WORKSAFE
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HSWA

TECHNICAL BULLETIN

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Breathing oxygen and enriched mixtures while diving

This bulletin provides guidance about the use of elevated partial pressures of oxygen and oxygen enriched mixtures when diving.

This technical bulletin clarifies whether the use of oxygen enriched mixtures and elevated partial pressures of oxygen (PPO_2) are suitable practice for an occupational diver.

What are oxygen enriched mixtures and elevated PPO_2?

An oxygen (O_2) enriched mixture is any breathable mixture of gases containing more than 21% oxygen.

The partial pressure of oxygen (PPO_2) in a breathing mixture increases in direct proportion to the absolute pressure (depth). For example, the PPO_2 of air at the surface is 0.2bar, but when it is breathed at 50m the PPO_2 elevates to 1.2bar.

The risk

When O_2 is breathed at elevated partial pressures it can have a toxic effect on the diver. Central nervous system (CNS) oxygen toxicity represents the greatest risk of oxygen use to a diver. It can cause a seizure underwater with little or no warning, leading to a loss of consciousness, drowning, and death.

Acceptable exposure levels

Breathing oxygen enriched mixtures and elevated partial pressures of oxygen can provide physical and operational benefits to divers.

In order to reduce the risk of CNS oxygen toxicity to as low as reasonably practical, international good practice guidelines recommend limiting a diver's working PPO_2 level to a maximum of 140kPa, or 1.4bar.

For in-water oxygen decompression, guidelines recommend limiting a resting free-swimming diver's PPO_2 level to a maximum of 160kPa, or 1.6bar.

For those divers undertaking established surface supplied breathing apparatus (SSBA) in-water oxygen decompression procedures, guidelines recommend limiting a resting diver's PPO_2 level to a maximum of 190kPa, or 1.9bar.

Other conditions (for example, duration of exposure, workload, cold, carbon dioxide retention, the diver's health and other factors) may also influence the risk of CNS oxygen toxicity.

The maximum exposure limit above is not intended to limit the use of 100% oxygen for specialised military systems, or where surface decompression on oxygen ($SurDO_2$) procedures may involve short periods breathing oxygen above 190kPa, or above 1.9bar, inside a hyperbaric chamber.

Recommendations

The use of oxygen and elevated PPO_2 gas mixtures should only be used by suitably qualified divers undertaking planned diving or decompression activities.

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Cylinders should be clearly marked in accordance with the Guide to Gas Cylinders and controls put in place to ensure other divers do not inadvertently breathe these mixtures.

Where it is appropriate for a diver to breathe elevated PPO_2 in-water, the following examples can be used as part of a suitable safety management plan:

- an SSBA helmet or band mask
- a full face mask incorporating an integrated mouthpiece and retaining straps design to ensure that the mask is held on the face at all times
- a normal dive mask with a separate mouthpiece that incorporates a neck/head strap and lip seal system designed to prevent water ingress in the event the diver becomes unconscious
- maintaining exposures within recommended exposure limits (for example, NOAA Oxygen Exposure Tables).

Not all examples above may be suitable for every location and dive operation.

Divers using oxygen enriched mixtures and elevated partial pressures of oxygen should be suitably trained in the gas mixtures being used and familiar with the procedures and systems in place prior to entering the water.

When breathing elevated PPO_2 during surface decompression the use of suitable Built-In-Breathing Systems (BIBS) for recompression chambers is recommended.

All equipment used with breathing mixtures other than air should be clean and compatible for the use with such mixtures (see the Guide to Gas Cylinders for additional information).

References

Oxygen and the diver (1992); Kenneth Donald; SPA in conjunction with K. Donald, University of California.

Vann RD, Hamilton RW. Central nervous system oxygen toxicity. In: Vann RD, Mitchell SJ, Denoble PJ, Anthony TG (editors). Technical diving. Proceedings of the Divers Alert Network 2008 Conference. Durham NC: Divers Alert Network. P. 38-66. Available from: www.diversalertnetwork.org

Further information

- WorkSafe occupational diving guidance
- WorkSafe Guide to Gas Cylinders

Acknowledgement

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