
Sickle cell index	X	
White blood count	X	X
Urinalysis	X	X

[1] To be given to the employee once, at age 35 or over.

(e) *Physician's written report.* (1) After any medical examination required by this standard, the employer shall obtain a written report prepared by the examining physician containing:

(i) The results of the medical examination; and

(ii) The examining physician's opinion of the employee's fitness to be exposed to hyperbaric conditions, including any recommended restrictions or limitations to such exposure (see Appendix B).

(2) The employer shall provide the employee with a copy of the physician's written report.

(f) *Determination of employee fitness.* (1) The employer shall determine the extent and nature of the dive team member's fitness to engage in diving or be otherwise exposed to hyperbaric conditions consistent with the recommendations in the examining physician's report.

(2) If the examining physician has recommended a restriction or limitation on the dive team member's exposure to hyperbaric conditions, and the affected employee does not concur, a second physician selected by the employee shall render a medical opinion on the nature and extent of the restriction or limitation, if any.

(3) If the recommendation of the second opinion differs from that of the examining (first) physician, and if the employer and employee are unable to agree on the nature and extent of the restriction or limitation, an opinion from a third physician selected by the first two physicians shall be obtained. The employer's determination of the dive team member's fitness shall be consistent with the medical opinion of the third physician, unless the employer and employee reach an agreement which is otherwise consistent with the recommendation or opinion of at least two of the physicians involved.

(4) Nothing in this procedure shall be construed to prohibit either a dive team member from accepting, or an employer from offering, an assignment which is otherwise consistent with at least one medical opinion while a final determination on the employee's fitness is pending.

GENERAL OPERATIONS PROCEDURES

§ 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.

§ 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.

§ 1910.422 Procedures during dive.

(a) *General.* The employer shall comply with the following requirements which are applicable to each diving operation unless otherwise specfied.

(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.

§ 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 or 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.

(4) Treatment tables, treatment gas appropriate to the diving mode, and sufficient gas to conduct treatment shall be available at the dive location.

(5) 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.

SPECIFIC OPERATIONS PROCEDURES

§ 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 operation.

(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.

§ 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.

§ 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.

§ 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 impede diver mobility or work function; or

(5) In other than daylight hours.

(d) *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.

EQUIPMENT PROCEDURES AND REQUIREMENTS

§ 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 systems.* (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 ppm;

(ii) A level of carbon dioxide (CO_2) greater than 1,000 ppm;

(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 six 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 § 1910.166–171;

(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% 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 six months, and when there is a discrepancy greater than two percent (2%) 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.

RECORDKEEPING

§ 1910.440 Recordkeeping requirements.

(a) *Recording and Reporting.* (1) The employer shall record and report occupational injuries and illnesses in accordance with requirements of 29 CFR Part 1904.

(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, Education and Welfare or their designees, the employer shall make available for inspection and copying any record or document required by this standard.

(2) Upon request of any employee, former employee or authorized representative, the employer shall make available for inspection and copying any record or document required by this standard which pertains to the individual employee or former employee.

(3) Records and documents required by this standard shall be retained by the employer for the following period:

(i) Dive team member medical records (physician's reports) (§ 1910.411)—5 years;

(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) After the expiration of the retention period of any record required to be kept for 5 years, the employer shall forward such records to the National Institute for Occupational Safety and Health, Department of Health, Education, and Welfare.

(5) In the event the employer ceases to do business:

(i) The successor employer shall receive and retain all dive and employee medical records required by this standard; or

(ii) If there is no successor employer, dive and employee medical records shall be forwarded to the National Institute for Occupational Safety and Health, Department of Health, Education, and Welfare.

§ 1910.441 Effective date.

This standard shall be effective on October 20, 1977, except that for provisions where decompression chambers or bells are required and such equipment is not yet available, employers shall comply as soon as possible thereafter but in no case later than 6 months after the effective date of the standard.

APPENDIX A

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.

PART 1915—SAFETY AND HEALTH REGULATIONS FOR SHIP REPAIRING

2. A new § 1915.59 is added to 29 CFR Part 1915 to read as follows:

§ 1915.59 Commercial diving operations.

Commercial diving operations shall be subject to Subpart T of Part 1910, §§ 1910.401–1910.441, of this Chapter.

PART 1916—SAFETY AND HEALTH REGULATIONS FOR SHIPBUILDING

3. A new § 1916.59 is added to 29 CFR Part 1916 to read as follows:

§ 1916.59 Commercial diving operations.

Commercial diving operations shall be subject to Subpart T of Part 1910, §§ 1910.401–1910.441, of this Chapter.

PART 1917—SAFETY AND HEALTH REGULATIONS FOR SHIPBREAKING

4. A new § 1917.59 is added to 29 CFR Part 1917 to read as follows:

§ 1917.59 Commercial diving operations.

Commercial diving operations shall be subject to Subpart T of Part 1910, §§ 1910.401–1910.441, of this Chapter.

PART 1918—SAFETY AND HEALTH REGULATIONS FOR LONGSHORING

5. A new section 1918.99 of 29 CFR Part 1918 is added to read as follows:

§ 1918.99 Commercial diving operations.

Commercial diving operations shall be subject to Subpart T of Part 1910, §§ 1910.401–1910.441, of this chapter.

PART 1926—SAFETY AND HEALTH REGULATIONS FOR CONSTRUCTION

6. Paragraph (e) of § 1926.605 is amended to read as follows:

§ 1926.605 Marine operations and equipment.

* * * * *

(e) *Commercial diving operations.* Commercial diving operations shall be subject to Subpart T of Part 1910, §§ 1910.401–1910.441, of this Chapter.

PART 1928—SAFETY AND HEALTH STANDARDS FOR AGRICULTURE

§ 1928.21 [Amended]

7. Section 1928.21(b) of 29 CFR Part 1928 is amended by substituting the letter T for S in the fourth line of the paragraph.

(Secs. 6, 8, 84 Stat. 1596, 1599 (29 U.S.C. 655, 657); Sec. 41, 44 Stat. 1444 (33 U.S.C. 941); Sec. 107, 83 Stat. 96 (40 U.S.C. 333); Secretary of Labor's Order 8–76 (41 FR 25059); 29 CFR Part 1911).

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