

by § 1910.401(a)(2)(i) must use compressed air supplied to open-circuit SCUBAs under no-decompression diving limits. Therefore, under the proposed alternative, the Agency would not require employers to maintain a decompression chamber at the dive site when they comply with the specified requirements because it believes that compliance with these requirements will reduce the risk of AGE and DCS to the minimal levels already experienced by recreational diving instructors covered by § 1910.401(a)(2)(i).

B. Alternative Conditions of Proposed Appendix C

Proposed Appendix C would be mandatory for any employer who uses the alternative means of compliance for recreational diving instructors and diving guides. The following section sets out the requirements in proposed Appendix C, and provides the rationale for each requirement.

1. Equipment Requirements for Rebreathers

(a) *Manufacturer's instructions.* Proposed Condition 1(a) requires employers to ensure that their recreational diving instructors and diving guides (hereafter, "divers") use rebreathers (*i.e.*, semi-closed circuit and closed-circuit SCUBA) according to the rebreather manufacturer's instructions. The manufacturers of these rebreathers 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. Accordingly, a wide range of SCUBA designs and capabilities are available, and no uniform standards govern the design, function, and use of this equipment. Therefore, OSHA believes that the SCUBA manufacturer is in the best position to identify and specify the components, configuration, and operation of its product, a position that several SCUBA manufacturers endorse (see Ex. 3–4, p. 14–2).

(b) *Counterlungs.* Under the proposed condition, employers must ensure that each rebreather has a counterlung (also referred to as an "inhalation bag" or "breathing bag") that supplies a sufficient volume of breathing gas to the divers to sustain their respiration rate, and that contains a baffle system that prevents moisture from entering the scrubber or breathing hoses. Counterlungs are low-breathing-resistance reservoirs that supply the nitrox breathing-gas mixture to a diver during inhalation; accordingly, the National Oceanic and Atmospheric

Administration (NOAA) considers counterlungs a necessity for rebreather diving (see Ex. 3–12, p. 14–3).

While the proposed condition does not specify a particular counterlung configuration, it would require that the counterlung have a minimum volumetric displacement sufficient to sustain a diver's respiration rate during diving operations. In this regard, OSHA believes that rebreather manufacturers currently provide this information as a usual and customary practice. Accordingly, the proposal would require the employer to ensure that its divers' rebreathers have adequate counterlung volume, and that their divers use the rebreathers according to the manufacturer's instructions. The employer of these divers is in the best position to determine the respiratory requirements associated with their diving operations, and to identify and select a rebreather based on these requirements.

The proposed condition also specifies that a rebreather must contain a baffle system that keeps moisture from entering the scrubber. Accordingly, the proposed baffle system would prevent rapid deterioration of the CO₂-sorbent material housed in the scrubber, thereby decreasing the risk of CO₂ toxicity (see Ex. 3–12, p. 14–8).

(c) *Moisture traps.* Proposed Condition 1(c) requires that the employer use a moisture trap in the breathing loop of each rebreather, and that both the moisture trap and its location in the breathing loop be approved by the rebreather manufacturer. Moisture traps are necessary to keep water out of the CO₂-absorbing canisters; when such water leakage occurs, it can substantially reduce the CO₂-absorbing properties of the sorbent material inside the canister. Evidence from the record of the Dixie Diver variance proceedings (Exs. 3–5, 3–6, and 3–7) indicates that moisture traps are available commercially and that existing rebreathers routinely use them.

(d) *Moisture sensors.* Under proposed Condition 1(d), employers 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 divers of moisture in the breathing loop in sufficient time to terminate the dive and return safely to the surface. Moisture sensors detect excessive water leakage into the canister that can compromise the CO₂-sorbent material; therefore, they supplement the information provided by CO₂ sensors (see proposed Condition 1(e) below). Therefore, moisture sensors warn divers

of hazardous water leakage into the canister, allowing them to return to the surface before CO₂ in the recycled breathing gas reaches dangerous levels. Information submitted in response to the Dixie's variance request (Ex. 3–7) indicates that moisture sensors are commercially available.

Rebreather manufacturers determine the appropriate design and location of moisture sensors and moisture traps for their products. The proposal requires employers to ensure that their divers use these components consistent with the rebreather manufacturer's instructions. The moisture sensor must alert the diver of moisture in the breathing loop in sufficient time to terminate the dive and return safely to the surface.

(e) *CO₂ sensors.* An important component in controlling excessive CO₂ is the CO₂ sensor. Proposed Condition 1(e) specifies that employers must ensure that each rebreather contains a continuously functioning CO₂ sensor in the breathing loop, and that the rebreather manufacturer has approved the CO₂ sensor and its location in the breathing loop. Additionally, employers must integrate this CO₂ sensor with an alarm that operates in a visual (*e.g.*, digital, graphic, or analog) or auditory (*e.g.*, voice, pure tone) mode, is readily detectable by divers under the diving conditions in which they operate, and remains continuously activated when the inhaled CO₂ level reaches and exceeds 0.005 atmospheres absolute ("ATA").¹

(f) *Calibrating CO₂ sensors.* To ensure that CO₂ sensors operate correctly, proposed Condition 1(f) states that employers must, before each day's diving operations (and more often when necessary) calibrate each CO₂ sensor according to the sensor manufacturer's instructions. In doing so, they are to maintain the accuracy of the equipment and procedures used to perform the calibration to within 10% of a CO₂ concentration of 0.005 atmospheres absolute or less according to the sensor manufacturer's instructions. Using this equipment, they must calibrate the CO₂ sensor to within 10% of a CO₂ concentration of 0.005 ATA or less.

(g) *Faulty CO₂ sensors.* When a sensor fails to meet this accuracy standard, proposed Condition 1(g) requires employers to replace the faulty sensor, and to ensure the accuracy of the

¹ ATA, as used in this notice, is the partial pressure of a constituent gas in the total pressure of a breathing gas. When the percentage of the constituent gas in the breathing gas remains constant throughout a dive, its partial pressure or ATA, increases in direct proportion to increases in diving depth.