DEPARTMENT OF LABOR

Occupational Safety and Health Administration

[V–97–1]

Dixie Divers, Inc.; Grant of Permanent Variance

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

ACTION: Grant of permanent variance.

SUMMARY: This notice announces the grant of a permanent variance to Dixie Divers, Inc. (Dixie). The permanent variance is from the Occupational Safety and Health Administration (OSHA) requirements for decompression chambers during mixed-gas diving operations, including paragraphs (b)(2) and (c)(3)(iii) of 29 CFR 1910.423 and paragraph (b)(1) of 29 CFR 1910.426.

The permanent variance covers recreational diving instructors and diving guides employed by Dixie. Using both classroom instruction and practice dives, recreational diving instructors train novice divers individually or in small groups in recreational diving knowledge and skills, including conventional diving procedures and the safe operation of diving equipment. Dixie's recreational diving instructors accompany students during practice dives, which vary in depth from a few feet of sea water (fsw) to 130 fsw, and last between 30 minutes and one hour. Diving guides (who may also serve as recreational diving instructors) lead small groups of trained sports divers to local undersea locations for recreational purposes; the guides select the diving locations and provide the sports divers with information regarding the dive site, including hazardous conditions and safe diving practices. While leading divers to a dive site, the guides dive to a maximum depth of 130 fsw for periods of 30 minutes to one hour.

The permanent variance specifies the conditions under which Dixie's recreational diving instructors and diving guides may conduct their underwater training and guiding tasks using open-circuit, semi-closed-circuit, or closed-circuit self-contained underwater breathing apparatus (SCUBA) supplied with a breathing gas consisting of a high percentage of oxygen (O_2) mixed with nitrogen, and without a decompression chamber near the dive site. These conditions address: The requirements for SCUBA equipment, including carbon-dioxide canisters, counterlungs, moisture traps, moisture sensors, carbon-dioxide and O_2 sensors, and information modules; depth limits for diving operations; use of nationally-recognized no-decompression limits and O_2-exposure limits; the O_2 and nitrogen composition of the breathing-gas mixture; procedures and equipment for producing and analyzing breathing-gas mixtures; emergency-egress procedures and systems; management of diving-related medical emergencies; procedures for maintaining diving logs; use of decompression tables and dive-decompression computers; and training requirements for recreational diving instructors and diving guides.

DATES: The effective date of the permanent variance is December 20, 1999.

FOR FURTHER INFORMATION CONTACT: Office of Information and Consumer Affairs, Room N3647, U.S. Department of Labor, Occupational Safety and Health Administration, 200 Constitution Avenue, NW, Washington, DC 20210, Telephone: (202) 693–1999.

Additional information also is available from the following Regional and Area Offices:

Regional Office:

U.S. Department of Labor—OSHA, 61 Forsyth St., SW., Atlanta, GA 30303, Telephone: (404) 562–2300

Area Offices:

U.S. Department of Labor—OSHA, 5807 Breckenridge Parkway, Suite A, Tampa, FL 33610, Telephone: (813) 626–1177

U.S. Department of Labor—OSHA, 8040 Peters Road, Building H–100, Jacaranda Executive Court, Fort Lauderdale, FL 33324, Telephone: (954) 424–0242

U.S. Department of Labor—OSHA, Ribault Building, suite 227, 1851 Executive Center Drive, Jacksonville, FL 32207, Telephone: (904) 232–2895

SUPPLEMENTARY INFORMATION:

I. Table of Contents

The following Table of Contents identifies the major sections under ''Supplementary Information.'' To understand fully the information presented in the following sections, we recommend reviewing the 40 conditions of the permanent variance listed below under section VI.

II. Background

Dixie Divers, Inc. (Dixie) applied for a permanent variance from paragraphs (b)(2) and (c)(3)(iii) of 29 CFR 1910.423 and paragraph (b)(1) of 29 CFR 1910.426 under Section 6(d) of the Occupational Safety and Health Act of 1970 (29 U.S.C. 655) and 29 CFR 1905.11. These paragraphs address the availability and use of decompression chambers during mixed-gas diving operations.

Dixie operates six diving schools, either directly or as franchises. The schools employ 18 skilled and experienced recreational diving instructors to train novice divers in recreational diving knowledge and skills. The same 18 employees also serve as diving guides and lead groups of sport divers to local diving sites for recreational purposes. (We also refer to recreational diving instructors and diving guides jointly as ''employees'' or, more generally, as ''divers.'')

As recreational diving instructors, the employees train recreational diving students in conventional diving procedures and the safe operation of diving equipment. The diving students may use an open-circuit, semi-closed-circuit, or closed-circuit self-contained underwater breathing apparatus (SCUBA) during these training dives. [1] SCUBAs supply divers with compressed air or a breathing gas consisting of a high percentage of oxygen mixed with nitrogen or another inert gas. [2]

Dixie's training program for diving students involves both classroom instruction and practice dives in which the employees accompany diving students to maximum depths of 130 feet of sea water (fsw). These dives last between 30 minutes and one hour. During these dives, the recreational diving instructors provide underwater

[1] The acronym for ''self-contained underwater breathing apparatus'' is ''SCUBA.'' The term ''SCUBA'' refers to open-circuit diving equipment alone, or to open-circuit, semi-closed-circuit, and closed-circuit diving equipment combined. The term ''rebreather'' refers to semi-closed-circuit or closed-circuit diving equipment alone or combined; this diving equipment recycles part or all of the exhaled breathing gas into the system that delivers the breathing gas to the diver.

[2] The abbreviation ''O_2'' means ''oxygen,'' while the phrase ''nitrox breathing-gas mixture'' or the term ''nitrox'' refers to a breathing-gas mixture composed of nitrogen and O_2 in varying proportions.

instruction in, and allow the diving students to practice using, diving procedures and equipment. A recreational diving instructor may make as many as three to four training dives a day while training diving students either individually or in small groups.

As diving guides, the employees lead small groups of trained sports divers to local undersea diving locations for recreational purposes. The diving guide selects the diving location prior to departure, and provides the sports divers with information regarding the dive site, including hazardous conditions and safe diving practices. The divers in the recreational diving groups use open-circuit, semi-closed-circuit, or closed-circuit SCUBAs that supply compressed air or a nitrox breathing-gas mixture during the dive. During these diving excursions, diving guides dive to a maximum depth of 130 fsw for periods of 30 minutes to one hour. A diving guide may make as many as five recreational diving excursions a day.

The places of employment affected by this permanent variance are:

Dixie Divers of Boca Raton, 8241 Glades Road, Boca Raton, FL 33434
Dixie Divers of Boynton Beach, 340 North Congress, Boynton Beach, FL 33426
Dixie Divers of Deerfield, 1645 Southeast 3rd Court, Deerfield Beach, FL 33441
Dixie Divers of Key Largo, 103400 Overseas Highway, Key Largo, FL 33037
Dixie Divers of Palm Bay, 4651 Babcock Street, Northeast, Palm Bay, FL 32905
Dixie Divers of Panama City, 109B West 23rd Street, Panama City, FL 32405

III. Application for a Permanent Variance

In its application for a permanent variance (referred to as ''variance application,'' ''proposed variance,'' or ''proposal''), Dixie proposed an alternative to the decompression-chamber requirements of paragraphs (b)(2) and (c)(3)(iii) of 29 CFR 1910.423 and paragraph (b)(1) of 29 CFR 1910.426. Paragraph (b)(2) of 29 CFR 1910.423 requires that ''[f]or 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).'' Paragraph (c)(3)(iii) of 29 CFR 1910.423 requires that the decompression chamber be ''[l]ocated within 5 minutes of the dive location,'' while paragraph (b)(1) of 29 CFR 1910.426 permits mixed-gas diving only when a ''decompression chamber is ready for use at the dive location.'' The purpose of having a decompression chamber available and ready for use at the dive site is to treat two conditions: (1) Decompression sickness (DCS), which may occur from breathing air or mixed gases at diving depths and durations that require decompression; and (2) arterial-gas embolism (AGE), which may result from overpressurizing the lungs, usually while ascending rapidly to the surface during a dive.

In the variance application, Dixie proposed to implement alternative procedures that meet or exceed the level of employee protection afforded by OSHA's decompression-chamber requirements. As an alternative to a decompression chamber, Dixie proposed to have its employees use open-circuit, semi-closed-circuit, or closed-circuit SCUBA supplied with breathing-gas mixtures that contain a fraction of O_2 ranging from 22 to 40 percent (22–40%) by volume, with the remaining breathing-gas mixture consisting of nitrogen. In addition, the partial pressure of O_2 in the nitrox breathing-gas mixture would never exceed 1.40 atmospheres absolute (ATA)[3] for any SCUBA. Dixie would use one of the following procedures to produce nitrox breathing-gas mixtures: Mixing pure nitrogen with pure O_2; removing O_2 from air for mixing with pure nitrogen; adding pure O_2 to air; or de-nitrogenating air (e.g., removing nitrogen from air using filter-membrane systems[4]). According to the proposal, Dixie would: Analyze the O_2 fraction in the breathing-gas mixtures for accuracy; institute quality-assurance procedures for the analytic processes; and use breathing-gas mixing systems rated for O_2 service whenever the highest O_2 fraction used in the mixing process exceeds 40 percent (40%). Dixie also proposed to restrict diving operations under the variance to depths of 130 fsw or less, and to use the nationally-recognized no-decompression limits and O_2-exposure limits developed by the National Oceanic and Atmospheric Administration (NOAA) and Diving Science and Technology (DSAT).

By increasing the O_2 partial pressure and decreasing the nitrogen partial pressure of the breathing-gas mixture compared to air, and by restricting dives to no-decompression limits and depths of 130 fsw or less, Dixie asserted that both the rate and the severity of DCS would be no greater for its employees than for divers who operate according to paragraph (a)(2)(i) of 29 CFR 1910.401. In addition, Dixie contended that using nationally-recognized O_2-exposure procedures would reduce the risk of O_2 toxicity among its divers to the rate expected among divers who use hyperbaric air.

Dixie proposed a number of other requirements to ensure that its employees remain within safe diving parameters, thereby avoiding DCS and AGE. These requirements included limiting the maximum carbon dioxide (CO_2) level in the inhaled nitrox breathing-gas mixture to 0.01 ATA. Dixie would control excessive CO_2 levels as follows: By using pre-packed sorbent materials to absorb CO_2 from the exhaled breathing gas prior to rebreathing; by installing sensors for detecting high CO_2 levels or conditions that could result in high CO_2 levels (such as moisture sensors to detect flooding in the breathing loop); and by using counterlungs to serve as low-breathing-resistance reservoirs for the breathing gas. In addition, Dixie proposed that its divers use an information module that provides them with critical dive information (e.g., gas pressures, water-temperature); the required information would vary with the type of SCUBA. For rebreathers, visual or auditory warning devices would alert the diver to significant equipment problems (e.g., solenoid failure, low battery levels) or deviations from established diving parameters (e.g., diverging from the planned O_2 levels). Closed-circuit rebreathers would need to operate using a gas-controller package, a manually-operated gas-supply bypass valve, and separate O_2 and diluent-gas cylinders.

Dixie proposed a number of other conditions to safeguard its divers. For emergencies involving SCUBA malfunctions that could endanger diver health and safety (e.g., high CO_2 levels), the proposed variance required that Dixie have a reliable ''bail-out system'' available. The bail-out system would need to provide a separate supply of

[3] ATA, as used here, is the partial pressure of a constituent gas in the total pressure of a breathing gas. If the percentage of the constituent gas in the breathing gas remains constant throughout a dive, its partial pressure or ATA, increases in proportion to increases in diving depth.

[4] Filter-membrane systems produce nitrox breathing-gas mixtures in two steps: First, they route air through filters to remove hydrocarbons and other contaminants, then they pass the decontaminated air through membranes that transfer O_2 across the membrane fibers at higher rates than nitrogen (hence, ''de-nitrogenating air''). As the rate of air flow across the membrane fibers increases, the resulting ratio of O_2 to nitrogen also increases. Under the permanent variance, a filter-membrane system will reduce the hazards associated with producing high-O_2 breathing-gas mixtures because the proportion of O_2 in the system will never exceed 40 percent (40%).

breathing gas to the second stage of the SCUBA regulator; when rebreathers are used, the bail-out system could deliver a diluent supply of breathing gas to the second stage of the regulator. Other protective conditions, which refined or emphasized existing requirements currently specified in OSHA's Commercial Diving Operations Standard (CDO Standard), included the following: Maintaining decompression tables and diving logs at the dive site; assuring the availability of personnel, facilities, and equipment to treat DCS and AGE; and providing quality control of diver training.

In summary, Dixie stated that the occurrence and severity of DCS would be minimal when its divers breathe nitrox gas mixtures, while the risk of AGE would be negligible when they use the equipment and procedural safeguards specified in the variance application. Consequently, divers who use SCUBAs according to the proposed variance would experience a level of DCS and AGE that is equal to, or lower than, the level experienced by recreational diving instructors who dive under the conditions specified by the exemption to the CDO Standard at 29 CFR 1910.401(a)(2)(i). These conditions allow for the use of compressed air supplied to open-circuit SCUBAs under no-decompression diving limits. Dixie asserted, therefore, that it should not have to maintain a decompression chamber at the dive location for its recreational diving instructors and diving guides when it complies with the conditions specified in the variance application.

In a **Federal Register** notice published on October 31, 1997, we provided the public with a copy of Dixie's variance application (62 FR 58995). This notice invited interested parties, including affected employers and employees, to submit written comments, data, views, and arguments regarding the variance application. In addition, the notice informed affected employers and employees of their right to request a hearing on the variance application. At the request of several parties, we extended the comment period for this notice until March 2, 1998 in a **Federal Register** announcement dated January 6, 1998 (63 FR 579).

IV. Comments on the Proposed Variance

We received 123 comments in response to the two **Federal Register** notices. Of this total, two comments (Exs. 2–98 and 2–115) were duplications, and one comment (Ex. 2–112) consisted solely of a request to extend the comment period. (Exs. 6–1 to 6–17 also were requests to extend the comment period.) Two additional comments (Exs. 2–118 and 2–119) requested a hearing on the proposal. We denied these hearing requests because neither of the two requestors employed recreational diving instructors, the subject of this variance application. OSHA received 103 comments that were general, non-specific endorsements of the variance application; the vast majority of these comments varied only slightly in content. The remaining 15 commenters submitted detailed comments regarding the conditions and issues specified in the variance application.

We have organized our discussion of the substantive comments to the variance application into six parts. Comments concerning proposed section I (Background) are in Part 1, while Part 2 consists of comments made about the conditions specified in proposed section II (Proposed Alternative). Part 3 discusses comments made regarding proposed section III (Rationale for the Proposed Alternative), and Part 4 presents comments to the issues raised in proposed section VI (Issues). No commenters addressed sections IV and V of the variance application, titled ''References'' and ''Additional Information'' respectively. Part 5 consists of general and miscellaneous comments. Throughout each of these five parts, we explain the actions we are taking with regard to individual comments or groups of comments. The last part, Part 6, describes refinements to the proposed variance that we have made in developing the permanent variance; these refinements are based upon our interpretation of the proposed conditions and our overall review of the record.

We and other parties submitted additional exhibits (Exs. 4, 4A, 5, and 7 through 13) to the docket (see Table I). These exhibits, which contain scientific and technical information, provided additional information we used in replying to comments and discussing revisions to the proposal. The principal topics covered by the exhibits are: O_2 toxicity; nitrogen narcosis; decompression procedures; the operation and use of SCUBAs; and treatment of diving-related medical emergencies. Table I below provides specific reference information on these exhibits.

TABLE I.—REFERENCE INFORMATION ON EXHIBITS 4, 4A, AND 5 THROUGH 16

Ex. No.	Reference information
4	D. J. Kenyon and R. W. Hamilton. ''Managing Oxygen Exposure when Preparing Decompression Tables.'' In: N. Bitterman and R. Lincoln (eds.), *Proceedings of the XVth Meeting of the European Undersea Biomedical Society,* pages 72–77. European Undersea Biomedical Society, September 1989.
	R. W. Hamilton. ''IV. Oxygen Physiology, Toxicity, and Tolerance.'' In: R. W. Hamilton (author), *Special Mix Diving: Part One,* pages 25–38. Hamilton Research and Life Support Technologies, March 2, 1994.
4A	R. W. Hamilton, R. E. Rogers, M. R. Powell, and R. D. Vann. *The DSAT Recreational Dive Planner: Development and Validation of No-Stop Decompression Procedures for Recreational Diving.* Diving Science and Technology, Inc., and Hamilton Research, Ltd., February 28, 1994.
5	D. Richardson (ed.-in-chief). *Proceedings of Rebreather Forum 2.0.* Diving Science and Technology, Inc., 1996.
7	R. W. Hamilton. ''Tolerating Exposure to High Oxygen Levels: *Repex* and Other Methods.'' *Marine Technology Society Journal,* volume 23, number 4, pages 19–25, December 1989.
8	R. J. Kiessling and C. H. Maag. ''Performance Impairment as a Function of Nitrogen Narcosis.'' *Journal of Applied Psychology,* volume 46, number 2, pages 91–95, 1962.
9	A. D. Baddeley. ''Influence of Depth on the Manual Dexterity of Free Divers: A Comparison Between Open Sea and Pressure Chamber Testing.'' *Journal of Applied Psychology,* volume 50, number 1, pages 81–85, 1966.
10	A. D. Baddeley, J. W. De Figueredo, J. W. Hawkswell Curtis, and A. N. Williams. ''Nitrogen Narcosis and Performance Under Water.'' *Ergonomics,* volume 11, number 2, pages 157–164, 1968.
11	W. B. Wright. ''Use of the University of Pennsylvania, Institute for Environmental Medicine Procedure for Calculation of Cumulative Pulmonary Oxygen Toxicity.'' U.S. Navy Experimental Diving Unit, Report 2–72, 1972.
12	R. J. Biersner. ''Request for Your Recommendation Regarding Acceptable Delay in Recompression Treatment of Diving-Related Medical Emergencies.'' Memorandum to Dr. Edward D. Thalmann, August 28, 1998.

TABLE I.—REFERENCE INFORMATION ON EXHIBITS 4, 4A, AND 5 THROUGH 16—Continued

Ex. No.	Reference information
13	E. D. Thalmann. Letter to R. J. Biersner Responding to the Memorandum in Ex. 12, October 5, 1998.
14	J. R. Clarke. CO_2 Canister Test Parameters and Procedure at NEDU. Attachment to U.S. Navy Experimental Diving Unit E-mail Memorandum, November 22, 1999.
15	J. R. Clarke. ''Statistically Based CO_2 Canister Duration Limits for Closed-Circuit Underwater Breathing Apparatus.'' U.S. Navy Experimental Diving Unit, Report 2–99, 1999.
16	P. B. Bennett. ''Nitrox?'' *Alert Diver,* March/April, 1998.

Part 1. Comments to proposed section I (Background).

(a) The skills and experience of, and the diving operations performed by, the applicant's divers (62 FR 58996, second column) received two comments. Both comments were primarily concerned about Dixie's recreational diving instructors and diving guides engaging in diving activity beyond the scope of the proposed variance. The Association of Diving Contractors, Inc. (Ex. 2–99) contended that recreational diving instructors and diving guides ''[engage] in services of a commercial nature,'' and implied that the conditions of the variance application would allow them to extend their commercial diving activities beyond the scope of the proposed variance.

The second commenter (Ex. 2–105) did not object to the proposed variance for no-decompression dives to depths of 130 fsw or less if they are ''of an instructional, training, or scientific nature and [do] not involve any form of salvage or underwater construction or related working tasks.'' This commenter stated that the recreational diving must ''not encompass working dives (i.e.[,] salvage, construction). This is a very [important] distinction as the commercial diving industry cannot bear the financial burden imposed by the insurance companies who would lump professional recreational instructors in with professional commercial divers.''

In reply to these commenters, we note that the permanent variance will not cover recreational diving instructors and diving guides when they engage in activities that do not involve recreational diving instruction and diving guide activities. They must comply with our CDO Standard as appropriate, including the decompression-chamber requirements, while engaged in these other activities. To ensure that Dixie understands under what conditions the permanent variance applies, we are specifying in Condition (1) (see below at section VI, titled ''Order'') that the permanent variance covers only recreational diving instructors and diving guides who are employees of Dixie Divers, Inc., and then only while they are performing as diving guides and recreational diving instructors.

(b) The background information noted that the applicant's employees ''may make as many as three or four training dives a day while training diving students'' and that ''[a] guide may make as many as five * * * excursions a day'' (62 FR 58996, second column). This background information elicited one comment. This commenter (Ex. 2–109) stated that ''[b]oth NAUI [National Association of Underwater Instructors] and PADI [Professional Association of Diving Instructors], the two largest certifying agencies in the U.S., limit instructors teaching entry-level classes to no more than two dives per day with a single class.'' The commenter also noted that ''Dixie could hire more instructors, which would lessen their time in the water, decreasing [their] nitrogen exposure, lessening their susceptibility to DCS, thus obviating the need for the variance.''

The basis for the NAUI and PADI limitations is unclear (e.g., do these limits address diver safety or training effectiveness). Nevertheless, we believe that adopting the no-decompression procedures for repetitive diving published in the 1991 NOAA Diving Manual and by DSAT (Ex. 4A) as a condition of the permanent variance will protect Dixie's recreational diving instructors and diving guides at least as well as recreational diving instructors who use compressed air supplied to open-circuit SCUBAs under no-decompression diving limits specified in paragraph (a)(2)(i) of 29 CFR 1910.401.

(c) The statement in this section that ''[e]mployees who use high-oxygen breathing-gas mixtures will be able to make more or longer repetitive-training [or] excursion dives than they would using compressed-air open-circuit SCUBA'' (62 FR 58995, third column) received one comment. This commenter (Ex. 2–109) disagreed with this statement, claiming that nitrox breathing-gas mixtures may not reduce susceptibility to DCS and that ''[w]e know of no studies or evidence to show that diving to limits on the nitrox tables while breathing nitrox produces a lower incidence of DCS than diving to limits on air tables while breathing air.''

We agree that the mathematical probability of DCS is similar for dives that result in equivalent levels of nitrogen saturation (e.g., dives made to a specific depth using air, and longer-duration dives made to the same depth using nitrox breathing-gas mixtures). Accordingly, for dives made using nitrox breathing-gas mixtures, the risk of DCS is lower only when these dives are at the same depths and for the same durations as the air dives. Note, however, that Condition J of the proposed variance limits the risk of DCS by requiring that divers remain within the no-decompression limits of NOAA's decompression tables, or other tables or formulas that Dixie demonstrates are equally effective in preventing DCS.

(d) We stated in the ''Background'' section of the proposed variance that ''[a]s a result [of using nitrox breathing-gas mixtures], the mathematical probability of developing decompression sickness (DCS) is reduced compared to divers who use compressed air under the same diving conditions (i.e., depth, bottom time, and descent and ascent rates)'' (62 FR 58997, first column). This statement elicited two comments. The first commenter (Ex. 2–98) stated that high-O_2 nitrox breathing-gas mixtures will result in a reduced risk of DCS when used at the same depths and for the same durations as air, but only if the divers use the depth and duration limits specified for air decompression and do not extend the duration of the dive. The reduction in risk occurs because the nitrogen partial pressure in the nitrox breathing-gas mixture is less than the partial pressure of nitrogen in air at the specified depth. The second commenter (Ex. 2–109) asserted that Dixie has economic incentives to extend the duration of dives.

We believe these commenters are correct that extending the duration of dives using high-O_2 nitrox breathing-gas mixtures would increase the risk of DCS. However, we conclude that the resulting risk would be comparable to using the equivalent partial pressure of nitrogen in air for that extended period. The basis for this conclusion is the equivalent-air-depth (EAD) formula published by NOAA, which is the nation's lead Federal agency for developing mixed-gas decompression schedules used in scientific and technical diving operations. According to NOAA, EAD ''is the depth at which air will have the same nitrogen partial pressure as the [oxygen-]enriched mix has at the depth of the dive'' (1991 NOAA Diving Manual, page 15–7). NOAA applies its EAD formula in determining what equivalent air decompression limits to use with nitrox breathing-gas mixtures, and assumes that equivalent nitrogen partial pressures and dive durations will result in similar DCS risk. However, to provide Dixie's divers with an added margin of safety against DCS, the permanent variance requires that the partial pressure of nitrogen in the high-O_2 nitrox breathing-gas mixture used for a specific dive duration must never exceed the no-decompression limits for the equivalent partial pressure of nitrogen in air for that same duration published in the 1991 NOAA Diving Manual.

Part 2. Comments to proposed section II (Proposed Alternative).

(a) Conditions A.1 and A.2 of the proposal, which specified requirements for CO_2 scrubbers, CO_2 sensors, moisture traps, moisture sensors, and over-pressure valves, received a number of comments. Several commenters (Exs. 2–98, 2–99, 2–105, and 2–117) pointed out a typographical error in the stated CO_2 level in Condition A.1. The correct level is 0.01 ATA, not 0.1 ATA, and we have corrected it in the permanent variance.

Condition A.1 in the proposed variance (Condition (4) in the permanent variance) stated that rebreathers must use commercially-available, pre-packed, disposable scrubber cartridges or an equally effective alternative. Three commenters (Exs. 2–101, 2–105, and 2–114) took exception to the requirement that CO_2 scrubbers must use sorbent cartridges that are commercially available, pre-packed, and disposable. They contended that such cartridges are not available for some rebreathers and, when available, are expensive. They also argued that rebreather manufacturers do not require pre-packed, disposable cartridges because many divers manually fill and pack most rebreather canisters. One commenter (Ex. 2–105) stated that ''no scientific evidence [shows that] a disposable[,] pre-packaged canister would perform safer or with greater efficiency than one packed by the user.'' Another commenter (Ex. 2–117), however, stated that ''[u]se [of disposable scrubber cartridges] in rebreathers reduces return to service time and reduces human error during servicing,'' and that [several manufacturers] have canisters that simplify replacement of sorbent material, while [at least one manufacturer] uses a disposable cartridge.''

In reply to these commenters, we note that Condition A.1 in the proposed variance allowed Dixie to use an alternative to pre-packed CO_2-sorbent materials, including manually-filled cartridges; Condition (4)(b) in the permanent variance will also permit this alternative, if it is acceptable to the rebreather manufacturer. However, Dixie bears the burden of demonstrating to us that its manually-filled cartridges are at least as effective as pre-packed sorbent materials in removing CO_2 from the breathing loop; Dixie likely would get this information from the rebreather manufacturer.

Proposed Condition A.2 required the use of CO_2 sensors. One commenter (Ex. 2–25) endorsed this proposed requirement for closed-circuit rebreathers, but claimed these sensors were unnecessary for semi-closed-circuit rebreathers because these rebreathers ''are regularly venting gas from the system which is replaced with high oxygen content gas * * * to prevent the buildup of carbon dioxide.'' We believe that CO_2 sensors are necessary for semi-closed-circuit rebreathers because divers can ''overbreathe'' these rebreathers. Overbreathing occurs when the diver's breathing rate is faster than the rate at which fresh breathing gas enters the inhalation bag; consequently, overbreathing causes the diver to rebreathe exhaled gas containing elevated levels of CO_2. The information in Ex. 5 (pages P–19 through P–22) supports this conclusion. Therefore, CO_2 sensors enable divers to detect increased CO_2 before it reaches hazardous levels.

The commenter in Ex. 2–98 endorsed the use of CO_2 sensors, but claimed that this technology is ''currently unavailable even in the current U.S. Navy rebreathers.'' Two other commenters (Exs. 2–105 and 2–114) also asserted that continuously-functioning CO_2 sensors are not available commercially. However, another commenter (Ex. 2–117) contradicted these assertions; this commenter stated that CO_2 sensors are available in several rebreathers.

Four commenters (Exs. 2–99, 2–106, 2–113, and 2–114) claimed that few, if any, rebreathers on the market met proposed Conditions A.1 and A.2. One of these commenters (Ex. 2–106) stated, ''[M]any of the specifications for rebreathers represent the manufacturer-specific features of an intended unit that was never brought forward as a production model. We also manufacture diving rebreathers and protest any regulation that would arbitrarily bias compliance to one model.'' Four other commenters contended that the proposed variance favors or enhances the competitive position of one or more rebreather manufacturers (Exs. 2–99, 2–101, 2–105, and 2–114); no commenter, however, indicated which manufacturer(s) would benefit. One commenter (Ex. 2–114) stated that ''[implementing the proposed variance] would put every dive store and instructor who teaches rebreather diving in the U.S. out of business,'' and claimed that ''this [proposed] variance would in essence be a restraint of trade.''

The information provided in Ex. 2–117 demonstrates that the required components are commercially available and used in several existing rebreathers. Other evidence in the record (Ex. 5, page 6–4) also shows that effective CO_2 sensors are commercially available for closed-circuit rebreathers. We find that each proposed condition is necessary for diver safety, and that Dixie can either purchase rebreathers, or retrofit its existing rebreathers, to meet these conditions. In addition, we observe that no commenter found that any required component was unsafe.

While the proposed variance did not require any CO_2 alarms, the commenter in Ex. 2–98 recommended that CO_2 sensors activate two alarms: The first alarm when the inhaled CO_2 partial pressure is at 0.005 ATA (3.8 mmHg), to warn divers that they are approaching the upper CO_2 limit; and the second alarm when inhaled CO_2 reaches the partial pressure limit of 0.01 ATA (7.6 mmHg), to alert the diver to terminate the dive immediately. We agree with much of this comment, but we believe that once the alarm is activated at a CO_2 partial pressure of 0.005 ATA, it must continue to provide a visual or auditory warning to the diver to take corrective action or terminate the dive before reaching the maximum CO_2 limit of 0.01 ATA. The use of an activation level is similar to the action-level requirement found in many of OSHA's standards for toxic substances. Therefore, the permanent variance requires Dixie to integrate the CO_2 sensors with an alarm (either visual or auditory) that operates continuously at and above a CO_2 partial pressure of 0.005 ATA.

The proposed variance did not specify calibration requirements for CO_2 sensors. Nevertheless, the commenter in Ex. 2–98 stated that any CO_2 sensor adopted for use in rebreathers must be ''tested both in the laboratory and in manned diving trials,'' and that the ''[d]ata from these trials must support [the] accuracy, reliability and ruggedness'' of CO_2 sensors. While this commenter did not specify a protocol or criteria for testing these factors, we agree that, at a minimum, Dixie must determine the accuracy of CO_2 sensors before its divers use them. Such a determination is necessary to enable Dixie to eliminate sensors that are unreliable or that cannot function under rugged diving conditions. Therefore, in developing provisions for calibrating and maintaining the accuracy of CO_2 sensors (see Condition (9) in the permanent variance), we have adopted the requirements that Dixie specified for O_2 sensors in Condition A.4 of the variance application, with one major revision: Instead of using an accuracy of 1 percent (1%) by volume, Condition (9)(c) of the permanent variance requires that CO_2 sensors be accurate ''to within 10 percent (10%) of a CO_2 concentration of 0.005 ATA or less,'' based on the comments in Ex. 2–98. Using a test or standard gas containing a CO_2 concentration of 0.005 ATA or less will ensure that the sensors can accurately detect CO_2 levels that can be harmful to Dixie's divers. Additionally, in view of the harmful effects that can result from high levels of CO_2, we consider a maximum error rate of no more than 10 percent (10%) of a CO_2 partial pressure of 0.005 ATA to be within acceptable limits.

The commenter in Ex. 2–98 also argued that, as an alternative to CO_2 sensors, ''the breathing apparatus manufacturer [must] produce data from manned trials that substantiate [the] operational CO_2 canister-duration limits over the entire depth, water temperature, and exercise range for which the breathing apparatus is designed. Furthermore, the manufacturer must clearly state what these limits are.'' While the proposed variance did not mention such an alternative, we agree with the general approach recommended by this commenter. However, we believe that valid and reliable data for determining CO_2-sorbent replacement schedules can be obtained from carefully controlled and executed testing protocols that use breathing machines instead of divers to evaluate the canisters. Therefore, Condition (10)(a)(i) of the permanent variance permits Dixie to use a schedule for replacing the CO_2-sorbent material in canisters if the rebreather manufacturer developed the replacement schedule using the canister-testing protocol specified in Appendix A of this notice. We adapted this protocol from the canister-testing parameters and procedure provided by the U.S. Navy Experimental Diving Unit (NEDU) (Ex. 14); NEDU is the lead federal agency for testing CO_2-sorbent replacement schedules, and the diving industry recognizes the NEDU canister-testing protocol as the industry standard. Additionally, the employer can use a CO_2-sorbent replacement schedule developed by a rebreather manufacturer only if the manufacturer analyzed the protocol results using the statistical procedures specified by NEDU (Ex. 14 and 15).

The canister-testing protocol developed by NEDU addresses the three factors recommended by the commenter in Ex. 2–98: Depth, exercise level (ventilation rate), and water temperature. Depth is the maximum depth at which a diver would use the CO_2-sorbent material, which for the permanent variance is 130 fsw. We selected three combinations of ventilation rates and CO_2-injection rates from the NEDU protocol to simulate three diverse levels of exercise (light, moderate, and heavy). The four water temperatures used in the NEDU protocol are 40, 50, 70, and 90 degrees F (4.4, 10.0, 21.1, and 32.2 degrees C, respectively); these temperatures represent the wide range of water temperatures that Dixie's recreational diving instructors are likely to encounter. We revised the NEDU protocol slightly by: Limiting the maximum depth to 130 fsw; requiring an O_2 fraction of 0.28 in a nitrox breathing gas (this fraction being the maximum O_2 concentration permitted at this depth by the permanent variance); providing tolerance limits for water temperatures; and defining canister duration as the time taken to reach 0.005 ATA of CO_2 (the CO_2 level specified in the permanent variance at which divers are to eliminate excessive CO_2 in the breathing gas or terminate the dive). In addition, our protocol uses only mandatory language, and expressly prohibits the use of replacement schedules based on extrapolation of the protocol results. OSHA prohibits extrapolation of the protocol results because the statistical-analysis procedures developed by NEDU (Ex. 15) do not provide a method for estimating the duration of CO_2-sorbent materials beyond the results obtained during the canister-testing trials. OSHA believes this approach significantly improves the validity and reliability of the replacement schedules derived from these results. After thoroughly reviewing the NEDU canister-testing protocol and adapting it the conditions of the permanent variance, we believe that CO_2-sorbent replacement schedules based on the requirements of Appendix A of the permanent variance will enable Dixie to replace CO_2-sorbent materials in a timely manner, thereby ensuring the health and safety of its divers.

While we are confident that CO_2-sorbent replacement schedules developed according to Condition (10) of the permanent variance will protect divers under ordinary diving conditions, we believe that these schedules do not address a condition that can seriously compromise canister effectiveness: Moisture in the canister, which usually results from canister flooding. Based on our review of the record, we find that moisture traps and moisture sensors can effectively control this condition. In this regard, proposed Condition A.2 required the use of moisture traps and moisture sensors. Several commenters (Exs. 2–101, 2–105, and 2–117) claimed that existing rebreathers already use moisture traps. The commenter in Ex. 2–101 stated, without explanation, that ''making them a requirement would be restrictive.'' This commenter also asserted that moisture sensors are unnecessary because CO_2 sensors perform the same function. (The commenter did not specify the term ''function,'' but we assume that it refers to the capability to indicate canister flooding.) A second commenter (Ex. 2–105) noted that moisture sensors would be an important safety feature, but asserted that they were not available commercially. However, another commenter (Ex. 2–117) claimed that moisture sensors are available from several companies. One commenter (Ex. 2–105) noted that excessive moisture can impair electrical systems in rebreathers, and asked us to specify where to place the moisture sensors to prevent these problems.

Moisture traps are necessary to keep water out of the canisters because water leakage into canisters can substantially reduce the CO_2-absorbing properties of the sorbent material. Moisture sensors, in turn, detect excessive water or flooding inside the canister that can compromise the CO_2-sorbent material. Moisture sensors, therefore, warn the diver of hazardous water leakage into the canister. The commenters in Exs. 2–101, 2–105, and 2–117 noted that moisture traps are available commercially and that existing rebreathers routinely use them. The information in Ex. 2–117 also indicates that moisture sensors are commercially available. While we believe that rebreather manufacturers should place moisture sensors on the inhalation side of the breathing loop, we leave the design and location of moisture sensors and moisture traps to their technical expertise. Dixie must ensure that its divers use these components consistent with the rebreather manufacturer's instructions, and that the moisture sensors alert the diver of moisture in the breathing loop in sufficient time to terminate the dive and return safely to the surface. We have incorporated these conditions into the permanent variance.

In the proposed variance, Condition A.2 specified that rebreathers contain over-pressure valves. Regarding over-pressure valves, one commenter (Ex. 2–101) asked us to define the term ''over-pressure valve,'' while two commenters (Exs. 2–105 and 2–117) asserted that existing rebreathers already have over-pressure valves. One of these commenters (Ex. 2–105) noted that over-pressure valves are ''important protection to reduce the risk of [AGE] and associated pressure[-]induced injuries and [rebreather] damage.''

An over-pressure valve is a valve on the counterlung that releases breathing gas from the counterlung when the pressure reaches a set level; we have incorporated this meaning into the permanent variance. Rebreathers routinely are designed with over-pressure valves. These valves perform a critical safety function by helping to regulate breathing-gas volume and pressure.

Condition A.2 of the proposed variance also specified that Dixie use redundant (i.e., at least two) CO_2 sensors and redundant moisture sensors; it also required that these sensors function continuously. One commenter (Ex. 2–101) agreed with the proposed requirement for a continuously-functioning CO_2 sensor, but did not believe that additional CO_2 sensors were necessary. This commenter noted that both CO_2 and moisture sensors will alert the diver whenever the breathing loop, most likely the CO_2-sorbent material, is no longer capable of removing exhaled CO_2. We agree with this commenter that CO_2 and moisture sensors serve much the same purpose—to inform the diver of conditions (for example, reduced efficiency of the CO_2-sorbent material) that may cause CO_2 to accumulate in the breathing loop. By measuring the amount of CO_2 in the inhaled breathing gas (after the gas passes through the sorbent material in the canister to remove CO_2) CO_2 sensors can detect an elevated CO_2 level that may indicate depletion of the CO_2-sorbent material because of canister flooding. An elevated CO_2 level, in turn, warns the diver to take corrective action, including terminating the dive.[5] As noted previously, moisture sensors detect excessive water or flooding inside the canister that can reduce the sorbent material's capacity to remove CO_2 from the inhaled breathing gas. The independent functions performed by these sensors (i.e., a CO_2 sensor measures CO_2 in the breathing gas, while a moisture sensor detects excessive moisture in the canister) indicates that a malfunction in one sensor is unlikely to result in a malfunction in the other sensor.

Several other conditions make sensor redundancy unnecessary. First, the symptoms of excessive CO_2 do not develop as rapidly as the symptoms of O_2 toxicity;[6] consequently, a properly trained and experienced diver will be able to recognize a number of effects associated with excessive CO_2 and take appropriate action, including terminating the dive. These effects include: Reduced buoyancy (from the increased weight caused by canister flooding); shortness of breath (from CO_2 displacing O_2 in the diver's lungs); an increase in breathing resistance during inhalation (caused by difficulty moving the breathing gas through wet CO_2-sorbent material); and a large number of bubbles vented through the rebreather's exhaust valve (venting related to the increased exhaust pressure caused by exhaling against wet CO_2-sorbent material). Secondly, the permanent variance (Conditions (7) and (8)) requires that both the moisture sensor and CO_2 sensor function continuously, ensuring early detection of a CO_2-related problem by the diver. Lastly, Condition (30) of the permanent variance requires that the divers use an open-circuit emergency-egress system (a ''bail-out'' system); this system will provide the divers with the capability to shift to a known, safe, and immediately-available breathing gas, and to terminate the dive safely whenever a CO_2-related problem occurs.

Based on this record, we find that: Carbon-dioxide sensors and moisture sensors provide independent means of detecting a CO_2-related problem; symptoms related to excessive levels of CO_2 develop more slowly than the symptoms of excessive O_2; a properly trained and experienced diver will recognize the effects of excessive CO_2 in sufficient time to take correct action; the requirement that CO_2 sensors and moisture sensors be continuously functioning assures real-time detection of CO_2-related problems; and the required bail-out system provides the diver with a safe means to terminate a dive following detection of a CO_2-related problem. This record demonstrates that the proposed requirements for redundant CO_2 sensors and redundant moisture sensors are unnecessary; we believe that the only basis for requiring redundant sensors is if the rebreather manufacturer includes them in the equipment design or specifications. Therefore, we have revised the conditions accordingly in the permanent variance.

(b) Proposed Condition A.3, which required the use of flexible breathing bags (also known as ''counterlungs'') with rebreathers, elicited the following comment (Ex. 2–105):

> Not all rebreathers use breathing bags. However, they all employ some type of counter lung providing a compliant volume. Certain types of rebreathers utilize a large diaphragm or bellows assembly. There would be no purpose in mandating a particular counterlung configuration. The only regulation that could be mandated might be a minimum volumetric displacement.

We consider breathing bags to be a type of counterlung. Even though the proposed variance used the terms ''breathing bags'' and ''counterlungs'' interchangeably, we agree with the commenter that the permanent variance should not specify a particular counterlung configuration. We have revised the condition accordingly in the permanent variance. In addition, while we agree with the need to specify a minimum volumetric displacement, we believe that the rebreather manufacturer should determine this value. In this regard, Dixie must ensure that its divers use the counterlung according to the rebreather manufacturer's instructions, and the counterlung must displace enough volume to sustain the diver's respiration rate during any diving condition. We have incorporated these conditions into the permanent variance.

(c) Proposed Condition A.4 addressed ''bail-out systems,'' which are supplemental breathing-gas systems used by divers for emergency ascent to the surface if the SCUBA malfunctions. The proposed condition specified that bail-out systems must integrate the

[5] In addition, a CO_2 sensor alerts the diver to increased CO_2 levels in the inhaled breathing gas that may result from other conditions, including depleted sorbent material (saturated with CO_2) and channeling or overbreathing (exhaled air bypassing the sorbent material).

[6] The rapid onset of symptoms resulting from O_2 toxicity provides a major rationale for requiring redundant O_2 sensors.

second stage of the SCUBA regulator with either a separate supply of emergency breathing gas or, for semi-closed-circuit and closed-circuit rebreathers, a diluent supply of emergency breathing gas. Two commenters (Exs. 2–100 and 2–105) responded to the proposed condition. The first commenter (Ex. 2–100) recommended that the system contain at least 35 cubic feet of emergency breathing gas. This volume was based on maximum consumption rates related to a number of variables, including water temperature, diver's thermal protection, speed of current, lung volume, and psychological stress. The second commenter (Ex. 2–105) stated that ''[a] bail-out system is a necessity for all rebreather use.''

We agree that the bail-out system must enable the diver to terminate the dive safely under ''worst-case'' conditions. We believe, however, that the rebreather manufacturer is in the best position to determine what capacity of breathing gas is needed for safe operation of the bail-out system. In this regard, Dixie must ensure that its divers use the bail-out system according to the rebreather manufacturer's instructions. Dixie must also ensure that the bail-out system supplies sufficient emergency breathing gas to enable a diver to terminate the dive and return safely to the surface; the rebreather manufacturer can make this determination after Dixie provides the critical diving parameters (e.g., depth of dive and breathing rate). We have revised this condition accordingly in the permanent variance.

(d) Proposed Condition A.5 specified requirements for information modules, which provide divers with information about the dive, including gas pressures, dive times, and descent and ascent rates. One commenter (Ex. 2–114) stated that the information module is a dive computer, that no rebreathers are available commercially that integrate dive computers with breathing systems, and that no dive computer ''includes displays that directly warn of rebreather solenoid failure and excessive descent rates.'' In response, although we believe that it would be advantageous if dive computers included such information and warning displays, neither the proposed nor the permanent variance require it. The permanent variance requires Dixie to equip its divers with sensor and display systems that provide information on time, depth, ascent, and descent to divers who use closed-circuit rebreathers, and time, ascent, and descent information to divers who use semi-closed-circuit rebreathers. Both types of rebreathers must also have alarms or visual displays that warn the diver about excessive ascent and descent rates, as well as depth levels that are shallower than the ceiling-stop depth. The permanent variance does not require that a dive computer provide this capability.

(e) Proposed Condition B required that closed-circuit rebreathers must use the following sensors: (1) Sensors that measure supply pressures for O_2 and diluent gas; (2) depth sensors; (3) continuously-functioning and redundant temperature-compensated O_2 sensors; and (4) continuously-functioning gas-loop and ambient water-temperature sensors. One commenter (Ex. 2–114) asserted that no existing rebreathers have continuously-functioning sensors for assessing gas-loop and ambient water temperatures. A second commenter (Ex. 2–117) contradicted this assertion, claiming that ''transducers and thermocouples are readily available from numerous companies'' for sensing pressure, depth, and ambient water temperature.

We believe that temperature sensors are necessary for diver safety. Water-temperature sensors alert divers to the possibility of hypothermia. In addition, gas-loop temperature sensors and water-temperature sensors allow divers to estimate the duration of their CO_2-sorbent material. Efficiency of the CO_2-sorbent material deteriorates with decreasing temperatures (1991 NOAA Diving Manual, page 16–9). Thus, if divers are able to estimate the duration of their CO_2-sorbent material, they can judge how long they can dive even if their CO_2 sensors malfunction. Even if no existing rebreather incorporates temperature sensors as stated by the commenter in Ex. 2–114, Dixie's proposal to use such sensors will provide its divers with additional protection from temperature-related diving hazards; therefore, we have included this condition in the permanent variance.

(f) For open-circuit SCUBA, proposed Condition C specified that the concentration of O_2 must not exceed 40 percent (40%) of the breathing gas by volume, or, for any SCUBA, an O_2 partial pressure of 1.40 ATA. Three commenters (Exs. 2–104, 2–106, and 2–113) recommended that we increase the partial pressure of O_2 in the breathing-gas mixture from 1.4 to 1.6 ATA; these commenters asserted that recreational divers use the 1.6 ATA level regularly and safely, and that this use conforms to prevailing rebreather practices.

In reply to these commenters, we believe that the research data cited in the proposed variance support our conclusion that a maximum O_2 level of 1.40 ATA prevents O_2 toxicity. The commenters provided no data or studies to support a maximum O_2 exposure of 1.6 ATA, nor could we find any relevant data or study to support this recommendation for SCUBA diving. Evidence in the record (see Exs. 4, 4A, 5 (pages 3–5 through 3–15, P–15, and P–37 through P–43), and 7) also demonstrates that breathing 1.6 ATA of O_2 for extended periods increases the risk of O_2 toxicity compared to breathing 1.4 ATA of O_2. The increased risk of O_2 toxicity means that little tolerance exists for errors in O_2 control and delivery equipment (e.g., O_2 sensors, solenoids) and in calculating O_2 exposures.

One commenter (Ex. 2–106) noted that we should consider both partial pressure and the duration of a dive when determining O_2 exposure limits. Another commenter (Ex. 2–109) maintained that when they use high-oxygen breathing-gas mixtures, Dixie's recreational diving instructors and diving guides can dive for longer periods than when they use air as the breathing gas. Long dive durations extend a diver's exposure to elevated levels of oxygen, thereby increasing the diver's risk of developing O_2 toxicity, as well as DCS. Regarding the first comment (Ex. 2–106), we note that the O_2 exposure limits specified in the proposed variance address both duration and level of O_2 exposure. Similarly, in response to the second commenter (Ex. 2–109) we believe that Conditions C and E in the proposed variance address the concern about O_2 toxicity expressed in Ex. 2–109; these proposed conditions cited research studies attesting to the safety of breathing O_2 at a partial pressure of 1.40 ATA.

(g) Condition D in the proposal limited the diving depth to ''no deeper than 130 fsw, or to a maximum oxygen partial pressure delivered to the diver of 1.40 ATA, whichever is most restrictive.'' The proposed condition elicited two comments. The first commenter (Ex. 2–99) stated that the Association of Diving Contractors, a trade association for the commercial-diving industry, requires decompression chambers at the dive site for dives deeper than 80 fsw or for dives outside the no-decompression limits because ''there is still a possibility of a rapid ascent to the surface and hence, a [risk of AGE] brought on by eliminated or accelerated decompression [during] the ascent.'' The second commenter (Ex. 2–113) considered a maximum diving depth of 160 or 170 fsw to be safe.

The proposal reduced the risk of DCS resulting from ''eliminated or accelerated decompression'' to minimal levels by requiring Dixie to ensure that its divers use nationally-recognized no-decompression diving limits. The proposal lowered the risk of AGE by including a number of procedural and equipment requirements (e.g., specified O_2 levels in the breathing-gas mixture and installation of O_2 and CO_2 sensors) that would minimize the need to make rapid (emergency) ascents to the surface during a dive; such ascents can cause AGE by overpressurizing the lungs. We believe that these proposed requirements would protect recreational diving instructors from the risks associated with DCS and AGE as well as, or better than, the provisions of 29 CFR 1910.401(a)(2)(i) (the exemption in OSHA's CDO Standard for recreational diving instructors who use open-circuit, air-supplied SCUBA).

We are not extending the depth limit to 160 or 170 fsw because we believe that doing so would place the diver at increased risk of nitrogen narcosis (as well as DCS). This increased risk would occur because the partial pressure of nitrogen in the breathing gas would be higher at 160–170 fsw than at 130 fsw. Previous research (Exs. 8, 9, and 10) demonstrates that hyperbaric air has significant narcotic effects even at 100 fsw or about 4.00 ATA (which is equivalent to a nitrogen partial pressure of 3.16 ATA). Using 28 percent (28%) O_2 at 130 fsw (equivalent to about 1.40 ATA O_2), the partial pressure of nitrogen would be 3.56 ATA, which is only slightly above the narcotic threshold specified by the previous research.

(h) Proposed Condition E established O_2-exposure limits for the breathing-gas mixtures, requiring that divers "not exceed the 24-hour single-exposure time limits specified by the 1991 NOAA Diving Manual or other oxygen-exposure limits, such as the Diving Science and Technology (DSAT) Oxygen Exposure Table, that provide a level of oxygen-toxicity protection at least equivalent to the level of protection afforded by the 1991 NOAA Diving Manual." The proposed condition received two comments. One commenter (Ex. 2–98) agreed with using the NOAA O_2-exposure limits and a maximum O_2 partial pressure of 1.4 ATA, stating that these limits "should not make the probability of oxygen toxicity * * * significantly different than when breathing air." At O_2 partial pressures above 1.3 ATA, this commenter recommended using the exposure durations specified in Table 15–1 of NOAA's 1991 Diving Manual. According to this commenter, using the NOAA table "would make the probability of CNS O_2 toxicity [extremely low]." The second commenter (Ex. 2–100) asserted that a commercial subsidiary of the Professional Association of Diving Instructors developed the DSAT O_2-exposure limits. The commenter contended that this subsidiary is not a recognized research authority and is "motivated by profit and not necessarily the public benefit." According to this commenter:

> NOAA is a highly regarded and recognized source of diving research and operational protocol. If oxygen exposure limits are not to exceed the 24-hour single exposure time limits specified in the 1991 NOAA Diving Manual[,] then citing additional sources of oxygen exposure limits[] that[,] by default, can only be the same or more conservative, is unnecessary and likely confusing.

The comments in Ex. 2–98 support the maximum O_2-exposure limit of 1.40 ATA specified in proposed Condition E. We agree with the commenter that CNS toxicity is the principal basis for specifying O_2 exposure limits; accordingly, we discussed the need to prevent O_2-induced CNS toxicity in detail in the proposed variance (62 FR 58999–59000).

Regarding the comments in Ex. 2–100, we find that the O_2-toxicity protection afforded to divers by the DSAT tables under the diving conditions specified in the variance application is at least equivalent to the level of safety that they get from the O_2-exposure limits specified in the 1991 NOAA Diving Manual. The rationale provided in the proposed variance, as well as additional evidence submitted to the record (Exs. 4 and 7), support this conclusion.

We have deleted the proposed general language that would have allowed Dixie to use non-NOAA O_2-exposure limits (other than DSAT's) when these limits "provide a level of oxygen-toxicity protection at least equivalent to the level of protection afforded by the 1991 NOAA Diving Manual." We believe this provision would introduce unnecessary uncertainty into the permanent variance when two adequate sources of O_2 limits are already available for Dixie's use. Accordingly, we have revised this provision so that only the O_2-exposure limits identified in the proposal are acceptable for the permanent variance; these limits are from the 1991 NOAA Diving Manual, and the Enriched Air Operations and Resources Guide published in 1995 by the Professional Association of Diving Instructors (commonly referred to as the "1995 DSAT Oxygen Exposure Table"). If other O_2-exposure limits become available in the future, Dixie may request us to amend the permanent variance if it provides evidence that demonstrates their safety.

(i) Proposed Condition F, which required that "[n]itrogen shall be the only inert gas used to obtain the breathing-gas mixture," elicited two comments. One commenter (Ex. 2–103) asserted that recreational diving instructors and diving guides "use gas blends to increase safety," implying that we should allow divers to use additional inert gases in the breathing-gas mixture. The second commenter (Ex. 2–113) also noted that tri-mix breathing gases (usually consisting of O_2, N_2, and He) have been used safely by many divers.

Dixie proposed to use nitrogen as the only inert gas in the breathing-gas mixture under the specified conditions encountered by its divers (i.e., no-decompression dives to depths that do not exceed 130 fsw). We need not consider the use of other inert gases as part of Dixie's permanent variance because Dixie did not seek our approval for the use of these gases. In any case, we believe that other inert gases (e.g., helium) have limited, if any, application under the conditions of this variance.

(j) Proposed Conditions G, H, and I specified, respectively, the requirements for: Mixing and analyzing nitrox breathing-gas mixtures; compressors used to produce the nitrox breathing-gas mixtures; and SCUBAs exposed to high-pressure (pressures exceeding 300 psi) nitrox breathing-gas mixtures. These proposed conditions received four comments. The first commenter (Ex. 2–99) contended that the proposal did not provide specifications for O_2-clean systems and measurement accuracy, and did not require the delivery of pre-mixed breathing gas "from a reliable and competent source with high standards of documented quality control in place."

The second commenter (Ex. 2–105) asked: What is the basis for the O_2-cleaning and O_2-service requirements and the 300 psi limit; at what minimum O_2 level would these requirements apply; and how does OSHA define "O_2 compatible." The commenter agreed with the use of oil-free compressors for mixing nitrox breathing-gas mixtures. The commenter noted, however, that employees who use these compressors need proper training and that "[s]pecial consideration must be given * * * to material use, material compatibility, system design, cleaning[,] and maintenance." The commenter described several hazards associated with mixing nitrox breathing gases, including: Partial-pressure blending into cylinders not prepared properly for O_2 service; inducing O_2-enriched breathing-gas mixtures into the intake of compressors not designed for this purpose; and contamination of mixtures with hydrocarbons or oil. The commenter also recommended that we permit the use of O_2 analyzers that involve processes or mechanisms other than fuel-cells (e.g., gas chromatography, thermal conductivity), stating that such analyzers are accurate and ''have been in use worldwide for many years.''

A third commenter (Ex. 2–116) made a number of recommendations to improve the safety of mixing nitrox breathing gases, including: Prohibit the use of oil-lubricated air compressors for mixing nitrox breathing gases containing 22–40 percent (22–40%) O_2; require compressor and filter-system manufacturers to certify that their equipment is safe for the gases used in the breathing mixtures; require filter-system manufacturers to certify that the equipment used to clean air (for mixing with pure O_2) produces O_2-compatible breathing gases (*i.e.,* breathing gases with low hydrocarbon levels); and require Dixie to monitor hydrocarbon contamination continuously. The commenter also submitted suggested revisions to the proposed text based on these recommendations.

In reply to the commenters who requested information on which standards we would use to ensure accurate mixing and decontamination (especially hydrocarbon removal) of nitrox breathing gases, we note that Dixie must comply with 29 CFR 1910.101 (Compressed Gases (General Requirements)) and 29 CFR 1910.169 (Air Receivers), and applicable provisions of 29 CFR 1910.134 (Respiratory Protection). We agree with the comment in Ex. 2–105 that Dixie must use only properly trained personnel to mix breathing gases, and we have revised the permanent variance accordingly.

To reduce the risk of O_2 explosions, proposed Condition I required that SCUBA using high-O_2 breathing-gas mixtures or pure O_2 at pressures exceeding 300 psi be designed for O_2 service. We derived the 300 psi limit by interpolating between the pressure limit (125 psi) for pure O_2 and the pressure limit (500 psi) for compressed air specified in paragraph (i)(3) of 29 CFR 1910.430. We note, however, that § 1910.430(i)(1) requires that equipment using O_2 mixtures exceeding 40 percent (40%) O_2 by volume be designed for O_2 service; this requirement is based on the serious explosion risk associated with these O_2 mixtures. Therefore, to reduce the risk of an O_2 explosion, we have revised the permanent variance to require that SCUBA using breathing-gas mixtures that exceed 40 percent (40%) O_2 by volume at pressures over 125 psi be designed for O_2 service.

The proposed variance explained that an O_2 analyzer that uses a fuel-cell process would be acceptable. However, O_2 analyzers based on other processes are also acceptable if they meet the requirements specified in Conditions 22 and 24(a) of the permanent variance.

We agree with the commenter in Ex. 2–116 that Dixie must only use compressors and filters that manufacturers have certified will produce O_2-compatible breathing-gas mixtures and will withstand the pressures involved. We believe these requirements substantially reduce the risk of O_2-related explosions that can occur while mixing nitrox breathing gases under high pressure. Accordingly, we have incorporated these requirements into the permanent variance. Consistent with existing requirements in our CDO Standard, the permanent variance also requires an O_2-service rating for compressors used for mixing high-pressure O_2 whenever O_2 fractions could exceed 40 percent (40%) by volume, as specified in paragraphs (i)(1) and (i)(2) of 29 CFR 1910.430.

A fourth commenter (Ex. 2–117) stated that O_2 analyzers, oil-less compressors, and filter-membrane systems are available commercially, and identified several companies that manufacture this equipment. These comments demonstrate that Dixie can readily meet the requirements in the permanent variance to use O_2 analyzers, oil-less compressors, and filter-membrane systems when mixing nitrox breathing gases for rebreathers.

(k) Proposed Condition J, which identified the no-decompression limits that Dixie must use, elicited three comments. One commenter (Ex. 2–98) asserted that using high-O_2 breathing-gas mixtures and diving in accordance with the no-decompression limits for air diving specified in the 1991 NOAA Diving Manual would reduce the risk of developing DCS. This commenter also recommended comparing other, ''equivalent,'' no-decompression limits to the NOAA limits using a method that ''give[s] acceptable prediction of DCS probability when applied to data bases * * * where the dive profile is accurately known and the outcome (DCS or no DCS) is known.'' The commenter added that ''the employer must show through adequate records that the DCS incidence using these other procedures [is] acceptably low,'' and asserted that ''an ongoing evaluation of safety through record keeping is essential.''

Another commenter (Ex. 2–109) stated that the ''DSAT [no-decompression air] tables, [which] are based on a shorter tissue half-time, predict more rapid out-gassing and therefore allow much longer repetitive dives than the Navy [no-decompression air] tables would following similar bottom times and surface intervals.'' This commenter concluded, however, that the DSAT and U.S. Navy no-decompression limits provide similar levels of diver protection.

The third commenter (Ex. 2–99) noted that the proposal did not consider ''omitted decompression'' that may occur while instructing and supervising novice divers. This commenter asserted that novice divers are ''prone to panic and thus more susceptible to an occurrence that [may require] * * * a decompression chamber on site.''

Based on these comments, we conclude that the permanent variance needs to contain specific recommendations for no-decompression limits. Therefore, we have decided to remove the provision for ''equivalent'' no-decompression limits from the permanent variance. In doing so, we have carefully reviewed the findings and recommendations of Dr. R. W. Hamilton et al. in Ex. 4A (''DSAT Recreational Dive Planner: Development and Validation of No-Stop Decompression Procedures for Recreational Diving'' or ''the Planner''). Based on evidence cited in the Planner, we find that the scientific community accepts the DSAT no-decompression tables; in addition, the program of extensive laboratory and field testing described in the Planner has demonstrated that the DSAT no-decompression tables are reliable and valid. Accordingly, the permanent variance allows Dixie to use the DSAT no-decompression tables and the no-decompression limits in the 1991 NOAA Diving Manual. Should other no-decompression limits become available in the future, Dixie may request us to amend the permanent variance. The application would need to demonstrate that the alternative no-decompression limits are at least as protective as the limits specified in the permanent variance.

In an earlier response to the commenter in Ex. 2–109 in paragraph (d) of Part 1, we stated that NOAA's EAD formula can accurately estimate the DCS risk associated with nitrox breathing-gas mixtures based on equivalent nitrogen partial pressures and dive durations used in air diving. In addition, we disagree with this commenter's recommendation to adopt the U.S. Navy's no-decompression limits. If we were to adopt these limits, we would unnecessarily restrict a major application of rebreathers (i.e., to use high levels of O_2 in the breathing-gas mixture to extend the diving duration at a specific depth beyond the duration limit specified for air).

As previously noted, the commenter in Ex. 2–99 expressed concern about diving-related incidents among novice divers, and implied that recreational diving instructors could be placed at risk of DCS or AGE under these conditions. We find that the risk of DCS is negligible under these conditions because the recreational diving instructors and novice divers will be using the NOAA or DSAT no-decompression tables and, therefore, will have no need to decompress. If a novice diver panics and makes a rapid ascent to the surface, the recreational diving instructor has been trained and has the necessary experience to follow the novice diver to the surface in an orderly fashion, thereby avoiding AGE.

(l) Proposed Condition K.3, which specified the entries that divers must make in the diving log, received only one comment (Ex. 2–109). This commenter asked who would make the entries, stating that ''frequently, other than the paying passengers * * * there is only the boat captain and the instructor [or] guide.'' Dixie Divers consists of several small commercial diving businesses that may have difficulty finding an employee to make entries in the diving log. After we published the proposed variance, Dixie asked us to revise the proposed condition to permit non-employees to make entries in the log. In addition, Dixie asked for a similar revision to proposed Condition L, which required the employer to verify the availability of treatment resources for medical emergencies, and to enter the verification in the diving log. Recognizing that any properly-qualified individual can make such entries, we have revised these provisions to permit Dixie to use non-employees to perform these tasks, but only after verifying their qualifications to do so. As the employer, Dixie will be responsible for assuring that the entries are made, regardless of who makes them.

(m) Proposed Condition L required that Dixie confirm, on a daily basis before commencing diving operations, the availability of resources to treat a diving-related medical emergency, including ''transportation * * * capable of delivering [an injured diver] to the decompression chamber within two hours of the injury.'' A commenter (Ex. 2–109) asked, ''Does this imply that if they are told a chamber is down or the Coast Guard can't confirm readiness, that they'll cancel the diving for that day?'' This commenter cautioned that ''if an accident happens after a significant amount of time has passed since the call, [a decompression chamber] may not be available at that time [because it's in use or undergoing maintenance].'' Based on these comments, we have clarified the requirement in the permanent variance by specifying that Dixie must confirm that the required treatment resources are ''available during each day's diving operations.''

This commenter (Ex. 2–109) also argued that a decompression chamber should be within one hour from the dive site, instead of two hours, because of the ''relatively short distance off-shore that most Florida diving is done,'' and any ''[t]ime delay in getting an injured diver to a chamber can severely lessen the chances of full recovery from DCS.'' In reviewing this recommendation, we asked the Divers Alert Network (DAN) for assistance. DAN is the nation's leading private-sector organization providing DCS treatment recommendations to recreational divers and diving guides.

With DAN's assistance, we identified 13 locations in Florida where suitable decompression chambers (6.0 ATA pressure capability, dual-lock, multiplace) are available to the public for treating diving-related medical emergencies. These chambers are in Pensacola, Panama City, Tallahassee, Gainesville, Jacksonville, Inverness, Orlando, Tampa, Fort Myers, Miami, Tavernier, Marathon, and Key West. These 13 decompression-facility sites are within two hours transit time of any diving location in Florida, including off-shore, state-controlled waters. This transit time assumes the use of surface vehicle transportation traveling at the maximum legal speed limit, and includes 30 minutes to make land when diving off-shore. In response to the commenter's statement that increases in treatment delay will ''severely lessen the chances of full recovery from DCS,'' we sought evidence with respect to one-hour or two-hour treatment delays from Dr. Edward D. Thalmann (Ex. 12). Dr. Thalmann is a world-renowned expert in treating diving-related medical emergencies among recreational divers; he is also the author of a number of scientific publications that address the causes and treatment of diving-related medical emergencies, especially DCS.

In his reply (Ex. 13), Dr. Thalmann compared the risk of AGE and DCS among recreational divers who breathe air as opposed to nitrox. He then estimated the maximum delay in decompression treatment that would not worsen the treatment outcome. Dr. Thalmann noted that AGE is the most life-threatening diving-related medical emergency that can occur and that, to treat the most serious cases, a decompression chamber should be available at the dive site. He recognized that this recommendation went far beyond our existing requirements for some types of recreational diving (e.g., recreational diving instruction covered by paragraph (a)(2)(i) of 29 CFR 1910.401). In this regard, Dr. Thalmann stated that AGE ''is a rare occurrence and can be avoided with proper training and experience.'' Dr. Thalmann concluded that AGE ''is essentially independent of the time at depth'' and that ''there is no evidence * * * [to] suggest that the occurrence and outcome of [AGE] would be any different breathing a [n]itrox mixture [other] than air.''

Regarding DCS, Dr. Thalmann asserted that research data show that the EAD approach (see the discussion above under paragraph (d) of Part 1) is valid for computing no-decompression limits for O_2 partial pressures as high as 1.5 ATA. Based on this research and his field experience, Dr. Thalmann stated that DCS associated with breathing a nitrox gas mixture ''should not be substantially different in incidence and severity compared to diving on air[,] provided the [n]itrox no-decompression times are computed from accepted air no-decompression limits using the [NOAA's] EAD [formula].'' Dr. Thalmann concluded that, within these constraints, ''there is no rationale for having different requirements for recompression chamber availability for air and [n]itrox no-decompression diving.''

In addressing treatment delay, Dr. Thalmann reviewed available research studies, as well as data from DAN. According to Dr. Thalmann, the DAN data ''apply to recreational diving only where the vast majority of diving is within no-decompression limits.'' The results show that, for both pain-only DCS and DCS with severe neurological symptoms, a treatment delay of four hours can occur without diminishing treatment success (i.e., complete relief of symptoms). In conclusion, Dr. Thalmann stated, ''There is no significant body of evidence to suggest that, so long as one is diving within accepted no-decompression limits breathing air or [n]itrox, having access to a recompression facility within 4 hours is inadequate.''

Dr. Thalmann's reply demonstrates several points: (1) The risk of AGE and DCS while breathing air or a nitrox gas mixture should not differ when the dive conforms to accepted no-decompression limits computed using the EAD approach; (2) maintaining a decompression chamber at the dive site to treat AGE is unnecessary and impractical because AGE is a rare occurrence that proper training and diving experience can prevent; and (3) as much as a four-hour delay in treating DCS does not diminish treatment outcomes. Based on this evidence, as well as a complete review of the existing record, we have decided to keep the provision permitting a two-hour timeframe for treating DCS, as proposed by Dixie.

As part of his reply, Dr. Thalmann also recommended that we revise the phrase ''within two hours of the injury'' in proposed Condition L.1 to read ''[2] hours after it is recognized that symptoms of [a decompression incident] are present.'' We acknowledge that the proposed language was unclear, but we also believe that the recommended wording may be confusing as well. Therefore, we have adopted new language in the permanent variance that expresses the requirement in terms of the maximum delay permitted in transporting the injured diver to a suitable decompression chamber; the revised language reads, ''* * * within two (2) hours travel time from the dive site.''

(n) Proposed Condition N specified that Dixie was responsible for initial treatment of diving-related medical emergencies, and that it had to ensure that ''two personnel, one of whom shall be a diver employed by [Dixie] and both of whom are qualified in first-aid and the administration of treatment oxygen'' were available at the dive site for this purpose. Two commenters responded to this provision. The first commenter (Ex. 2–100) stated that the provision appears to be ''an attempt by Dixie Divers * * * to use the process to gain an unfair advantage in the recreational diving market by requiring all diving operations to contract with a 'diver employed by the applicant.' '' The second commenter (Ex. 2–109) asserted that this requirement would be difficult to satisfy because the ''typical crew on a Florida boat is [a] captain and instructor.'' Dixie, as a small business with few employees, supported the second commenter's assertion, and requested that it be permitted to use qualified non-employees to meet this requirement.

In reply to these comments, we note that Dixie and all other employers engaged in commercial diving operations must already provide, as appropriate, on-site support personnel to perform a variety of tasks (see, e.g., the requirements in paragraph (c) of 29 CFR 1910.410 and paragraph (c)(2) of 29 CFR 1910.426). These personnel can also perform duties as specified in proposed Condition N. We recognize, however, that the main purpose of this provision is to ensure that properly-qualified personnel are available, regardless of their employment status. Therefore, we have revised this provision to permit Dixie to use non-employees for first-aid and O_2 treatment. However, Dixie may do so only if it verifies their qualifications to perform these tasks before it starts the day's diving operations.

(o) Proposed Condition O specified the training requirements for Dixie's recreational diving instructors and diving guides, including the requirement that an industry-recognized training agency certify that the divers are capable of using the diving equipment and breathing-gas mixtures needed for their recreational diving operations. The National Association of Underwater Instructors (NAUI) (Ex. 2–100) noted its affiliates offer ''a full range of training programs from Skin Diver through Instructor Course Director, including certification in oxygen enriched air, semi-closed circuit and closed circuit rebreather diver.'' Nonetheless, NAUI found the proposed condition ambiguous because it ''does not provide a definition of the diving industry or outline any process or criteria to evaluate and recognize a training agency that would establish the legitimacy of its training.''

We agree with NAUI's comment that this provision in the proposed variance was confusing. Additionally, we believe that an employer is in the best position to determine if the training that its divers obtain is adequate to perform their jobs safely and effectively. Therefore, we have revised the proposed provision and have made the training requirement in the permanent variance performance-based; that is, Dixie must ensure that its employees receive training that enables them to perform safely and effectively while using open-circuit SCUBAs or rebreathers supplied with nitrox breathing-gas mixtures. However, we specified several critical tasks that the recreational diving instructors and diving guides employed by Dixie must be trained to perform safely and effectively, including: Recognizing the effects associated with breathing excessive CO_2 and O_2; taking appropriate action after detecting the effects of breathing excessive CO_2 and O_2; and properly evaluating, operating, and maintaining their open-circuit SCUBAs and rebreathers. We addressed the importance of recognizing and responding properly to the effects of excessive CO_2 and O_2 in our earlier discussions of Conditions A.2 and E of the proposed variance. Based on our review of Ex. 5 (especially pages 11–1 through 11–15), we believe that divers must also know how to evaluate, operate, and maintain their rebreathers under the diving conditions that they encounter as recreational diving instructors and diving guides. We have specified these revisions in Condition 38 of the permanent variance.

Part 3. Comments to Proposed Section III (Rationale for the Proposed Alternative)

(a) In discussing Conditions A and B in the proposed variance, we noted that the existing exemption for recreational diving instructors in paragraph (a)(2)(i) of 29 CFR 1910.401 in our CDO Standard does not refer to rebreathers. We explained that ''such equipment was not available or in common use by recreational diving instructors when OSHA's [CDO] Standard was promulgated in 1977'' (62 FR 58999, first column). A commenter (Ex. 2–109) noted that this statement gave the false impression that rebreather equipment ''is readily used by the recreational diving community.'' Regarding the experience of the recreational diving community with rebreathers, this commenter asserted that ''while the argument can be made that [rebreathers have] been used safely within the scientific and commercial diving industries, it can also be argued that those divers are more highly trained and the operations more closely monitored than is the norm in the recreational diving industry.''

Our discussion of the rationale for Conditions A and B as proposed noted that ''data related to the reliability and safety of [rebreather equipment] are difficult to obtain because its use by recreational divers is still uncommon''; however, we now believe that data are available showing that recreational diving instructors and diving guides can use rebreathers safely and reliably. We revised our opinion after reviewing Ex. 5 (especially pages 2–2, 7–1, and 7–2), which shows that various military organizations have a 50-year history of using rebreathers safely, scientific and technical divers have been doing so for over 20 years, and, currently, recreational diving instructors and diving students safely perform rebreather diving. We believe, therefore, that we have sufficient knowledge about rebreather technology and diving procedures to determine that the conditions specified in the permanent variance will protect Dixie's recreational diving instructors and diving guides at least as well as having an on-site decompression chamber.

(b) The rationale for proposed Conditions C through E justified the use of DSAT's Oxygen Exposure Table (62 FR 58999, second and third columns). This rationale elicited one comment (Ex. 2–109). This commenter stated that specifying time limits in the DSAT Oxygen Exposure Table in terms of total dive time ''is * * * a very common industry practice and not some great concession on Dixie's part, as the wording of the sentence would perhaps lead you to believe.'' In this case, we agree that the use of a common industry practice will enable Dixie to comply with the permanent variance without additional effort, while providing adequate diver protection.

(c) Proposed Condition K provided a rationale for using dive-decompression computers, noting that no-decompression limits for repetitive dives can involve ''tedious and time-consuming calculations * * * made by hand.'' It concluded that dive-decompression computers would ''assist divers in decreasing their exposure to excessive ascent rates, oxygen toxicity, and DCS that could result from errors in calculating repetitive no-decompression diving schedules manually.'' (62 FR 59000, third column.) The single commenter (Ex. 2–109) on this point claimed that manual calculations ''[can be] taught in the first or second lecture of most entry-level [SCUBA] classes'' and performed in a couple of minutes. This commenter also asserted that manual calculations may provide an additional margin of safety from DCS because they typically determine decompression using the deepest depth attained during a dive. By contrast, dive-decompression computers may reduce decompression (and therefore increase the risk of DCS) by ''measur[ing the] exact depth every few seconds and recalculat[ing decompression] based on actual depth.''

In reply, we note that Condition K as proposed allowed Dixie the flexibility to use either manual calculations or dive-decompression computers. Nevertheless, manual calculation is subject to human error, and computer use can reduce such error. The permanent variance will reduce problems associated with using dive-decompression computers to avoid decompression by restricting the no-decompression limits to the most recent decompression tables and formulas published by NOAA and DSAT.

(d) The rationale for proposed Conditions O and P addressed the requirements for diver certification, noting that ''Condition O provides general uniformity to the diver qualification and training process, as well as quality control over the certifying agencies.'' (62 FR 59001, third column.) A commenter (Ex. 2–109) stated that the certification requirement imposed no burden on Dixie because it was consistent with existing industry practice; in addition, the requirement was unlikely to bring uniformity to diver qualifications because ''different dive stores, certifying under the same national standards, can still turn out divers [and] instructors of varying proficiency levels.'' In reply, we note that we do expect these requirements to make training programs more uniform (than is presently the case) in the way that they train recreational diving instructors and diving guides, and this uniformity should substantially reduce much of the variability in diver proficiency.

Part 4. Comments to Proposed Section VI (Issues)

In the proposal, we invited the public to submit information and specific comments and rationale on nine other issues. Only one commenter (Ex. 2–109) did so. This commenter addressed the first issue, which requested commenters to differentiate the underwater tasks and types of diving performed by recreational diving instructors and diving guides, and to relate these differences to the probability of experiencing diving-related medical problems. The commenter stated that, during training dives, recreational diving instructors ''will probably do multiple ascents * * * but may be exposed to less time in the water than a dive guide since students generally are excited and [consume more air] than experienced divers.'' The commenter stated that, during the ascent-training phase, recreational diving instructors must ''make multiple, generally rapid, ascents with each of the students, increasing the chances of a DCS hit.'' The commenter added that recreational diving instructors are ''at a slightly greater risk [than diving guides] of AGE from the ascents and perhaps a slightly elevated chance of DCS due to rapid ascents,'' although ''[t]he likelihood of the instructor getting DCS or AGE * * * is probably extremely small.''

Regarding diving guides, the commenter asserted that it escorts experienced divers who, typically, are less excitable than novice divers; based on this assumption, the commenter asserted that experienced divers would consume breathing gases at slower rates than novice divers. The commenter concluded that slow rates of gas consumption would extend dive durations which, combined with the deeper dives made by diving guides compared to recreational diving instructors, would increase the diving guides' risk of DCS. In response to this commenter, we refer to our earlier discussion of this issue in Part I. In this discussion, we agreed that ''using high-O_2 nitrox breathing-gas mixtures would increase the risk of DCS,'' but concluded that ''the resulting risk would be comparable to using the equivalent partial pressure of nitrogen in air for that extended period.''

Part 5. General Comments to the Proposed Variance

One commenter (Ex. 2–105) indicated that a number of topics needed clarification or were ''so controversial or comprehensive in nature that this level of detail in a policy document may not be appropriate.'' These areas are: Validating dive-decompression computers, including the programmable safety factors used in these computers; updating decompression data; identifying programmable gas-percentage options; using failure mode and effects analysis of critical components and assemblies to develop consensus regarding the general safety and accuracy of dive-decompression computers; determining the relevance of, and necessity for, monitoring environmental temperatures and the breathing-loop gases in closed-circuit rebreathers; and recognizing standards developed by the equipment manufacturers. The commenter stated that ''[t]o expand on just a few of [these areas] would make this document much [too long].'' Nevertheless, the commenter asserted, without explanation, that ''from a standpoint of technical diving facts [the proposed variance] is grossly inaccurate and in many cases written with twisted facts,'' and that the ''[proposed] variance as written has the potential to expose employees (*i.e.*[,] dive shop technicians, instructors) to dangerous situations.''

In large part, these areas of concern address the safety and standardization of dive-decompression computers. Under the permanent variance, use of dive-decompression computers is optional; however, if Dixie uses these computers, it must also provide its divers with specific decompression information. Regardless of computer use or availability, Dixie must have hard-copy decompression tables at the dive site. Thus, the permanent variance specifies the conditions that Dixie must meet to ensure that its employees' diving activities conform to accepted no-decompression practices, whether or not Dixie uses dive-decompression computers.

Another commenter (Ex. 2–109) stated that ''[t]o retailers * * * nitrox is marketed as a new profit center. In an industry with flat growth over the past few years, and where profit margins are small to begin with, nitrox * * * can be sold to the diving consumer as a 'safer' alternative to air, thus generating more profits * * * through the sale of classes and equipment specific to nitrox.'' Regarding diving safety, this commenter asserted that the high level of diving skills acquired by commercial divers made them safer than recreational diving instructors and diving guides, and referred to statistics from the Divers Alert Network (DAN) to support this assertion:

> [T]he statistics [for 1996] show that 0.2% of the reported accidents involved commercial divers, but 17.1% of the accidents involved Instructors or Divemasters (dive guides). The latter are the same two categories * * * who make up Dixie Diver's employees who would be exempt under the variance. In 1995, the numbers were 0.5% for commercial divers versus 15.9% for instructors[-] divemasters. In 1994, the numbers were 0.0% for commercial divers and 21.5% for instructors[-]divemasters.

The statistics cited by this commenter do not address the principal conditions specified in the permanent variance (*i.e.*, recreational diving instructors and diving guides who make no-decompression dives using nitrox breathing-gas mixtures). In a recent editorial in *Alert Diver* (Ex. 16, page 2), DAN's director (Dr. Peter B. Bennett) addressed the safety of nitrox dives made by recreational divers (which includes sports divers, as well as recreational diving instructors and diving guides). Dr. Bennett stated that ''[b]etween 1990 and 1993 DAN collected data on 21 cases of mixed-gas diving injuries. In 1994 there were 10, and in 1996, 16 injuries occurred. The 1996 data [are] based on 23 nitrox or mixed-gas injuries requiring recompression treatment. * * * The International Association of Nitrox and Technical Divers * * * certified 17,780 U.S. nitrox divers from 1985 to 1996.'' Based on this information, an average of less than 0.001 per cent of recreational divers who use nitrox breathing-gas mixtures are injured each year. Additionally, both Dr. Bennett (Ex. 16, pages 2 and 6) and other DAN representatives (Ex. 4A, page 60) admit that valid comparisons cannot be made between different categories of divers because adequate baseline data (e.g., the number and types of dives made by all divers in a category) are not available.

In conclusion, we believe that the protections afforded by the conditions specified in the permanent variance will reduce the prevalence of diving-related injuries among Dixie's recreational diving instructors (who also have substantial experience in using nitrox breathing-gas mixtures) below the already low injury rates cited in Dr. Bennett's editorial.

Part 6. Our Revisions to the Proposed Variance

(a) When divers use rebreathers, proposed Condition A.4 provided for a supplemental supply of breathable gas during emergency egress (referred to as the ''bail-out system''); this supply would consist of a diluent breathing gas connected to the second stage of the regulator. We have added a phrase to the permanent variance to address alternative means of emergency egress when open-circuit SCUBA provides the nitrox breathing-gas mixture. It allows Dixie to use the reserve breathing-gas supplies specified in paragraph (c)(4) of 29 CFR 1910.424 for this purpose. This alternative, specified in Condition (30)(b)(i) in the permanent variance, is an existing requirement for open-circuit SCUBA.

When the bail-out system consists of a separate supply of emergency breathing gas, Condition A.1 of the proposed variance permitted Dixie to use air as the emergency breathing gas. The permanent variance retains this provision.

(b) Conditions A.5.a and A.5.b in the proposed variance specified the use of an information module that provides time, depth, ascent, and descent data to divers who use closed-circuit rebreathers, and time, ascent, and descent information to divers who use semi-closed-circuit rebreathers. Proposed Condition A.5.c required both types of rebreathers to have alarms or visual displays that warn the diver about excessive ascent and descent rates, as well as depth levels that are shallower than the ceiling-stop depth. While Dixie's recreational diving instructors and diving guides could use dive-decompression computers for this purpose, we believe that such computers are unnecessary because the divers will be diving within no-decompression limits, and the technical capability of dive-decompression computers exceeds the requirements of no-decompression dives. An information module that provides the divers with the specified dive information will permit them to remain within no-decompression limits and to descend and ascend the water column at the rates specified by the diving tables. We believe, therefore, that the information module will ensure that Dixie's divers remain as safe as they would if they used dive-decompression computers.

(c) Proposed Condition A.5.c also requires that, for both semi-closed-circuit and closed-circuit rebreathers, the information module must warn the diver of low battery voltage. As noted in Ex. 5 (page P–59), a partial or total electronic failure interferes with sensor and control systems and may have serious safety consequences for the diver. We believe that the diver's safety depends on properly-operating electrical power supplies and electrical and electronic circuits. Accordingly, we have revised the proposal by requiring that Dixie perform the following procedure: ''Before each day's diving operations, and more often when necessary, * * * ensure that the electrical power supplies and electrical and electronic circuits in each rebreather are operating as required by the rebreather manufacturer's instructions.'' Condition (12) of the permanent variance contains this revision.

(d) Proposed Conditions B.1 and G.1.c addressed O_2 sensor and control requirements for closed-circuit rebreathers. Conditions (13) through (17) in the permanent variance consolidate these requirements in a single location.

(e) For closed-circuit rebreathers, proposed Condition G.1.c specifies the use of O_2 sensors to assess the O_2 fraction in the breathing loop, while proposed Condition G.1.d requires Dixie to determine (i.e., calibrate) sensor accuracy according to the rebreather manufacturer's instructions. As noted in the proposal, maintaining accurate O_2 partial pressures in the breathing loop is critical to diver health and safety. To assure safe operation of O_2 sensors, we believe that the permanent variance must specify the frequency for assessing the accuracy of O_2 sensors. Such an approach is consistent with the rebreather community's use of regular diving-equipment assessments (see Ex.5, pages 4–1 through 4–13, and 14–2). Condition (15) of the permanent variance, therefore, requires that ''[b]efore each day's diving operations, and more often when necessary, [Dixie] must calibrate O_2 sensors as required by the sensor manufacturer's instructions[.]'' Removing inaccurate O_2 sensors from service and replacing them with correctly-calibrated sensors is a logical and expected consequence of the calibration process; we are specifying this requirement in Conditions (15)(d) and (15)(e) of the permanent variance.

(f) Proposed Condition G.1.c accepted O_2 sensors only if they were electromechanical. Evidence in the record (Ex. 5, page 5–11) indicates that O_2-sensor technology is undergoing continued development and refinement. We believe, therefore, that specifying ''electromechanical'' O_2 sensors is too limiting, and we have revised this provision to specify that Dixie must use O_2 sensors approved by the rebreather manufacturer (see Condition (14)(b) in the permanent variance).

(g) Condition G.1.d in the proposed variance required Dixie to maintain the accuracy of the equipment used to analyze O_2 in the breathing-gas mixture ''in accordance with the manufacturer's instructions.'' We intended this requirement to apply to the analytic equipment used both to calibrate O_2 sensors and to determine the O_2 fraction in nitrox breathing-gas mixtures. To clarify this intention, we have included the requirement separately in Conditions (15)(b) and (22)(b) in the permanent variance.

(h) We have clarified the provision in proposed Condition G.2.a that addressed the analysis of O_2 in nitrox breathing-gas mixtures obtained from commercial suppliers. This revision requires Dixie to ensure that the supplier of the mixture analyzes the O_2 fraction in the mixture in the charged tank after disconnecting the tank from the charging apparatus. This clarification prevents the supplier from using the O_2 sensor on the charging apparatus for this purpose, a procedure that could result in an incorrect determination. The revised provision is in Condition (23)(b) of the permanent variance.

(i) Proposed Conditions K.3 and K.4 required that Dixie maintain a diving log and decompression tables at the dive site. The diving log documents the critical dive parameters. Divers who do not use dive-decompression computers must use the decompression tables; the tables also serve as a back-up resource to divers with dive-decompression computers. We have revised the proposed conditions to ensure that Dixie maintains a diving log and decompression tables at the dive sites for all diving operations covered by the permanent variance, whether or not its divers use a dive-decompression computer. The revised provision also clarifies that the decompression tables must be hard copies and conform to the no-decompression limits specified in Condition (28) of the permanent variance. Condition (37) of the permanent variance contains the revised requirements.

(j) Regarding the term ''portable oxygen,'' proposed Condition M specified that ''the oxygen shall be available for administration to the diver during the entire period the diver is being transported to a decompression chamber.'' The O_2 supplied for this purpose must be pure O_2, and the injured diver must receive the O_2 continuously from the time Dixie detects the diving-related medical emergency until the diver begins treatment in a decompression chamber. We have revised the proposal to clarify these requirements. Therefore, Condition (33) in the permanent variance requires Dixie to ensure that the portable O_2 equipment supplies pure O_2 to the injured diver's transparent mask, and that sufficient O_2 is available to treat injured divers until they reach a decompression chamber.

(k) In the proposed variance, one provision (Condition G.1.d) required Dixie to maintain the accuracy of the equipment used to analyze the O_2 fraction of the breathing gas ''in accordance with the manufacturer's instructions.'' To clarify which manufacturer is being addressed in this provision, we revised the relevant conditions of the permanent variance (Conditions (15)(b) and (22)(b)) to refer specifically to the manufacturer of the O_2 analyzer (who seems to us to be in the best position to specify how its O_2 analyzer should be calibrated). We have made similar revisions to other provisions of the permanent variance, including Condition (9) (which specifies calibration requirements for CO_2 sensors) and to Condition (15) (which specifies the calibration requirement for O_2 sensors).

The permanent variance contains a general requirement (Condition (3)) to use rebreathers according to the manufacturer's instructions. We repeat this requirement in several other important conditions of the permanent variance. We have added this provision because SCUBA manufacturers select and develop the characteristics and parameters of SCUBA equipment, design and integrate the equipment accordingly, procure or manufacture the equipment components, and then assemble and test the final products. There is a wide range of SCUBA designs and capabilities, and there are no uniform standards for the design, function, and use of SCUBA. We believe, therefore, that the SCUBA manufacturer is in the best position to specify the components, configuration, and operation of its product. In addition, the rebreather conference held recently in Redondo Beach, California, recommended that ''[m]anufacturers must provide written procedures, pre and post dive checklists, and a schedule for required maintenance.'' The SCUBA manufacturers who attended the conference endorsed this recommendation (see Ex. 5, page 14–2).

V. Decision

Dixie Divers, Inc. seeks a permanent variance from the decompression-chamber requirements of paragraphs (b)(2) and (c)(3)(iii) of 29 CFR 1910.423 and paragraph (b)(1) of 29 CFR 1910.426. These provisions require an employer to have a decompression chamber available and ready for use at the dive site to treat two diving-related medical emergencies that employees may experience—decompression sickness (DCS) and arterial-gas embolism (AGE). Divers may develop DCS after decompressing inadequately during dives in which they breathe a mixed gas (*e.g.,* nitrox). AGE results from overpressurizing the lungs, usually during a rapid ascent to the surface; overpressurization causes the air sacs in the lungs to rupture and disperse bubbles into the pulmonary veins.

These decompression-chamber provisions require employers to ensure that: Employees remain awake and in the vicinity of a decompression chamber for at least one hour after the dive whenever they make no-decompression dives, dive to depths deeper than 100 feet of sea water, or use a mixed-gas breathing mixture (paragraph (b)(2) of 29 CFR 1910.423); and a decompression chamber is located within five minutes from the dive site and is ready for use (paragraph (c)(3)(iii) of 29 CFR 1910.423 and paragraph (b)(1) of 29 CFR 1910.426).

In its variance application, Dixie stated that nitrox breathing-gas mixtures reduce the occurrence and severity of DCS, while the equipment and procedural safeguards specified in the variance application lower the risk of AGE. (See section II, ''Application for a Permanent Variance,'' of this notice for a thorough review of Dixie's variance application.) Dixie asserted that the risk of DCS and AGE for divers who use the SCUBA equipment and diving procedures proposed in the variance application would be equal to, or less than, that experienced by divers exempted from our CDO Standard. This exemption, specified in paragraph (a)(2)(i) of 29 CFR 1910.401, applies to recreational diving instructors who use compressed air supplied to open-circuit SCUBAs under no-decompression diving limits. Dixie concluded, therefore, that we should not require it to maintain a decompression chamber at the dive site if it complies with the conditions proposed in the variance application.

After reviewing the variance application, comments made to the record about the application, and other technical and scientific information submitted to the record, we have revised the proposed variance to require Dixie to use specific procedures and equipment safeguards for its divers when they engage in recreational diving instruction and perform services as diving guides. Therefore, under § 6(d) of the OSH Act, and based on the record discussed above, we find that when Dixie complies with the conditions of the following order, its divers will be exposed to working conditions that are at least as safe and healthful as they would be if Dixie complied with paragraphs (b)(2) and (c)(3)(iii) of 29 CFR 1910.423 and paragraph (b)(1) of 29 CFR 1910.426.

VI. Order

We issue this order authorizing Dixie Divers, Inc. to comply with the following conditions instead of complying with paragraphs (b)(2) and (c)(3)(iii) of 29 CFR 1910.423 and paragraph (b)(1) of 29 CFR 1910.426:

Application of the Permanent Variance

(1) This permanent variance applies only to the recreational diving instructors and diving guides (''divers'') employed by Dixie Divers, Inc. (designated as ''you'' or ''your'') when your:

(a) Recreational diving instructors train diving students in the use of recreational diving procedures and the safe operation of diving equipment, including open-circuit, semi-closed-circuit, or closed-circuit self-contained underwater breathing apparatus (SCUBA) during these training dives;

(b) Diving guides lead small groups of trained sports divers who use open-circuit, semi-closed-circuit, or closed-circuit SCUBAs to local undersea diving locations for recreational purposes; and

(c) Divers use a nitrox breathing-gas mixture consisting of a high percentage of oxygen (O_2) (i.e., over 22 percent (22%) by volume) mixed with nitrogen and supplied by an open-circuit, semi-closed-circuit, or closed-circuit SCUBA.

(2) This permanent variance does not apply when your divers engage in diving activities other than recreational diving instruction or diving guide duties.

Equipment Requirements for Rebreathers

(3) You must ensure that your divers use rebreathers (*i.e.,* semi-closed-circuit and closed-circuit SCUBAs) in accordance with the rebreather manufacturer's instructions.

(4) Regarding CO_2-sorbent materials in canisters:

(a) You must ensure that each rebreather uses a manufactured (i.e., commercially pre-packed), disposable scrubber cartridge containing a CO_2-sorbent material that:

(i) Is approved by the rebreather manufacturer;

(ii) Removes CO_2 from your divers' exhaled gas; and

(iii) Maintains the CO_2 level in the breathable gas (*i.e.,* the gas that your divers are inhaling directly from the regulator) below a partial pressure of 0.01 atmospheres absolute (ATA); or

(b) You may use an alternative scrubber method if:

(i) The rebreather manufacturer permits such use;

(ii) You use the alternative method according to the rebreather manufacturer's instructions; and

(iii) You demonstrate that the alternative method meets the requirements specified above in Condition (4)(a) of this order.

(5) You must ensure that each rebreather has a counterlung that supplies a volume of breathing gas to your divers that is sufficient to sustain their respiration rate and contains an over-pressure valve.

(6) You must ensure that each rebreather uses a moisture trap in the breathing loop, and that the moisture trap and its location in the breathing loop are approved by the rebreather manufacturer.

(7) You must ensure that each rebreather has a continuously-functioning moisture sensor that connects to a visual (e.g., digital, graphic, or analog) or auditory (e.g., voice, pure tone) alarm that warns your divers of moisture in the breathing loop in sufficient time to terminate the dive and return safely to the surface.

(8) You must ensure that each rebreather contains a continuously-functioning CO_2 sensor in the breathing loop, and that the CO_2 sensor and its location in the breathing loop are approved by the rebreather manufacturer. You must also integrate the CO_2 sensor used in a rebreather with an alarm that:

(a) Operates in a visual (e.g., digital, graphic, or analog) or auditory (e.g., voice, pure tone) mode;

(b) Is readily detectable by your divers under the diving conditions in which they operate; and

(c) Remains continuously activated when the inhaled CO_2 level reaches and exceeds 0.005 ATA.

(9) Before each day's diving operations, and more often when necessary, you must calibrate the CO_2 sensor according to the sensor manufacturer's instructions. In doing so, you must:

(a) Ensure that the equipment and procedures used to perform this calibration are accurate to within 10 percent (10%) of a CO_2 concentration of 0.005 ATA or less;

(b) Maintain this accuracy as required by the sensor manufacturer's instructions;

(c) Ensure that the calibration of the CO_2 sensor demonstrates an accuracy to within 10 percent (10%) of a CO_2 concentration of 0.005 ATA or less;

(d) Replace the CO_2 sensor when it fails to meet the accuracy requirements specified above in Condition (9)(c) of this order; and

(e) Ensure that the replacement CO_2 sensor meets the accuracy requirements specified above in Condition (9)(c) of this order before you place a rebreather in operation.

(10) As an alternative to using a continuously-functioning CO_2 sensor, you may use schedules for replacing CO_2-sorbent material provided by the rebreather manufacturer. You may use these CO_2-sorbent replacement schedules only if:

(a) The rebreather manufacturer has:

(i) Developed the replacement schedules according to the canister-testing protocol provided below in Appendix A of this order;

(ii) Analyzed the canister-testing results using the statistical procedures described in U.S. Navy Experimental Diving Unit Report 2–99 (see section VII (''References'') below); and

(iii) Specified the replacement schedule in terms of the lower prediction line (or limit) of the 95% prediction interval. In this regard, the rebreather manufacturer may derive replacement schedules by interpolating among, but not by extrapolating beyond, the depth, water temperatures, and exercise levels used during canister testing; and

(b) You replace the CO_2-sorbent material in the canister as required by Condition (4) of this order.

(11) You must ensure that each rebreather has an information module that provides:

(a) Visual (*e.g.,* digital, graphic, or analog) or auditory (*e.g.,* voice, pure tone) displays that will effectively warn your divers of solenoid failure (when the rebreather uses solenoids) and other electrical weaknesses or failures (*e.g.,* low battery voltage);

(b) For semi-closed circuit rebreathers, visual displays for the partial pressure of CO_2, or deviations above and below a preset CO_2 partial pressure of 0.005 ATA; and

(c) For closed-circuit rebreathers:

(i) Visual displays for the partial pressures of O_2 and CO_2, or deviations above and below a preset CO_2 partial pressure of 0.005 ATA and a preset O_2 partial pressure of 1.40 ATA; and

(ii) A visual display for the gas temperature in the breathing loop.

(12) Before each day's diving operations, and more often when necessary, you must ensure that the electrical power supplies and electrical and electronic circuits in each rebreather are operating as required by the rebreather manufacturer's instructions.

Special Requirements for Closed-Circuit Rebreathers

(13) You must ensure that closed-circuit rebreathers use supply-pressure sensors for the O_2 and diluent (i.e., air or nitrogen) gases and continuously-functioning sensors for detecting temperature in the inhalation side of the gas-loop and the ambient water.

(14) You must ensure that:

(a) At least two O_2 sensors are located in the inhalation side of the breathing loop;

(b) The O_2 sensors are continuously-functioning, temperature-compensated, and approved by the rebreather manufacturer.

(15) Before each day's diving operations, and more often when necessary, you must calibrate O_2 sensors as required by the sensor manufacturer's instructions. In doing so, you must:

(a) Ensure that the equipment and procedures used to perform the calibration are accurate to within 1 percent (1%) of the O_2 fraction by volume;

(b) Maintain this accuracy as required by the manufacturer of the calibration equipment;

(c) Ensure that the sensors are accurate to within 1 percent (1%) of the O_2 fraction by volume;

(d) Replace O_2 sensors when they fail to meet the accuracy requirements specified above in Condition (15)(c) of this order; and

(e) Ensure that the replacement CO_2 sensors meet the accuracy requirements specified above in Condition (15)(c) of this order before you place a rebreather in operation.

(16) You must ensure that closed-circuit rebreathers have:

(a) A gas-controller package with electrically-operated solenoid O_2-supply valves;

(b) A pressure-activated regulator with a second-stage diluent-gas addition valve;

(c) A manually-operated gas-supply bypass valve to add O_2 or diluent gas to the breathing loop; and

(d) Separate O_2 and diluent-gas cylinders to supply the breathing-gas mixture.

O_2 Concentration in the Breathing Gas

(17) You must ensure that the fraction of O_2 in the nitrox breathing-gas mixture:

(a) Is greater than the fraction of O_2 in compressed air (i.e., exceeds 22 percent (22%) O_2 by volume);

(b) For open-circuit SCUBA, never exceeds a maximum fraction of breathable O_2 of 40 percent (40%) by volume or a maximum O_2 partial pressure of 1.40 ATA, whichever exposes your divers to less O_2; and

(c) For rebreathers, never exceeds a maximum O_2 partial pressure of 1.40 ATA.

Depth and O_2 Partial Pressure Limits

(18) Regardless of the diving equipment your divers use, you must ensure that they dive no deeper than 130 feet of sea water (fsw) or to a maximum O_2 partial pressure of 1.40 ATA, whichever exposes them to less O_2.

(19) Regarding O_2 exposure, you must:

(a) Ensure that the exposure of your divers to partial pressures of O_2 between 0.60 and 1.40 ATA does not exceed the 24-hour single-exposure time limits specified either by the 1991 National Oceanic and Atmospheric Administration Diving Manual (the ''1991 NOAA Diving Manual'') or by the report entitled *Enriched Air Operations and Resources Guide,* published in 1995 by the Professional Association of Diving Instructors (known commonly as the ''1995 DSAT Oxygen Exposure Table'') (see section VII (''References'') below); and

(b) Determine your diver's O_2-exposure duration using the diver's maximum O_2 exposure (partial pressure of O_2) during the dive and the total dive time (*i.e.,* from the time the diver leaves the surface until the diver returns to the surface).

Mixing and Analyzing the Breathing Gas

(20) You must ensure that only properly trained personnel mix nitrox breathing gases, and that nitrogen is the only inert gas used in the breathing-gas mixture.

(21) When mixing nitrox breathing gases, you must mix the appropriate breathing gas before you deliver the mixture to the breathing-gas cylinders, using the continuous-flow or partial-pressure mixing techniques specified in the 1991 NOAA Diving Manual, or using a filter-membrane system.

(22) Before the start of each day's diving operations, you must determine the O_2 fraction of the breathing-gas mixture using an O_2 analyzer. In doing so, you must:

(a) Ensure that the O_2 analyzer is accurate to within 1 percent (1%) of the O_2 fraction by volume; and

(b) Maintain this accuracy as required by the manufacturer of the analyzer.

(23) When the breathing gas is a commercially-supplied nitrox breathing-gas mixture, you must ensure that the supplier:

(a) Determines the O_2 fraction in the breathing-gas mixture using an analytic method that is accurate to within 1 percent (1%) of the O_2 fraction by volume;

(b) Makes this determination when the mixture is in the charged tank and after disconnecting the charged tank from the charging apparatus;

(c) Documents the O_2 fraction in the mixture; and

(d) Provides you with a written certification of the O_2 analysis.

(24) For commercially-supplied nitrox breathing-gas mixtures, you must ensure that the O_2 is Grade A (also known as ''aviator's oxygen'') or Grade B (referred to as ''industrial-medical oxygen''), and meets the specifications, including the purity requirements, found in the 1991 NOAA Diving Manual. In doing so, you must:

(a) Ensure that the analytic method used to make this determination is accurate to within 1 percent (1%) of the O_2 fraction by volume; and

(b) Obtain a written certificate to this effect from the supplier.

(25) Before producing nitrox breathing-gas mixtures using a compressor in which the gas pressure in any system component exceeds 125 pounds per square inch (psi), you must:

(a) Have the compressor manufacturer certify in writing that the compressor is suitable for mixing high-pressure air with the highest O_2 fraction used in the nitrox breathing-gas mixture;

(b) Ensure that the compressor is oil-less or oil-free and rated for O_2 service unless you comply with the requirements of Condition (26) of this order; and

(c) Ensure that the compressor meets the requirements specified in paragraphs (i)(1) and (i)(2) of 29 CFR 1910.430 whenever the highest O_2 fraction used in the mixing process exceeds 40 percent (40%).

(26) Before producing nitrox breathing-gas mixtures using an oil-lubricated compressor to mix high-pressure air with O_2, regardless of the

gas pressure in any system component you must:

(a) Have the compressor manufacturer certify in writing that the compressor is suitable for mixing the high-pressure air with the highest O_2 fraction used in the nitrox breathing-gas mixture;

(b) Filter the high-pressure air to produce O_2-compatible air;

(c) Have the filter-system manufacturer certify in writing that the filter system used for this purpose is suitable for producing O_2-compatible air;

(d) Continuously monitor the air downstream from the filter for hydrocarbon contamination; and

(e) Use only uncontaminated air (i.e., air containing no hydrocarbon particulates) for the nitrox breathing-gas mixture.

(27) You must ensure that diving equipment using nitrox breathing-gas mixtures or pure O_2 under high pressure (i.e., exceeding 125 psi) conforms to the O_2-service requirements specified in paragraphs (i)(1) and (i)(2) of 29 CFR 1910.430.

Use No-Decompression Limits

(28) For diving conducted while using nitrox breathing-gas mixtures, you must ensure that each of your divers remains within the no-decompression limits specified for single and repetitive air diving and published in the 1991 NOAA Diving Manual or the report entitled *Development and Validation of No-Stop Decompression Procedures for Recreational Diving: The DSAT Recreational Dive Planner,* published in 1994 by Hamilton Research Ltd. (known commonly as the ''1994 DSAT No-Decompression Tables'') (see section VII (''References'') below).

(29) You may permit your divers to use a dive-decompression computer designed to regulate decompression if the dive-decompression computer uses the no-decompression limits specified above in Condition (28) of this order and provides output that reliably represents those limits.

Emergency Egress

(30) Regardless of the diving equipment your divers use (i.e., open-circuit SCUBA or rebreathers), you must ensure that the diving equipment consists of:

(a) An open-circuit emergency-egress system (a ''bail-out'' system) in which:

(i) The second stage of the regulator connects to a separate supply of emergency breathing gas; and

(ii) The emergency breathing gas consists of air or the same nitrox breathing-gas mixture used during the dive; or

(b) One of the following alternative bail-out systems:

(i) For open-circuit SCUBAs, the emergency-egress systems specified in paragraph (c)(4) of 29 CFR 1910.424; or

(ii) For semi-closed-circuit and closed-circuit rebreathers, a system configured so that the second stage of the regulator connects to a diluent supply of emergency breathing gas.

(31) You must ensure that the bail-out system performs reliably and provides sufficient emergency breathing gas to enable your diver to terminate the dive and return safely to the surface.

Diving-Related Medical Emergencies

(32) Before each day's diving operations, you must ensure that:

(a) A hospital, qualified health-care professionals, and the nearest Coast Guard Coordination Center (or an equivalent rescue service operated by a state, county, or municipal agency) are available for diving-related medical emergencies;

(b) These treatment resources are available when you notify them of the diving-related medical emergency;

(c) A list of telephone or call numbers for these health-care professionals and facilities is readily available at the dive site; and

(d) Transportation to a suitable decompression chamber is readily available when no decompression chamber is at the dive site, and that this transportation can deliver your injured diver to the decompression chamber within two (2) hours travel time from the dive site.

(33) You must ensure that portable O_2 equipment is available at the dive site to treat your injured divers. In doing so, you must ensure that:

(a) This equipment delivers pure O_2 to a transparent mask that covers the injured diver's nose and mouth; and

(b) Sufficient O_2 is available for administration to the injured diver from the time you recognize the symptoms of a diving-related medical emergency until the injured diver reaches a decompression chamber for treatment.

(34) Before each day's diving operations, you must:

(a) Ensure that at least two individuals, either employees or non-employees, qualified in first-aid and administering O_2 treatment are available at the dive site to treat diving-related medical emergencies; and

(b) Verify their qualifications for this task.

Diving Logs and Decompression Tables

(35) You must maintain a diving log at the dive site and ensure that:

(a) Before starting each day's diving operations, the individual who verifies the availability of the treatment resources required above under Condition (32) of this order makes a signed entry to this effect in the diving log; and

(b) The diving log contains the following information for each dive:

(i) The time when the diver left the surface, left the bottom, and returned to the surface;

(ii) The maximum depth of the dive; and

(iii) If a diver uses a dive-decompression computer, the name of the manufacturer and the model and serial numbers.

(36) Before starting each day's diving operations, you must:

(a) Designate an employee or a non-employee to make the entries in the diving log; and

(b) Verify that the designee understands the:

(i) Diving and medical terminology required to make proper entries; and

(ii) Procedures for making entries in the diving log.

(37) You must ensure that a hard-copy of the decompression tables used for the dives (as specified above in Condition (28) of this order) is readily available at the dive site, whether or not your divers use dive-decompression computers.

Diver Training

(38) You must ensure that your divers receive training that enables them to perform their work safely and effectively while using open-circuit SCUBAs or rebreathers supplied with nitrox breathing-gas mixtures. Accordingly, your divers must be able to perform critical tasks safely and effectively, including, but not limited to:

(a) Recognizing the effects of breathing excessive CO_2 and O_2;

(b) Taking appropriate action after detecting the effects of breathing excessive CO_2 and O_2; and

(c) Properly evaluating, operating, and maintaining their diving equipment under the diving conditions they encounter.

The Order: Notification and Duration

(39) You must notify the divers affected by this order using the same means that you used to inform them of the variance application.

(40) This order remains effective until modified or revoked under section 6(d) of the Occupational Safety and Health Act of 1970.

Appendix A (Mandatory).—Testing Protocol for Determining the CO_2 Limits of Rebreather Canisters

If the employer replaces CO_2-sorbent material using a schedule provided by the rebreather manufacturer (hereafter, manufacturer), then the employer must ensure that the manufacturer developed the schedule according to the protocol specified below in this appendix. The employer must also: Use only the CO_2-sorbent material specified by the manufacturer (and that is consistent with the requirements of Condition 10(b)(ii) of this order); ensure that the manufacturer analyzes the canister-duration results using the statistical analysis specified in U.S. Navy Experimental Diving Unit (NEDU) Report 2–99 (see Section VII (''References'') of the permanent variance); and ensure that the manufacturer specifies the replacement schedule in terms of the lower prediction line (or limit) of the 95% prediction interval.

1. The manufacturer must use the following procedures to ensure that the CO_2-sorbent material meets the specifications of the material's manufacturer: NATO CO_2 absorbent-activity test; RoTap shaker and nested sieves to determine granule-size distribution; NEDU-derived Schlegel test to assess friability; and NEDU's MeshFit software to evaluate mesh size conformance to specifications.

These procedures involve a quality-control assessment of the CO_2-sorbent material. Canister durations are suspect if these procedures indicate that the CO_2-sorbent material used in canister testing either exceeds or falls below the specifications provided by the material's manufacturer. Therefore, for the purposes of this canister-testing protocol, rebreather manufacturers must use only CO_2-sorbent materials that meet the specifications provided by the material's manufacturer.

2. While operating the rebreather at a maximum depth of 130 feet of sea water (fsw), the manufacturer must use a breathing machine to continuously ventilate the rebreather with breathing gas that is at 100% humidity and warmed to a temperature of 98.6 degrees F (37 degrees C) in the heating-humidification chamber. The breathing gas must be a nitrox mixture, with the oxygen (O_2) fraction maintained at 0.28 (equivalent to 1.4 ATA of O_2 at 130 fsw, the maximum O_2 concentration permitted at this depth by the permanent variance); the manufacturer must measure the O_2 concentration of the inhalation breathing gas delivered to the mouthpiece.

3. The manufacturer must test canisters using the following three ventilation rates (with required breathing-machine tidal volumes and frequencies, and CO_2-injection rates, provided for each ventilation rate):

Ventilation rates (liters/min., ATPS [1])	Breathing-machine tidal volumes (liters)	Breathing machine frequencies (breaths per min.)	CO_2–injection rates (liters/min., STPD [2])
22.5	l.5	15	0.90
40.0	2.0	20	1.35
62.5	2.5	25	2.25

[1] ATPS means ambient temperature and pressure, saturated with water.

[2] STPD means standard temperature and pressure, dry; the standard temperature is 0 degrees C.

The manufacturer must perform the CO_2 injection at a constant (steady) and continuous rate during each testing trial. An employer cannot use a rebreather at a work rate higher than the work rates simulated in this testing protocol unless the manufacturer adds the appropriate combinations of ventilation-CO_2-injection rates to the protocol.

4. The manufacturer must determine canister duration using a minimum of four (4) water temperatures, including 40, 50, 70, and 90 degrees F (4.4, 10.0, 21.1, and 32.2 degrees C, respectively). An employer cannot use a rebreather at a water temperature that is lower than the minimum, or higher than the maximum, water temperature used in this testing protocol unless the manufacturer adds a lower or higher temperature to the protocol.

5. The manufacturer must monitor the breathing-gas temperature at the rebreather mouthpiece (at the ''chrome T'' connector) and ensure that this temperature conforms to the temperature of a diver's exhaled breath at the water temperature and ventilation rate used during the testing trial. (NEDU can provide the manufacturer with information on the temperature of a diver's exhaled breath at various water temperatures and ventilation rates, as well as techniques and procedures used to maintain these temperatures during the testing trials.)

6. Testing must consist of at least eight (8) testing trials for each combination of temperature and ventilation-CO_2-injection rates. (For example, eight testing trials at 40 degrees F using a ventilation rate of 22.5 lpm at a CO_2-injection rate of 0.90 liters/min.) While water temperature may vary slightly (± 2.0 degrees F or 1.0 degree C) between each of the eight testing trials, the manufacturer must maintain strict control of water temperature (± 1.0 degree F or 0.5 degree C) within each testing trial. The rebreather manufacturer must use the average temperature for each set of eight testing trials in the statistical analysis of the resulting data.

7. The testing-trial result is the time taken for the inhaled breathing gas to reach 0.005 ATA of CO_2. Using the canister-duration results from these testing trials, the rebreather manufacturer must: Analyze the canister-duration results using the repeated-measures statistics described in NEDU Report 2–99 (see Section VII (''References'') of the permanent variance); and specify the replacement schedule for CO_2-sorbent materials in terms of the lower prediction line (or limit) of the 95% confidence interval.

VII. References

This order cites the following references:

(1) National Oceanic and Atmospheric Administration (1991). NOAA Diving Manual: Diving for Science and Technology. U.S. Government Printing Office, Washington, D.C.

(2) Diving Science and Technology (1995). Analysis of Proposed Oxygen Exposure Limits for DSAT Oxygen Exposure Table Against Existing Database of Manned Oxygen Test Dives. Enriched Air Operations and Resource Guide. International PADI, Inc., Rancho Santa Margarita, California.

(3) R. W. Hamilton, R. E. Rogers, M. R. Powell, and R. D. Vann (1994). Development and Validation of No-Stop Decompression Procedures for Recreational Diving: The DSAT Recreational Dive Planner. Hamilton Research, Ltd., Tarrytown, New York.

(4) J. R. Clarke. ''Statistically Based CO_2 Canister Duration Limits for Closed-Circuit

Underwater Breathing Apparatus.'' U.S. Navy Experimental Diving Unit, Report 2–99, 1999.

Copies of these references are available from the Docket Office, Room N–2625, Occupational Safety and Health Administration, U.S. Department of Labor, 200 Constitution Avenue, NW, Washington, DC 20210; telephone (202) 693–2350 or fax (202) 693–1648.

VIII. Authority and Signature

The authority for this order is section 6(d) of the Occupational Safety and Health Act of 1970 (29 USC 655), Secretary of Labor's Order No. 6–96 (62 FR 111), and 29 CFR part 1905.

Signed at Washington, DC, this 9th day of December 1999.

Charles N. Jeffress,

Assistant Secretary of Labor.

[FR Doc. 99–32824 Filed 12–17–99; 8:45 am]

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