

that this equipment is free of ignition sources that could cause an O₂ explosion. As noted above in the discussion of proposed Condition 3(d)(iii), paragraphs (i)(1) and (i)(2) of § 1910.430 would reduce this risk by requiring employers to use diving equipment designed for O₂ service and to clean the equipment of flammable materials before such use.⁸

6. Use of No-Decompression Limits

(a) *No-decompression procedures.*

Under this proposed condition, employers must ensure that divers using nitrox breathing-gas mixtures remain within the no-decompression limits specified for single and repetitive air diving and published in the 2001 NOAA Diving Manual (see Section III below, Reference (1)) or the 1994 DSAT report entitled "Development and Validation of No-Stop Decompression Procedures for Recreational Diving: The DSAT Recreational Dive Planner" (see Section III below, Reference (3)). This proposed condition allows employers to use the no-decompression limits published in the 2001 NOAA Diving Manual or the 1994 DSAT no-decompression tables. OSHA intends to ensure that the divers using nitrox mixtures under the proposed alternative receive the same protection against DCS as is afforded to divers who use air. For this reason, the proposed condition requires that employers ensure that their divers never exceed the no-decompression limits published in either the 2001 NOAA Diving Manual or 1994 DSAT report; in determining these limits, employers must use the partial pressure of nitrogen in the nitrox breathing-gas mixture to derive the equivalent air depth for a specific dive duration (see Ex. 3–12, p. 15–7).

OSHA believes that by adopting these no-decompression limits, the proposed alternative would protect recreational diving instructors and diving guides at least as well as the use of compressed air supplied to open-circuit SCUBAs under no-decompression diving limits. The 1994 DSAT no-decompression limits have been determined to be reliable and valid, based on extensive laboratory and field testing, and have been widely accepted by both the diving and scientific communities (see Appendix E ("Comment and critique

from the field") of the 1994 DSAT report).

In determining its no-decompression limits for nitrox breathing-gas mixtures in its 2001 Diving Manual, NOAA applies the equivalent-air-depth ("EAD") formula. Divers using nitrox breathing-gas mixtures can use the EAD formula to determine accurately the no-decompression limits for different nitrogen partial pressures. NOAA applies its EAD formula in determining what equivalent air decompression limits to use with nitrox breathing-gas mixtures. The formula assumes that equivalent nitrogen partial pressures and dive durations will result in similar DCS risk to dives performed with air. OSHA believes that the NOAA 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 the record granting a permanent variance to Dixie, OSHA received evidence addressing the safety and efficacy of the EAD formula from Dr. Edward D. Thalmann (Ex. 2–7). 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. 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] EAD [formula]." Dr. Thalmann concluded that, within these constraints, "there is no rationale for having different requirements for * * * air and [n]itrox no-decompression diving." Based on Dr. Thalmann's comments, OSHA concludes that NOAA's EAD formula will translate accurately the partial pressure of nitrogen in a nitrox breathing-gas mixture to an equivalent air depth for a specific dive duration, and that employers can rely on this formula to determine safe no-decompression limits for their divers based on the equivalent air dives.

(b) *Dive-decompression computers.* This proposed condition permits employers to use dive-decompression computers designed to regulate decompression when the computers use the NOAA or DSAT no-decompression limits specified in proposed Condition 6(a) and provide output that reliably represents these limits. OSHA believes

that dive-decompression computers are unnecessary because the divers would be diving within no-decompression limits, and the technical capability of most dive-decompression computers exceeds the requirements of no-decompression dives. Nevertheless, the proposal would allow employers the flexibility to use either manual calculations or dive-decompression computers to determine the no-decompression schedules, with the use of dive-decompression computers for this purpose being optional. However, when employers choose to use these computers, they also must provide their diver with specific decompression information, and have a hard-copy of the appropriate decompression tables at the dive site (see proposed Condition 9(c) below). Thus, the proposal specifies the conditions that employers must meet to ensure that their employees' diving activities conform to accepted no-decompression practices, whether or not they use dive-decompression computers.

The Agency finds that restricting the no-decompression limits programmed into the computers to those limits published by the 2001 NOAA Diving Manual and the 1994 DSAT report would prevent employers from using the computers to provide alternate no-decompression limits that could place divers at higher risk for DCS. Operating under this constraint, OSHA concludes that computers may provide an advantage over manual calculations because manual calculations are subject to human error, and computers may reduce such error.

7. Emergency Egress

(a) *Bail-out system for all SCUBAs.*

For emergencies involving SCUBA malfunctions that could endanger diver health and safety (e.g., high CO₂ levels), proposed Condition 7(a) requires employers to equip their divers with a reliable emergency-egress system (i.e., a "bail-out system"). The bail-out system would contain a separate supply of breathing gas, which can include air. In addition, the bail-out system would provide the breathing gas to the second stage of the SCUBA regulator. Accordingly, the proposed bail-out system would provide divers with the capability to shift to a known, safe, and immediately available breathing gas, and to terminate the dive safely whenever a CO₂-related problem or other emergency occurs.

(b) *Alternative bail-out system for open-circuit SCUBA.* The proposal would provide an alternative to the bail-out for divers using open-circuit SCUBA. Accordingly, when open-

⁸In addition, employers must comply with other OSHA standards that ensure accurate mixing and decontamination (especially hydrocarbon removal) of nitrox breathing gases, and that employees are protected properly during these activities. These standards include the appropriate provisions of §§ 1910.101 ("Compressed gas (general requirements)") and 1910.169 ("Air receivers").