Minimum Quantities of Gas Required Offshore

International Marine Contractors Association

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Date	Reason	Revision
July 1983	Initial publication as AODC 014	
May 2012	Updated and published as IMCA D 050	
September 2020	Text amended in Section 2.1 1) to clarify the minimum gas reserve requirements for surface orientated rescue dives.	Rev. 0.1

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1 Introduction

1.1 Scope

This guidance addresses the minimum amount of emergency breathing medium (air or mixed gas) required to be kept at an offshore dive site before the dive commences and during it. It does not replace the diving contractor's diving project plan which is designed for each operation based on a risk assessment of the conditions and work scope at the site.

1.2 Objectives

The objectives of this document are to:

- assist the diving contractor in preparing the diving project plan;
- ensure that the amounts of emergency air and gas held at the site have been carefully considered and calculated;
- ensure that these amounts are displayed in dive control and in saturation/chamber control;
- ensure that supervisors do not start a dive and that they cease diving if these amounts are reduced to below the identified minimum level.

This document is designed to achieve these objectives by providing diving contractors, supervisors and clients with operational guidance that is based on sound safety principles and which highlights the need for:

- an adequate safety management system;
- hazard identifications and an appropriate level of risk assessment;
- failure modes and effects analyses (FMEA).

1.3 Application

This guidance is applicable world-wide. A number of countries in the world have national regulations and/or standards that apply to diving operations. In case the national regulations and/or standards are more stringent than this guidance, they need to take precedence over this guidance and the contents of this guidance should only be used where they do not conflict with the relevant national regulations/ standards.

1.4 Variations

Attempting to formalise these minimum levels is difficult as they are heavily dependent on individual circumstances such as:

- breathing mixtures used;
- decompression schedules used;
- depth of dive;
- work rate;
- environmental conditions at the site.

This note only provides guidance on the **absolute minimum levels** to be carried onboard.

When determining minimum levels it is important to follow manufacturers' instructions and apply a risk assessment approach to the calculations.

1.5 Calculation Error

It is recognised that the calculations used to determine these quantities depend on the gases obeying the ideal gas laws and that gases used in diving are not ideal. However, the safety margins imposed are great enough that any variation in the calculation is minor compared to the total quantity of gas held.

2 Surface Orientated Diving (Air, Nitrox or Heliox)

2.1 General

i) Sufficient compressed gas always needs to be available for two thirty-minute rescue dives to the full intended diving depth. This gas is to be kept as a reserve. This gas should either be stored in containers or else supplied by two totally independent dedicated sources.

ii) Sufficient compressed air needs to be available to pressurise both locks of the deck decompression chamber to the maximum possible treatment depth (normally 50 metres) plus sufficient air for three complete surface decompression cycles. This air should either be stored in containers or else supplied by two totally independent dedicated sources.

NB: Two totally independent sources could be two separate compressors, one of which is connected to the rig or vessel emergency electric power or separate power source (e.g. diesel) or one compressor plus compressed air storage containers.

Rig air should not be considered as a dedicated air supply for diving as it is principally provided for other purposes and may not be available to the quality, or in the quantity or at the pressures required.

iii) $90m^3$ (3200 cu ft) of breathing quality oxygen needs to be available for emergency treatment procedures.

3 Closed Bell Diving

3.1 General

i) Helium and helium gas mixtures, due to the extremely small size of the helium atom, leak from storage cylinders even when precautions are taken to tighten fittings.

ii) Due allowance therefore always needs to be made for leakage, when calculating minimum quantities of gas required at the start of a diving operation.

iii) In mixed gas, bounce or saturation diving, there is always the possibility of the deck chamber atmosphere becoming fouled, due to smoke or other contaminant. In such circumstances the chamber occupants should use the built-in breathing system (BIBS), dumping the exhaust overboard while they transfer to another chamber or the main chamber atmosphere is cleansed or flushed out. Sufficient gas should always be available to allow each diver four hours' breathing on BIBS masks at the deepest storage depth in addition to other gas reserves.

iv) The composition and use of therapeutic or treatment gases varies from company to company, dependent on their detailed operating procedures and treatment tables used. Sufficient quantities of treatment gas for the depths involved need to be available to carry out any foreseeable treatments as detailed in the company's rules. This applies to both bounce and saturation diving.

3.2 Bounce Diving

Before commencing diving, certain quantities of gas and/or air should be available as follows:

i) Sufficient mixed gas should be available for the divers in the water or bell to carry out their planned work. Additional gas should be available to allow a complete dive to be made to the maximum depth as an emergency.

ii) Sufficient mixed gas and/or air should be available to pressurise the deck chamber to the transfer depth, twice. If atmospheric control in the chamber is to be achieved by flushing, then sufficient gas or air should be available for the necessary flushing for two complete decompressions from the intended transfer depth. Should it be intended to use air for the deck chamber, then this air should be available from two independent sources (see note in 2.1) or else be stored in containers.

iii) In the event of emergency medical treatment being required, there should be sufficient helium or mixed gas available to pressurise the deck chamber to maximum diving depth and allow a full saturation decompression to be completed. In this case sufficient oxygen should be available as identified in 3.3 iii).

3.3 Saturation Diving

Before commencing diving certain quantities of gas should be available as follows. If the gas supplies fall to a level such that the remaining gas only satisfies paragraphs 3.1 iii) and 3.3 ii) to iv), then decompression should be started immediately.

i) Sufficient mixed gas should always be available at the start of a bell run to carry out the intended bell run or for both intended bell runs if conducting bottom turn-rounds/continuous diving, plus the same quantity of gas should be held as a reserve. This gas will be in addition to the gas requirements in the following paragraphs. Gas carried onboard the bell or hyperbaric evacuation system (HES) in cylinders should not be included in these calculations.

ii) Before the start of a saturation, there needs to be sufficient mixed gas available to be able to pressurise the system (all deck chambers/HES involved in the saturation) required for the envisaged operation, to the maximum intended storage depth, plus at least an equal amount as a reserve. During the operation, the reserve of mixed gas, sufficient to completely repressurise the system, should be maintained at all times.

iii) There should be sufficient oxygen to allow for metabolic consumption by each diver, any oxygen make-up prior to decompression, plus that required to maintain the PPO_2 during decompression. This quantity should be doubled for safety reasons and held in two separate banks.

iv) Before a saturation dive there should be a minimum of three weeks' supply of calibration and zero gas for the analysers. This reserve needs to be maintained during the saturation.

4 Conclusions

This document provides guidance to supervisors and others as to when diving operations should not be commenced due to inadequate gas or air reserves or when decompression should be commenced in a saturation operation due to diminishing gas reserves.

The quantities referred to are for guidance only and are the **absolute minimum.** A risk assessment should be undertaken for the diving project and this is likely to result in much greater quantities of gas being required to be maintained onboard to cover all eventualities.

Gas Calculations

For assistance in calculating the minimum quantities required, as specified in this document, the following values may be of use. These are either proven figures or have been derived from reasonable assumptions based on many years of operating experience.

Note that breathing gas consumption rates are usually quoted as respiratory minute volumes (RMV). This is the volume of gas inhaled or exhaled from a person's lungs in one minute at surface pressure. The minimum quantities of gas required for diving purposes must always take depth into account, i.e. free volumes of gas need to be calculated, and:

Free gas volume = Consumption rate at surface pressure x Depth

Diver's Gas Consumption (in Water)

- Using open circuit equipment the value varies between 20 to 60 litres (0.7 to 2.1 cu ft) per minute depending on the type of work. A mean value of 35 litres (1.25 cu ft)/minute can be assumed for normal work.
- Using reclamation systems a mean value of 5 litres (0.18 cu ft)/minute can be assumed.
- When breathing in an emergency the diver's consumption will increase and it is necessary to use an elevated value. A mean value of 40 litres (1.5 cu ft)/minute can be assumed for an emergency scenario breathing rate.

NB: Certain global regions, regulatory authorities and company policies may stipulate or recommend other work and emergency breathing rates, i.e. 45 litres/minute, 62.5 litres/minute, etc.

The diving contractor should ensure, through risk assessment and regional compliance, that they are using appropriate breathing rates for the purpose of emergency air and gas calculations.

Maintenance of Oxygen Partial Pressure During Decompression

The following equation can be used to provide an approximate value for the minimum quantity of oxygen required to maintain the desired oxygen partial pressure levels in a system during decompression:

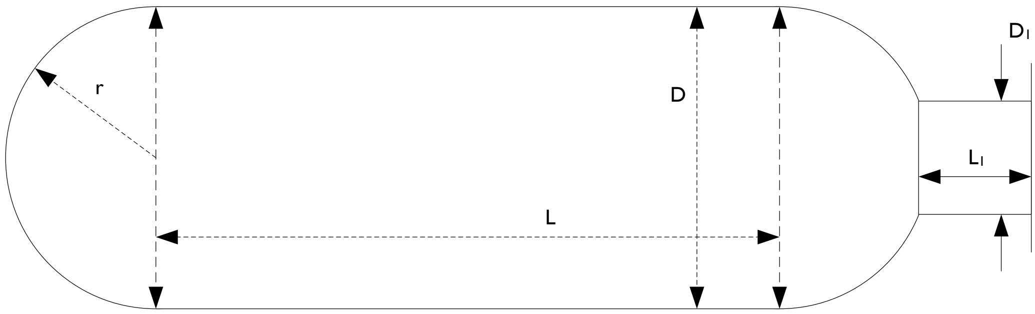
Minimum quantity of oxygen required = Ln (starting depth for decompression absolute pressure) x PPO_2 x FV

where:

- Ln is the natural logarithm;
- PPO_2 is the partial pressure of oxygen in bars; and
- FV is the floodable volume of the chamber in cubic metres.

The numbers inserted for the starting depth for decompression absolute pressure and the partial pressure of oxygen should be derived from the relevant values expressed in bars. The number inserted for the floodable volume should be the figure in cubic metres. The result of the calculation is expressed in cubic metres. The calculation should produce a conservative figure because it assumes a constant PPO_2 all the way to surface. Metabolic oxygen consumption is not included.

Volume of Chambers



Volume of chamber = $(\pi(D/2)^2 \times L) + 4/3\ \pi r^3$, where the domed ends of the chamber are true spheres as shown above (in this case r = D/2). If the domed ends are oblate spheroids, then a more complex calculation would be required.

NB: The volume of each compartment, any trunking, spool pieces or food locks should be known and recorded to give total volume used when determining the required gas quantities. The volume of the spool piece in the simple example above is $\pi r_1^2 \times L_1$ where $r_1 = D_1/2$.

Oxygen Metabolic Consumption (in Chambers)

- 0.5 litres (0.018 cu ft)/minute/diver.
- This equates to approximately 0.7 m^3 (25 cu ft)/day/diver.

BIBS Gas Consumption (at Surface Pressure)

- BIBS gas consumption is calculated at 20 litres (0.7 ft^3)/minute/diver.
- This equates to approximately 28.8 m^3 (1017 ft^3)/day/diver.