8.3.2 Cylinders

Specific requirements exist for cylinders containing EAN mixtures. Any cylinder containing EAN shall be a dedicated cylinder. Cylinders containing EAN should not be used to contain any gas other than EAN or oxygen-compatible air.

The cylinder shall—

(a) be colour-coded and marked in a distinguishable manner so as to ensure that there is no possibility of confusion regarding the contents of the cylinder;

(b) have a durable, non-removable adhesive label, visibly placed, which indicates that the cylinder and valve have been cleaned and inspected for use with EAN mixtures up to and including 40% oxygen by volume; and

(c) have a contents fill label indicating the—

(i) date of fill;

(ii) percentage of oxygen;

(iii) pressure; and

(iv) name of the person who analysed the gas in the cylinder.

NOTE: The marking of cylinders should include the word 'EAN' in letters not less than 50 mm high and in a contrasting colour to the body of the cylinder; however, other suitably identifiable words such as 'NITROX' may be used.

Cylinders which have previously contained air shall not be relabelled and used for oxygen-rich gases unless appropriate inspection, cleaning and filling procedures have been followed.

The adoption of a different valve system for air and EAN cylinders should be considered. Differentiation of valves may assist with the prevention of cross contamination.

8.3.3 Compressors

The compression of gases or gas mixtures intended for use with EAN, or the compression of air intended for use as oxygen-compatible air, shall not be generated using oil lubricants.

Compressors shall be capable of delivering air to meet the air purity requirements for oxygen-compatible air or EAN gas mixtures (Clause 4.4).

NOTE: Mineral oil lubricants are not compatible with high pressure or low pressure compressors used in EAN diving or in the compression of oxygen-compatible air.

8.3.4 Lubricants

Only oxygen-compatible lubricants shall be used in conjunction with any high pressure equipment used in EAN procedures.

NOTE: Silicone is not a safe lubricant to use in conjunction with elevated levels of oxygen.

8.4 EAN BREATHING GAS SUPPLY FOR SSBA

8.4.1 General

The general procedures and principles outlined in Clauses 6.5.2 to 6.5.5 shall be considered when planning an EAN dive.

8.4.2 Breathing gas supplies

8.4.2.1 *Primary and secondary EAN gas supplies*

Each diver shall breathe from a primary gas supply that is backed up by a secondary breathing gas supply of the same EAN composition. In the event of failure of the primary supply, the secondary supply shall enable the diver to be brought back to the surface, taking into account any decompression schedule that may be required.

When two divers are in the water at the same time, both the primary and secondary EAN gas supplies shall be individually capable of supporting both divers at the maximum depth of the dive. If one of the EAN gas supplies becomes unavailable, the dive shall be terminated immediately and the divers brought to the surface.

8.4.2.2 *Tertiary air gas supply*

Each diver shall have the ability to breathe from an oxygen-compatible air supply in the event of an oxygen toxicity emergency. Where two divers are in the water at the same time, consideration should be given to the provision of a primary and secondary oxygen-compatible air supply, i.e. two EAN (primary and secondary) and two oxygen-compatible air (primary and secondary).

A suitable means to ensure that the oxygen-compatible air supply cannot be accidentally turned on should be available.

8.4.2.3 *Emergency gas supply*

Each diver shall also carry an emergency gas supply (commonly known as a 'bail-out' cylinder) on their person. The emergency gas supply shall—

(a) have an oxygen concentration no greater than the diver's primary and secondary breathing gas supplies;

(b) be of sufficient capacity to enable the diver to return to the surface or a place of safety;

(c) not be used as a secondary gas supply; and

(d) be fitted with a submersible contents gauge.

8.4.3 Control system

8.4.3.1 *Gas control system*

The gas control system shall provide means for measuring the pressures of the primary, secondary and tertiary (where used) gas supplies and the diver's breathing gas supply. The gas control system shall include control valves and appropriate check and non-return valves. These shall be firmly mounted and arranged so that they can be easily and rapidly observed and operated.

NOTE: Where the tertiary gas supply is oxygen-compatible air there should be a suitable means to ensure that the oxygen-compatible air supply cannot be accidentally turned on.

8.4.3.2 *Control panel*

The dive panel and gas distribution system used shall be purpose built, designed and compatible for use with EAN operations.

The control panel(s) shall be constructed and labelled to provide a suitable primary, secondary and possibly tertiary diver supply, including a stand-by diver supply, and with the ability to provide gases in accordance with the employer's operational procedures.

The control panel used in an EAN diving operation shall be of such a design that—

(a) it meets the principles of design outlined in Clause 6.5.4.2;

(b) in the event of contamination or total failure of one EAN gas supply, both divers have the option of a second EAN supply;

(c) in the event of oxygen toxicity, both divers have the option of an oxygen-compatible air supply;

(d) in the event of a hose rupture between the supply and the panel, there will always be sufficient gas from the other supplies (alternate EAN or oxygen-compatible air) to safely return to the surface; and

(e) slow opening valves are used unless the pressure of the EAN entering the valve is less than 1500 kPa.

8.4.3.3 *Oxygen monitoring*

Continuous oxygen analysis of the mix supplied to the diver shall be provided using one or more oxygen analysers. Such analysers shall include a visual display of the oxygen content of the mix and an audio alarm.

8.4.4 Cleaning

All equipment used in conjunction with EAN shall be cleaned and stored in a method that is compatible with the use of elevated oxygen mixtures.

If any high pressure equipment is used in conjunction with non-oxygen-compatible air, the equipment shall be oxygen cleaned prior to use with gas containing oxygen levels greater than 21% by volume.

All high pressure equipment shall be clean of any visible contaminants. Only oxygen-compatible lubricants shall be used in conjunction with high pressure equipment.

Equipment cleaned and maintained for use with elevated levels of oxygen should be clearly labelled as such after cleaning.

8.5 SELECTING AN EAN MIX

Most tables provide guidance on the methodology for determining the most appropriate EAN mix. Tables should be consulted during dive planning to determine the most appropriate EAN mix for the planned dive.

The maximum partial pressure of oxygen to be breathed by a diver shall not exceed 140 kPa. See Clause 6.5.1 also for further information.

NOTE: The maximum partial pressure of oxygen being breathed by the diver may exceed 140 kPa during decompression (where undertaken in accordance with Clauses 3.11.1 to 3.11.3) or in military-type rebreather diving.

The recommended bottom time limits for various ppO_2 exposures are detailed in the tables and shall be adhered to.

All gases used in cylinder-supplied EAN operations shall be analysed upon filling and then, if stored, re-analysed when the gas source is connected to the gas delivery system. For SSBA diving using a low pressure compressor or a continuous mixing process, oxygen shall be continually monitored during operation, at the point of delivery.

8.6 PREPARATION OF EAN MIXTURES

8.6.1 General

EAN mixtures can be created by several methods. Due to the oxygen-rich nature of the mixtures, it is critical that operators understand and are suitably trained in the use of equipment, the cleanliness requirements for that equipment, and the process of mixing.

The fundamental process for the creation of EAN is the introduction of oxygen to air, or the removal of nitrogen from air. In either process, at some stage, the operator will be handling high pressure equipment with elevated oxygen levels.

Where EAN is being prepared or produced for a diving operation, that preparation or production shall be done in accordance with the organization's diving operations manual or a specific SWMS for the preparation of EAN.

The following clauses specify requirements for and provide information and guidance on some of the key aspects of the different methods of obtaining EAN.

More detailed information is available from a range of sources, including the current versions of the *NOAA Diving Manual* and the *US Navy Diving Manual*.

8.6.2 Validation of oxygen level in EAN mix

The percentage concentration of oxygen in an EAN mix is critical to the safety of the diver, in particular, to enable the calculation of the maximum safe depth allowable to avoid exceeding a partial pressure of 140 kPa oxygen. For mixtures obtained in cylinders from a third party, the oxygen level reported on the cylinder label shall be validated immediately prior to diving by analysing the oxygen content. Wherever EAN is continuously prepared for delivery directly to the diver via SSBA, robust, fail safe and redundant continuous oxygen analysis is required, with at least two analysers in use with audible alarms. Supply of SSBA divers with breathing gas fed to the dive panel from high pressure cylinders has the advantage of enabling the diver's gas to be validated prior to commencing the dive.

8.6.3 Pre-mix

Pre-mixed EAN is gas supplied from a commercial supplier which has previously been mixed to a specified percentage of oxygen. Gas mixed commercially is quite accurate in mixture, however, safe practice requires that it is also analysed prior to use.

This method of obtaining EAN is the simplest for the dive team and avoids the need to undertake any oxygen handling or maintain oxygen-handling equipment.

8.6.4 Blending compressed oxygen with air in cylinders

Cylinders can be filled with EAN by blending gas in the cylinder. This usually involves decanting a pre-calculated volume of oxygen into the empty cylinder from high pressure oxygen cylinders, followed by 'topping off' the EAN cylinder with oxygen-compatible air from a cylinder bank or directly from a compressor system designed for producing oil free air. As 100% oxygen passes into the cylinder at high pressure, it is essential that the cylinder and its valve are oxygen clean. Filling shall be slow to avoid excessive temperature rise. Experience is required for this process to be efficient and it is relatively slow, although a minimum of equipment is required.

8.6.5 Blending oxygen with compressed air prior to compression

EAN can be continuously mixed at atmospheric pressure by blending constant flows of oxygen from cylinders with oxygen-compatible air from a cylinder bank or from an oil free low pressure air compressor. Continuous oxygen analysis is required to confirm that the mixture obtained is as planned. The mixture thereby obtained can then be compressed for delivery to the diver, either directly via SSBA or via high pressure compression to fill SCUBA cylinders or SSBA supply cylinders.

8.6.6 Blending oxygen with ambient air prior to compression

Systems for blending oxygen with ambient air prior to compression are available. These systems are based on a mixing chamber mounted at the intake of a high pressure compressor, in which a constant flow of oxygen is blended with the ambient air being taken into the compressor. Although relatively simple, such systems are relatively susceptible to contamination of the mix from either intake contamination or degradation of compressor oils or filters. There shall be failure proof means to prevent high concentration oxygen being taken into the compressor with oxidation or explosion risks.

8.6.7 Continuous flow mixing of compressed gases

It is possible to continuously mix compressed oxygen and oxygen-compatible air at intermediate pressures suitable for passage directly to the diver via SSBA. This requires a highly accurate and reliable continuous flow mixing panel and continuous analysis of the gas composition. Such systems should allow for analyser failure or calibration 'drift' by incorporating two or more oxygen analysers.

8.6.8 Removing nitrogen from air

Nitrogen can be removed from air prior to final compression via use of either membrane separation or pressure swing absorption technologies. Both require a supply of low pressure compressed air. This low pressure air shall meet the standard of oxygen-compatible air in Clause 4.4.4. Both membrane systems and pressure swing systems can be used to supply either high pressure compressors or SSBA divers directly.

8.7 COMPRESSORS FOR EAN

When EAN passes through a compressor, the increased oxygen levels present in the gas increase the potential for oxidation of compressor materials or lubricants, as well as the potential for fire and explosion. Oxidized lubricants can have adverse health effects for the diver and, at high concentrations, can cause incapacitation underwater. Compressors shall only be used for EAN service if they have been approved by the manufacturer for EAN service and maintained in accordance with manufacturer's specifications. Low or high pressure compressors used for the compression of EAN shall be deemed suitable for the compression of EAN by the manufacturer and shall either be oil free in design or use EAN-compatible lubricant. The increased oxygen availability in EAN mixtures degrades most lubricants much faster than air does, resulting in the need for EAN-compatible lubricants and an increased frequency of oil changes. Older style mineral or organic oils are not suitable. Filter elements may also require an increased frequency of replacement. It is also important to note that additional diligence is needed to maintain the high standards of breathing gas purity required for EAN, especially if filter function or lifespan is diminished by high humidity or high temperature operation.

8.8 METHODS AND RECORDING OF GAS ANALYSIS

Accurate and reliable oxygen analysis is a key factor in safe EAN diving and all the technological and human factors involved shall be robust and reliable. Oxygen analysers shall be suitable for the purpose, and maintained and calibrated in accordance with the manufacturer's guidelines. When an EAN mix is transferred into a cylinder, the cylinder shall be labelled with the oxygen content, the date and their identity in accordance with Clause 8.3.2. On-site analysis by the dive team shall be performed by a competent person, preferably under the direct supervision of another person, such as the dive supervisor or the diver who will use the gas mixture. The source of the EAN mixture and the time, date and results of on-site gas analysis shall be recorded in the dive log.

SECTION 9 ACCIDENT REPORTING

9.1 ACCIDENT REPORT

All accidents and incidents shall be recorded and the reports retained.

NOTES:

1 Reports need to be made and retained in accordance with the relevant regulatory requirements. Reference should be made to the relevant regulatory authority for the requirements for reporting accidents and incidents.

2 Employers may be required by legislation to report all lost-time injuries, or serious incidents where no injury has occurred, to the relevant regulatory authority.

9.2 INVESTIGATION OF ACCIDENTS AND INCIDENTS

The employer shall investigate and document all diving-related incidents, accidents and injuries. Appropriate action to prevent further occurrences shall then be taken. This shall be done in consultation with employees and their representatives. The investigation report shall contain the following:

(a) A summary of all aspects of the event occasioning the injury or death, specifying—

  (i) the name and address of the injured diver;

  (ii) the date, location and time of the incident;

  (iii) details of the diving experience of the injured diver, if injured whilst diving;

  (iv) full details of the incident and cause (if known) or possible contributing factors;

  (v) the nature of the injury sustained by the diver; and

  (vi) the supervisor's recommendations to prevent a recurrence.

(b) Full narrative statements from all persons (including the supervisor, diver and diver's attendant) engaged in the relevant diving operation and who can detail any information pertinent to the occurrence of the incident.

(c) Such medical reports, in relation to the diver, as are available, being reports compiled both before and after the occurrence of the incident.

(d) Full details of the type of diving apparatus used by the diver, in particular noting the condition of such equipment immediately after the incident including, in the appropriate case—

  (i) whether cylinder valves were opened or closed and to what extent;

  (ii) remaining pressures in cylinder;

  (iii) the position of the emergency supply valve; and

  (iv) the type of breathing gas used.

In any case, where component malfunction was likely or was suspected to have been a likely cause of a serious accident, then this equipment should be immediately sealed.

In any case where a fatality has occurred, all equipment should be left in the condition that it was in at the time of the accident until it has been investigated by the relevant authorities.

Notwithstanding the above, the breathing gas supply should be isolated to retain the remaining gas. During such isolation, the number of turns, and any undue force or other actions required to isolate the gas supply shall be noted and recorded.

SECTION 10 MEDICAL REQUIREMENTS

10.1 INTRODUCTION

Since diving involves work under increased pressure and in a non-respirable environment, specific medical requirements apply with respect to the examination of occupational divers and those intending to undertake training for occupational diving.

NOTE: There are specific legislative requirements relating to occupational diver medical examinations in Australia and New Zealand. (See Appendix A for a list of relevant regulatory authorities.)

The medical requirements documented below are aimed at providing a minimum standard for occupational diving.

NOTE: Medical standards designed for recreational SCUBA divers are usually insufficient for occupational diving but may provide medical practitioners with useful guidance on specific medical conditions. The website of the South Pacific Underwater Medicine Society provides access to a current Australasian perspective on medical fitness to dive: http://www.spums.org.au/public-file-download/full-spums-medical.

10.2 MEDICAL ASSESSMENT

10.2.1 General

A comprehensive health evaluation and diving fitness assessment shall be conducted before the diver commences occupational diving or occupational diving training. Reassessment and ongoing health monitoring shall be undertaken at annual intervals thereafter in the case of a diver continuing to dive. No more than 12 months shall have passed between the most recent medical assessment and any dive that is undertaken. Where the assessing medical practitioner determines that earlier reassessment is necessary, diving shall not be undertaken until that reassessment has occurred.

10.2.2 Candidate

The minimum age for an occupational diver shall be 18 years. Prior to the medical examination, all divers and prospective divers shall complete a detailed, diving-fitness-specific medical questionnaire which will assist the examining medical practitioner in ensuring that all relevant history has been obtained and documented appropriately.

The Occupational Diving Medical Examination—Medical Questionnaire reproduced in Appendix L of this Standard is an example of such a form.

10.2.3 Medical practitioner

The medical assessment shall be conducted by a medical practitioner appropriately trained in underwater medicine.

NOTE: Appendix M suggests a minimum curriculum of courses that provide appropriate training in underwater medicine, and contains guidance for medical practitioners carrying out medical examinations on occupational divers and those intending to undertake training for occupational diving.

The assessing medical practitioner shall make a determination of fitness for diving, based upon all relevant information, including the history of diving activity and of general health, any relevant examination and investigation findings, and any specialist reports or opinion.

In New Zealand, where occupational divers health records are centralized, comprehensive medical assessment and physical examination shall be included as part of the initial assessment and subsequently as clinically indicated but at intervals not exceeding five years. Reassessment and ongoing health monitoring shall be undertaken at annual intervals thereafter with a comprehensive medical assessment and physical examination conducted every five years.

In Australia, the comprehensive medical assessment and physical examination shall be conducted annually.

NOTE: The frequency of physical and comprehensive medical assessments needs to be in accordance with relevant legislation.

The comprehensive medical assessment and physical examination shall test and record information equivalent to or exceeding that listed in the example record of examination findings form in Appendix L. Subsequent physical examinations should have the same coverage.

The forms in Appendix L may be copied for use by medical practitioners.

10.2.4 Record of examination

The record of examination shall be retained by the medical practitioner. A certificate of fitness, unfitness or temporary unfitness pending further examination shall be issued by the assessing medical practitioner and shall be entered in the diver's permanent record of diving (logbook).

An example certificate of fitness is provided in Appendix L.

10.2.5 Imposition of diving restrictions

Where the medical practitioner elects to impose limitations on the validity of the certificate of fitness to dive, such limitations shall be clearly identified on the certificate of fitness to dive.

APPENDIX A

LIST OF REGULATORY AUTHORITIES

(Informative)

A1 INTRODUCTION

This Appendix contains a list of some of the regulatory authorities throughout Australia and New Zealand at the time of publication of this Standard.

A2 COMMONWEALTH GOVERNMENT AUTHORITY (AUSTRALIA)

Visiting address:

Comcare
Level 4 Reception (Childers Street entrance)
121 Marcus Clarke Street
CANBERRA ACT 2600

Postal address:

GPO Box 9905
CANBERRA CITY ACT 2601

A3 AUSTRALIAN STATE AND TERRITORY GOVERNMENT AUTHORITIES

A3.1 Australian Capital Territory

Visiting address:

WorkSafe A.C.T
255 Canberra Avenue
FYSHWICK ACT 2601

Postal address:

PO Box 158
CANBERRA CITY ACT 2608

A3.2 New South Wales

Visiting address:

WorkCover New South Wales
92–100 Donnison Street
GOSFORD NSW 2250

Postal address:

Locked Bag 2906
LISAROW NSW 2252

A3.3 Northern Territory

Visiting address:

NT Worksafe
1st Floor, Darwin Plaza
41 Smith Street
The Mall
DARWIN NT 0800

Postal address:

GPO Box 3200
DARWIN NT 0801

A3.4 Queensland

Visiting address:

Workplace Health and Safety Queensland
Department of Justice and Attorney General
50 Ann Street
BRISBANE QLD 4000

Postal address:

GPO Box 69
BRISBANE QLD 4001

A3.5 South Australia

Visiting address:

SafeWork SA
Department of the Premier and Cabinet, SA
Level 4, World Park A
33 Richmond Road
KESWICK SA 5035

Postal address:

GPO Box 465
ADELAIDE SA 5001

A3.6 Tasmania

Visiting address:

WorkSafe Tasmania
30 Gordons Hill Road
ROSNY PARK TAS 7018

Postal address:

GPO Box 56
ROSNY PARK TAS 7018