IMCA

The International Marine Contractors Association

Surface Supplied Mixed Gas Diving Operations

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IMCA D 030 Rev. 1
August 2005

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The original edition of this guidance document was prepared for IMCA, under the direction of its Diving Division Management Committee, by members active in the IMCA Asia-Pacific Section.

This revision has been undertaken, again under the direction of its Diving Division Management Committee, by a workgroup chaired by Crawford Logan comprising members of the IMCA Americas Deepwater, Asia-Pacific and Europe & Africa sections.

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1 Background

Surface supplied diving using a mixture of helium and oxygen as the breathing gas can be used to increase the range or duration of surface diving operations without the use of saturation techniques.

This technique is not however intended to be used as an effective alternative to saturation diving.

The dive plan for the use of surface supplied mixed gas diving needs to consider all the relevant safety implications of using this technique instead of a closed bell. The restricted bottom time in the deeper range results in it only being suitable for a limited range of work, such as short duration inspection dives or simple tasks such as disconnecting a wire.

2 Scope

This guidance identifies what is generally regarded in the diving industry as good practice to achieve safe working during surface supplied mixed gas diving operations. Principal areas covered are safety considerations, personnel and equipment requirements.

National Regulations may exist in some parts of the world that limit or exclude the use of this technique (for example by restricting depth). In such cases these Regulations must always take precedence over this guidance.

3 Safety Considerations

There are a number of safety issues associated with surface supplied mixed gas diving operations. If the dive is at a depth shallower than 50 metres then the safety considerations are likely to be similar to those for other surface supplied diving operations (apart from the complexities of the gas mixes) however if the dive is in the depth range between 50 and 75 metres then further safety considerations will be required.

The application of the following will assist in providing a safe working environment:

- General requirements for safety, equipment and personnel as set out within the *IMCA International Code of Practice of Offshore Diving* (IMCA D 014 – Ref. 1) and the diving contractor's own diving procedures;
- An adequate safety management system;
- Detailed risk assessment and hazard identification;
- Provision of working procedures approved by relevant parties as defined within the safety management system;
- Adequate briefings prior to commencement of diving operations;
- Use of personnel experienced in this type of diving;
- Use of equipment suitable for this type of diving. Information on the equipment needed and the standards of this equipment are given in *Diving Equipment Systems Inspection Guidance Note for Surface Supplied Mixed Gas Diving Operations* (IMCA document D 0XX - Ref. 2)

3.1 Operational Limits

The technique has limitations and due to the inherent risks involved, this type of diving should only be conducted within the following parameters:

- A properly equipped wet bell is required for surface supplied mixed gas diving;
- Maximum depth should be limited to 75 metres;
- For depths between 0 and 50 metres, the bottom time should be limited such that the in-water decompression required is less than 100 minutes;
- For depths between 50 and 75 metres, the bottom time should be limited to a maximum of 30 minutes.

3.2 Risk Assessment

The immediate recovery of a diver from depth is not always possible during surface supplied mixed gas diving operations. Even using emergency schedules, the diver may be required to undergo some in-water decompression.

Dependent upon the tables used, this may be as much as 60 minutes or more. In many cases, the results of the risk assessment will preclude surface supplied mixed gas diving for this reason.

The risk assessment should consider:

- The depth at which the dive will take place;
- The diving platform being used (fixed installation, anchored barge etc);
- Using this technique from a DP vessel. This needs to be carefully considered as the divers do not have the same ready access to a pressure-controlled environment as they would if a closed bell were in use. In-water decompression from a vessel that has lost position-keeping ability may not be possible;
- Predictability of weather conditions, where the vessel may be subject to sudden squalls or unpredictable sea conditions endangering the wet bell in the water;
- Tidal conditions, e.g. where dives are limited to periods of slack water;
- Visibility;
- Diver recovery in the event of a vessel or platform emergency, particularly if long in-water decompression is planned;
- Evacuation of a diver undergoing decompression in the surface chamber if an emergency arose such as a vessel / installation fire.
- Working on, or in the vicinity of, offshore installations; in particular any obstructions or items that could snag an umbilical, causing equipment damage or over run of bottom time;
- The duration of the diver's bail-out bottle at maximum anticipated depth. This should be estimated to allow the diver with one minutes duration for each 10 metres of horizontal distance he is away from the safe refuge (the wet bell);
- The amount of emergency gas carried on the wet bell;
- Water temperature. Cold water adds an additional element of risk; the water temperature (cold water or warm water) may cause problems during long in-water decompression stops;
- Where the standby diver is located and the length of time it would take him to reach an incapacitated diver;
- Nature of work to be performed;

3.3 Equipment Failure

The possible exposure of the diver during long periods of in-water decompression requires the need for redundancy in the diving equipment used in order to prevent an emergency occurring as a result of an equipment failure.

A wet bell is required for surface supplied mixed gas diving. A wet bell provides a gas bubble in the event of umbilical failure or for an unconscious diver requiring cardio-pulmonary resuscitation.

- The wet bell will require adequate supplies of all breathing mixtures used during the course of the dive (including bottom mix in the event of a trapped diver). This will normally entail separate gases supplied by a surface umbilical coupled to a suitable manifold system, with gas in sufficient quantities for the decompression periods involved;
- Careful consideration needs to be given to the total amount of each gas to be provided taking into account the provision of gas for an emergency;
- The importance of adequate supplies of onboard gas fitted to the wet bell is highlighted because the diver's bail-out will contain only one of the breathing mixtures utilised (normally bottom mix) and will not be sufficient for emergency decompressions. This could have an impact on the size/weight of the wet bell and the handling spread.

- As a minimum, there should be 7m^3 of both bottom mix and compressed air for each diver at the maximum depth planned.

Consideration should also be given to the possible need for the provision of adequate supplies for hot water (taking into account the ambient water temperature) in the event of an emergency, particularly if long in-water decompression times are planned. Similarly heating or cooling for the chamber may be required during decompression in extreme ambient temperatures.

3.4 Recovery of an Injured Diver

The location of the stand-by diver (the primary method of rescue) should be considered in detail at the time of the risk assessment. The stand-by diver will then either be based on the surface or will tend from the wet bell itself. Some of the matters to be considered in the risk assessment are:

- The time taken for a surface stand-by to reach the diver. As the working depth increases, this factor will become more relevant. In general at depths shallower than 50 metres, the standby diver is likely to be located at the surface;
- Some decompression tables involve switching gases during descent; this practice may not favour emergency procedures involving a surface based standby diver;
- Strong currents, poor visibility or snagging hazards that could delay a surface standby from descending;
- Access to the water by a surface standby diver;
- The exposure of a diver acting as standby diver in a wet bell to possible lengthy decompression.

In addition to a standby diver located inside the wet bell, a surface standby diver may well be considered as a secondary means of providing assistance, particularly during in-water decompression at shallower depths.

The wet bell should have a securing mechanism for attachment to the diver's harness to ensure that the head of an unconscious or injured diver can be kept in the gas bubble of the wet bell dome.

Consideration of the size and layout of the wet bell is needed, particularly with regards to the umbilical stowage space (if relevant), as well as the space required for an unconscious diver plus the standby diver in the event of the stand-by diver having to rescue the working diver.

3.5 Operational Method

During surface supplied mixed gas diving operations, particularly at deeper depths, it is vital that the diver is always able to return to his safe refuge (the wet bell) as easily as possible. For that reason it is important that his umbilical is arranged such that it will always lead him back to the refuge. This can be done in a number of possible ways:

- His umbilical is terminated at the wet bell rather than coming from the surface;
- If using an umbilical from the surface then it is passed through a running shackle arrangement mounted on the wet bell;
- If using an umbilical from the surface then the diver makes a point of exiting through the side opening of the wet bell such that his umbilical is running through the bell. Care should be taken that his umbilical cannot become fouled on gas cylinders or other equipment mounted on the wet bell.

It is important that the dive team are familiar with the particular method in use on any specific work site and a written record should be maintained (preferably signed by each person) that this is the case.

4 Personnel

The use of surface supplied mixed gas techniques poses additional risks to divers, when compared with surface diving operations using compressed air or nitrox. Therefore, the following criteria should be applied to personnel selected for such operations.

4.1 Divers

Divers should hold a surface supplied diver certificate. However, it is also important that divers using this technique have logged surface supplied deep diving experience and are familiar with the use of a wet bell. Divers should have received adequate familiarisation training in the use of this technique. In-house familiarisation training should be carried out with content, date and performance recorded. This training should only be carried out by those familiar with, and experienced in, the running of such operations.

In general the working and standby divers should meet the following criteria (this does not include dives during diver training):

- A minimum of 200 logged offshore surface supplied dives (air or mixed gas) to depths greater than 30 metres;
- Logged verification of at least 10 previous dives completed from a wet bell.

The exact competences required for divers who will not be either the working diver or the standby diver will depend on the operating method in use. This will vary from tenders who are recently trained divers used for general deck duties to divers who are competent in chamber operations.

When reviewing competences consideration needs to be given to the role that the individual may be asked to play throughout the whole operation. For example the diver acting as a tender during one dive may be the standby diver in a subsequent dive and would then require to be competent for both roles.

4.2 Supervisors

The diving supervisor requires to be an experienced surface supplied air diving supervisor. He should also have previous experience of surface supplied mixed gas diving operations either as a diver or as a supervisor.

It should not be assumed that all supervisors holding an IMCA Bell Diving Supervisor certificate will be familiar with surface supplied mixed gas diving or that they will have the training, knowledge or experience required for running such an operation.

There are a wide variety of tables in use, many of which involve frequent changes of gas mixtures, and these need to be clearly understood by the supervisor in addition to the normal responsibilities that a supervisor has for the safe execution of a diving operation.

All supervisors should have received adequate familiarisation training in the use of the technique and the decompression tables to be utilised. In-house familiarisation training should be carried out with content, date and performance recorded. Since surface supplied mixed gas diving differs from saturation diving, such training should only be carried out by those familiar with, and experienced in, the running of such operations.

4.3 Manning Levels

The dive team size and composition must always be sufficient to enable the diving operation to be conducted safely and efficiently.

The absolute minimum number of personnel required to carry out an offshore surface supplied mixed gas dive is six. This is made up of 1 supervisor (who does not dive) and 5 personnel who are qualified to dive.

Depending on the exact operational method in use, the experience and competence requirements of the dive team may vary. Consideration may also be given to having extra personnel available to assist with umbilicals or similar in an emergency.

This team will allow one dive with one working diver in the water (N.B. there may also be an in-water standby diver). After that dive is complete, once the diver (and where appropriate the in-water standby diver) have been fully decompressed and are able to take their places as members of the diving team on the surface, it may be possible to carry out another dive using one of the other divers as the working diver (and one as the in-water standby if appropriate). This assumes the dive team still have adequate time available to carry out a second dive before they require a rest period.

If it is planned to carry out more than one working dive in the day then a larger team (normally at least eight) will be required.

The use of an in-water standby diver in the wet bell may increase the team size required for a surface supplied mixed gas diving operation from the minimum required for a normal such operation.

The provision of additional adequate and suitable personnel in the dive team will need to be carefully considered during the planning of this type of diving operation, for example whether a dedicated system technician and/or dedicated winch operator is required.

5 Equipment

5.1 Diving Equipment

The level of equipment required to conduct a surface supplied mixed gas diving operation will vary according to the work programme however there are certain key elements required.

Information on the equipment needed and the requirements for this equipment are given in *Diving Equipment Systems Inspection Guidance Note (DESIGN) for Surface Supplied Mixed Gas Diving Operations* (IMCA D 037 – Ref. 2)

The following represent the key elements if a safe dive is to be performed:

- A dive panel and gas distribution system that has been purpose designed for surface supplied mixed gas diving and is clearly marked to provide for suitable diver (and surface or in-water standby) supply and the proper switch of gases in accordance with the contractor's diving tables;
- Provision of sufficient and suitable back up gas supplies;
- Provision of sufficient and suitable oxygen analysers fitted with audio/visual alarms;
- Provision of a wet bell and deployment system, properly fitted out with adequate onboard gas supplies in the event of failure of the surface supply;
- *Note:* There is normally no foreseen requirement for high pressure oxygen to be fitted to the wet bell, which should ensure that there can be no accidental switch of pure oxygen to the diver's mask.
- Provision of a secondary recovery system sufficient to manage the controlled ascent of the bell in the event of failure of the main system. The secondary recovery system will also need to be adequate to provide for the in-water decompression stages that many tables call for;
- As many tables may require the use of high oxygen content gases to be administered during in-water decompression stops, all equipment should be subject to a frequent and thorough oxygen cleaning regime. There should also be a suitable means to ensure that this supply cannot be accidentally turned on;
- Consideration should also be given to the provision of adequate equipment to maintain the diver's body temperature both during time on helium-based mixtures and during long staged decompression. Diver exposure and body temperature requirements should be addressed as part of the detailed risk assessment, including potential failure of any hot water system.

5.2 Decompression Facility

Normal decompression after a surface supplied mixed gas diving operation requires the use of a deck decompression chamber (DDC) after the diver has returned to the surface. Such a chamber is also needed for any possible emergency or therapeutic treatments required.

For surface supplied mixed gas diving the following are the minimum requirements for the DDC:

- Two compartments;
- Minimum internal diameter of 1.37 metres (54") if only one diver in the water and only one diver requiring decompression at any one time;
- Minimum internal diameter of 1.5 metres (60") if more than one diver in the water or more than one diver requiring decompression at any one time;
- As a minimum there should be one mattress such that an injured diver can be given medical treatment while lying prone in the main compartment.
- In a 1.5 metre diameter (or larger) chamber there must also be at least one fixed bunk a minimum of 1.8 metres long
- A means of ensuring the chamber occupants are maintained in thermal balance. This could be by fitting heating / cooling inside the chamber or by siting the chamber in an area where the whole chamber can be maintained at a suitable temperature.

Decompression illness occurring as a result of a surface supplied mixed gas dive may require deeper therapeutic decompression than would normally be used for air diving. Surface supplied mixed gas diving procedures should clearly state the provisions made for treatment of decompression illness which does not respond to treatment on standard tables and sufficient quantities of therapeutic gas mixtures, in addition to the minimum quantities of medical oxygen, should be available to carry out two full treatments.

Consideration should be given to the possibility that a diver may require saturation techniques for treatment of serious decompression illness. This may be addressed in either of two ways:

- The ability to transfer a diver under pressure into a saturation diving system which will allow treatment to be carried out; or
- The adaptation of a two compartment chamber (with adequate working depth) to carry out therapeutic treatment in saturation conditions. In such a case careful consideration should be given to chamber size as well as additional gas supplies and controls. Environmental control will need to be maintained and facilities made available for toilet/washing etc.

6 Selection of Tables

The diving project plan should clearly identify the working depth, number of working divers, maximum umbilical lengths to reach the worksite, maximum bottom time, required decompression time, gas mix changes and depths at which they occur.

In addition to the diving contractor's own tables and procedures, several commercially available surface mixed gas tables exist (e.g. Canadian and US Navy). Whatever tables are used, the diving doctor on call as part of a project's emergency procedures should be familiar with and have immediate access to these tables.

7 References

Ref. 1 IMCA D 014 - IMCA International Code of Practice for Offshore Diving

Ref. 2 IMCA D 037 – Diving Equipment Systems Inspection Guidance Note (DESIGN) for Surface Supplied Mixed Gas Diving Operations