CCO Ltd

Diving management studies
Study No 1

Organize air & nitrox continuous diving operations

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Important note:
The decompression tables MT92/2012 and DCIEM are promoted in the manuals published by CCO Ltd. For this reason, they are used in this study. Nevertheless, the principles described will not change if the decompression models used are not those indicated above.

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Tables of contents

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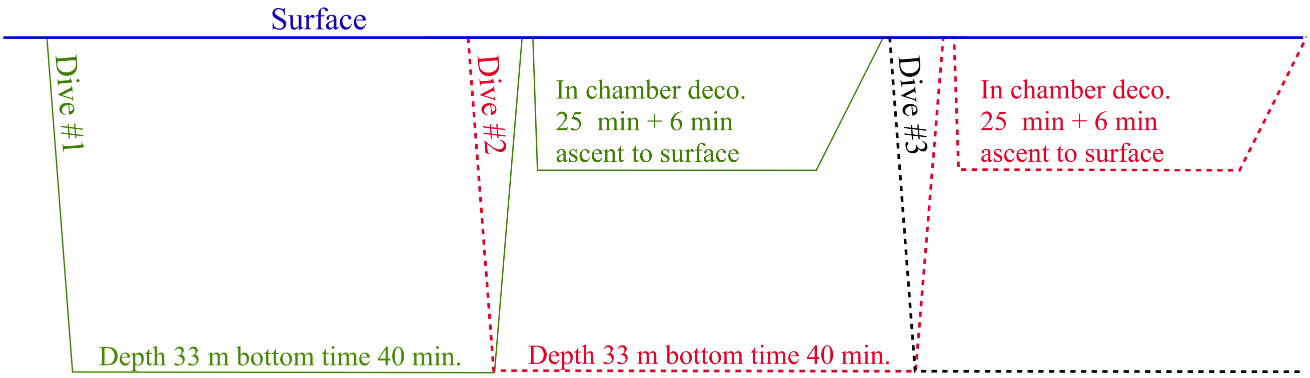
Organize air & nitrox continuous diving operations

There are no specific rules from IMCA or other competent bodies regarding the organization of continuous diving operations. The main reason is that there are numerous variables to manage for the selection of the diving procedures and of the additional equipment to be used. For this reason, the organization of such operations must be cautiously assessed. The purpose of this study is to give elements that can be used in this assessment.

1) Description

Continuous diving operations that are also called "back-to-back diving operations" are diving operations where there is no interruption of the work in progress by the decompression procedures.
To limit the lost time due to the decompression, the diver at work is relieved by another diver at the completion of his bottom time instead of the completion of his dive time.
This method implies that the time spent on decompression is shorter than the bottom time to have a continuous turnover.

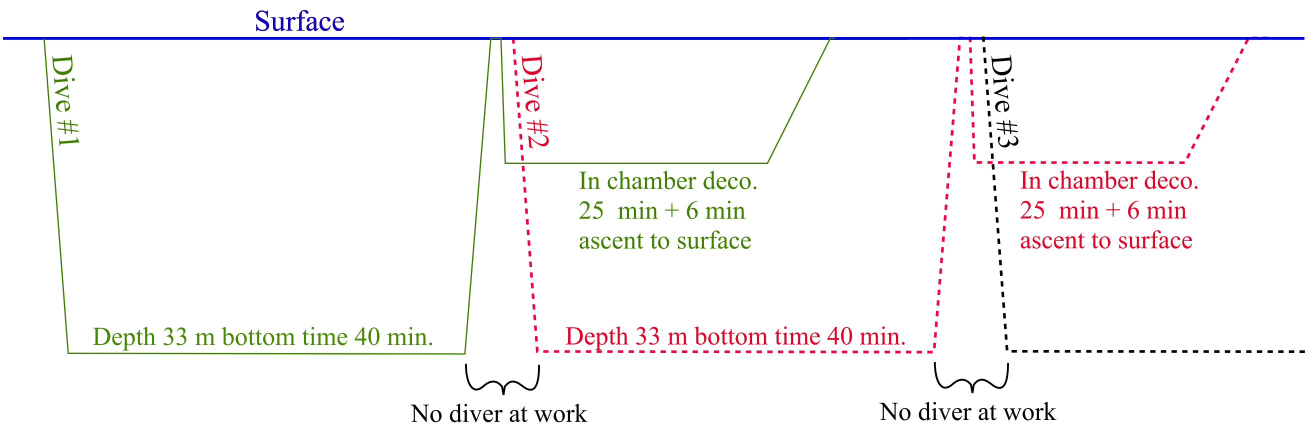


Two methods of decompression can be used:

- In-water or in-wet bell decompression (air or oxygen)
- Surface oxygen decompression

Two methods of continuous diving are practiced:

- The real continuous diving procedure, where the diver at work is replaced as soon his bottom time is completed (see picture above)
- What we can call the "pseudo" continuous diving procedure. With this procedure, the diver starting his dive is launched when the diver who was previously on the job is already in decompression. The duration of the gap depends on the tables selected and also the equipment available.



Note that continuous diving operations must offer, at a minimum, the level of safety of standard diving operations. To make sure that continuous diving operation can be organised and will be efficient we should assess:

- which method of decompression is appropriate and how the dives can be organised.
- the additional equipment that is necessary.
- the additional personnel.
- whether the additional personnel and equipment can be accommodated on the surface support
- that the method selected is economically realistic: A continuous diving operation increases the productivity, but it implies more investment. We must always remember that what is profitable for a project is not automatically profitable for another one. For this reason, the planned costs and gains of a continuous diving operations must always be compared with those of a standard diving operation.

2) Compare the methods of decompression

A lot of people consider that the sole method of decompression for continuous diving operation is surface oxygen decompression.
This belief is not based on proper scientific approaches and studies have proved that alternative methods can be implemented.

The main elements to consider when selecting the method of decompression can be summarised to:

- Efficiency: Decompression times must be compared and depending on the depth, a method of decompression giving less stop time can be considered advantageous.
- Safety: Physiological aspects of the method selected must be considered to minimize the risk of decompression accidents that can be detected, but also those that are not detected and will have an impact on the diver's health later on.
- The economic impact linked to the additional personnel and the additional equipment that are needed to dive safely, and how they can be welcomed by the surface support. This point will be discussed in the next chapters.

One aspect to consider for the selection of the diving procedures is that the possibilities of organizing continuous diving operations fully exploiting the IOGP/UK. HSE operational limits *(see reminder below)* decrease when the depth increases. Nevertheless, this effect can be partially limited by the decompression procedure selected.
To select the most efficient procedure, it is common to make a comparison that can help visualizing the limits of the different diving procedures applying the tables as they are published, so without any reinforcement (safety procedure), and also with the reinforcements a prudent supervisor should implement.

- Reminder

CCO Ltd recommends applying at a minimum a safety margin of one additional bottom time or one additional depth, except for light dives (perfect environmental conditions and light work) ****see #1 & #2 in Notes***.
This recommendation is based on what is indicated in IMCA D 022/chapter 11 "Surface-supplied air diving" / point 11.7 "Decompression procedures" and in MT 92 /2012 manual, point 2.37 "Factors contributing to decompression accidents".

IOGP/UK. HSE maximum operational limits are bottom times limitations that were studied by Tom Shields for the Health and Safety Executive (UK) and adopted by IOGP.
The bottom times beyond the IOGP/UK. HSE limit must not be used. The only exception is in the case of an emergency. Note that a dive beyond the limit reflects a failure in the management of the diving operation and will be considered an incident. These limits are explained in the manuals CCO Ltd and also included in the decompression tables.

2.1 - Compare the efficiency of decompression procedures without reinforcement at 33 m and 39 m:

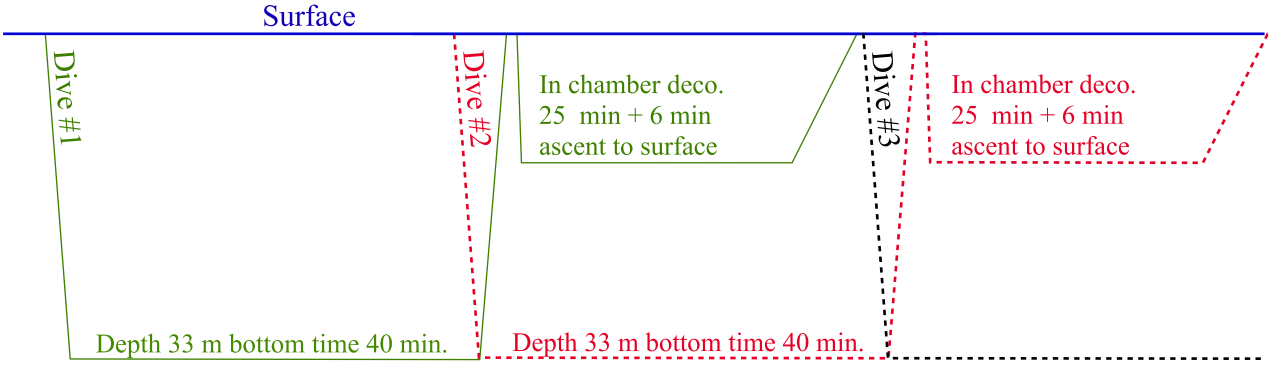
Two dive profiles that are IOGP/UK. HSE limits are used with MT92 tables:

40 minutes at 33 m

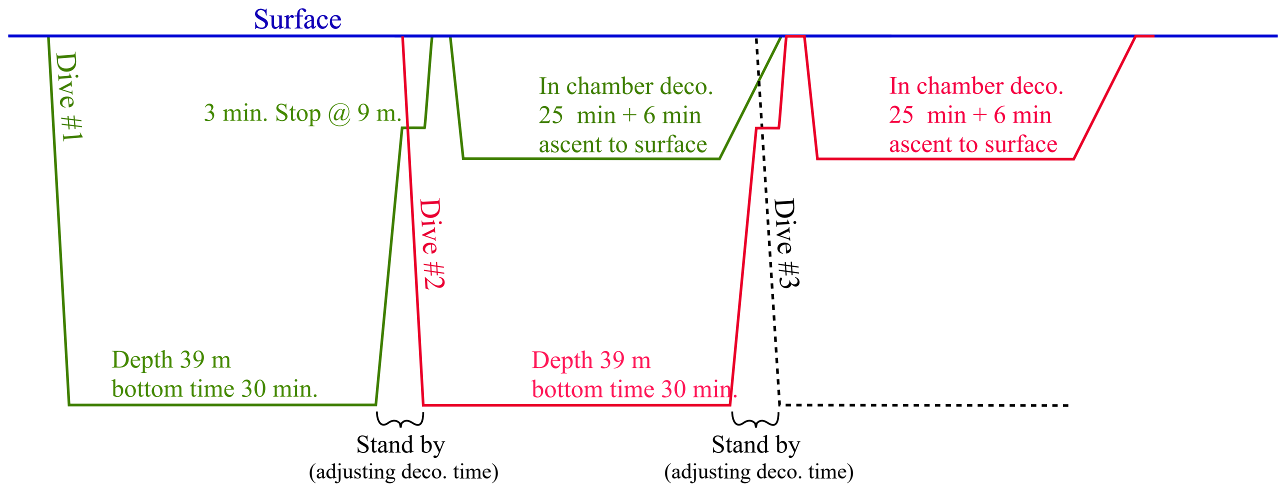
30 minutes at 39 m

2.1.1 - Using Surface O2 decompression

At 33 m and a bottom time of 40 minutes *(see scheme below)*:
The total deco time is 36.45 minutes.
There is less decompression time than the planned bottom time, and there is sufficient time to prepare the dive station for the next dive. As a result, real continuous diving operation can be organized.

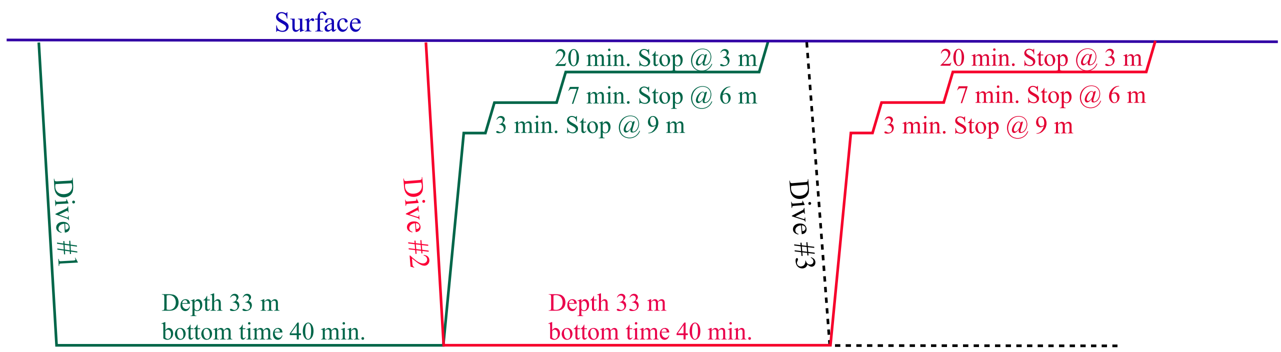


At 39 m for a bottom time of 30 minutes *(see scheme next page)*:
The decompression time is 39.30 minutes.
A real continuous diving operation cannot be organized, and the supervisor has to wait to have less remaining decompression than the planned bottom time before launching the next dive.
Note that depending on the circumstances; extra time may be necessary to prepare the dive station for the next diver.

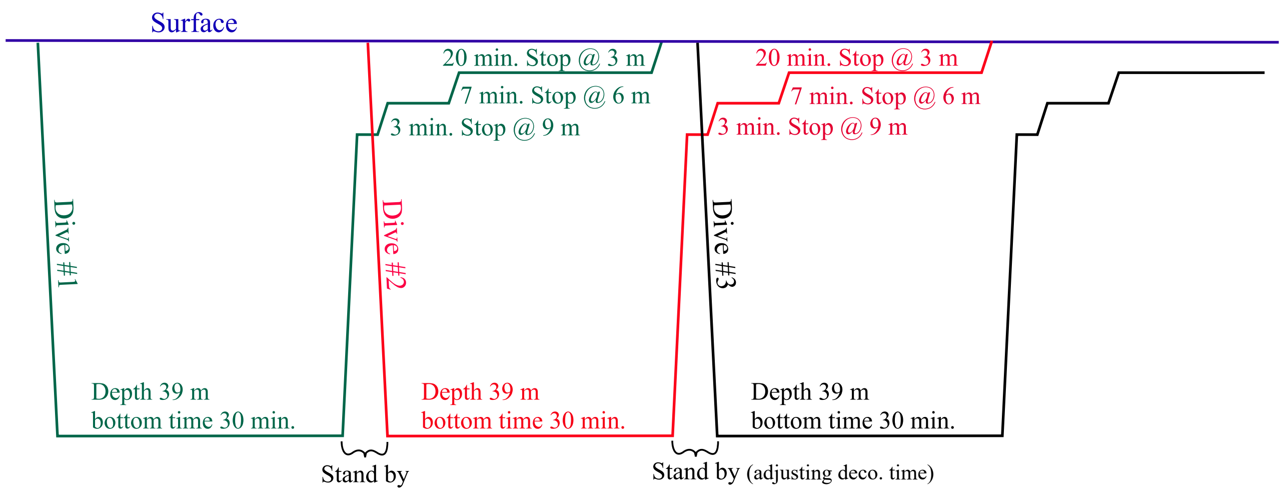


2.1.2 - Using in-water standard air decompression

At 33 m and a bottom time of 40 minutes *(see scheme below)*:
The total deco time is 32 minutes.
There less decompression time than the planned bottom time, and there is sufficient time to prepare the dive station for the next dive. As a result, real continuous diving operation can be organized.

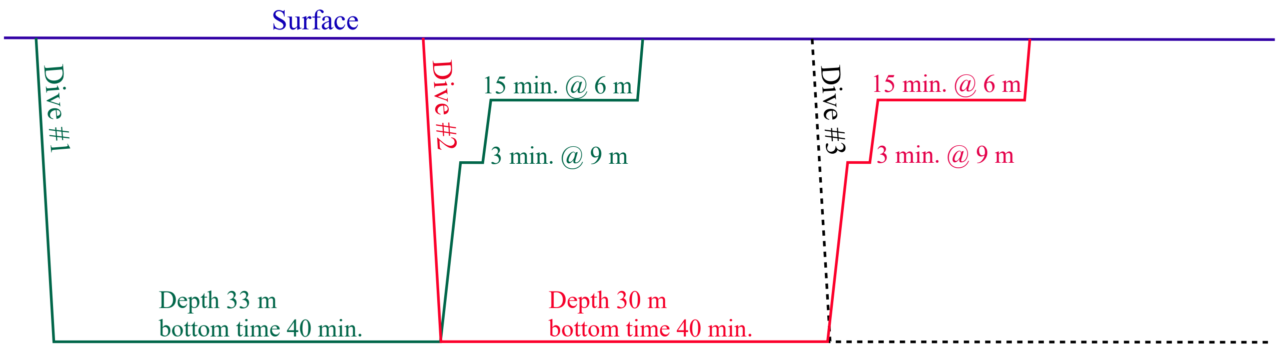


At 39 m for a bottom time of 30 minutes *(see scheme below)*:
The decompression time is 32.30 minutes.
A real continuous diving operation cannot be organized, and the supervisor will need to wait to have less remaining decompression than the planned bottom time before launching the next dive.
Note that, depending on the circumstances, extra time may be necessary to prepare the dive station for the next diver.

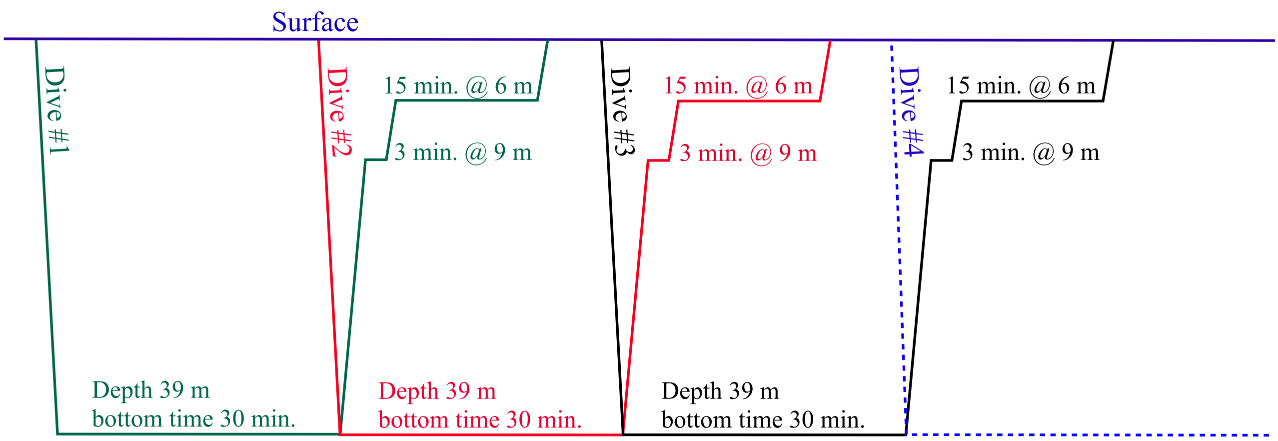


2.1.3 - Using in-water or in-wet bell oxygen decompression at 6 m

At 33 m and a bottom time of 40 minutes *(see scheme next page)*:
The total deco time is 20 minutes.
There is less decompression time than the planned bottom time, and there is sufficient time to prepare the dive station for the next dive. As a result, real continuous diving operation can be organized.



At 39 m and a bottom time of 30 minutes *(see scheme below)*::
The total deco time is 20.30 minutes.
There is less decompression time than the planned bottom time, and there is sufficient time to prepare the dive station for the next dive. As a result, real continuous diving operation can be organized.



2.2 - Check the limits where the operational limits IOGP/UK. HSE can be applied fully when implementing the safety procedures (reinforcement procedures):

2.2.2 - Purpose

For convenience, the comparison in the previous point has been made using the tables without any reinforcement procedure (safety procedure).
Nevertheless, it is uncommon to have conditions that allow very light dives. For most of the dives, the supervisor will have to apply at least one additional bottom time or one additional depth to reinforce the decompression procedure and be sure that the divers are protected from decompression accidents.

These reinforcements will have an impact on the efficiency of the decompression selected, and it is important to visualize these limits.
The purpose of this point 2.2 is to show when the IOGP/HSE operational limits can be applied fully.
Nevertheless, take into account that a prudent supervisor should never use the last bottom time within these limits to make sure that if the recovery of the diver is delayed, this last bottom time can be used.

Two decompression tables are used to highlight these limits as depending on its calculation a table can be more stringent than the other one for a particular decompression profile, and less stringent for another decompression profile. These two tables are those promoted by CCO Ltd, so the MT92/2012 and the DCIEM tables.

The depths proposed are from 27 m to the deepest depth that is applicable using the decompression selected.

It is agreed that the maximum operational limits IOGP/UK. HSE can be applied fully using the tables for depths shallower than 27 m.

The deco procedures studied are the same as in the previous point:

- Surface oxygen decompression
- Standard air in water decompression
- In-water or in-wet bell decompression

2.2.3 - Comparison using MT 92/2012 tables

2.2.3.1 - In-chamber decompression using surface oxygen decompression table MT92

Actual depth	IOGP/HSE limit	Safety procedure applied (reinforcement)		Comments
		1 additional depth	**1 additional bottom time**	
27 m	60 min	Possible	Possible	***Additional depth:*** 60 min. using Table 30 m = 53.45 minutes deco. ***Additional bottom time***: 70 min. Table 27 m = 53.30 minutes deco.
30 m	50 min	Not possible	Not possible	***Additional depth:*** 50 min. Using Table 33 m = 51 minutes deco. (In this case, limit the bottom time to 45 minutes) ***Additional bottom time***: 60 min. using Table 30 m= 53.45 minutes deco. (In this case, limit the bottom time to 45 min and apply 50 min bottom time @ 30 m for the decompression)
33 m	40 min	Not possible	Not possible	***Additional depth:*** 40 min. using Table 36 m = 44.15 minutes (In this case, because the bottom time 35 minutes gives 39.15 minutes deco, it is more realistic to limit your bottom time to 30 minutes) ***Additional bottom time***: 45 min. using Table 33 m = 44.45 minutes (In this case, limit the bottom time to 35 minutes and apply 40 minutes for the decompression)

2.2.3.2 - In-water decompression using standard air table MT92

Actual depth	IOGP/HSE limit	Safety procedure applied (reinforcement)		Comments
		1 additional depth	**1 additional bottom time**	
27 m	60 min	Possible	Possible	***Additional depth:*** 60 min. using Table 30 m = 54.45 minutes deco. ***Additional bottom time***: 70 min. Table 27 m = 51.45 minutes deco.
30 m	50 min	Not possible	Not possible	***Additional depth:*** 50 min. Using Table 33 m = 52 minutes deco. (In this case, limit the bottom time to 45 minutes) ***Additional bottom time***: 60 min. using Table 30 m = 54.45 minutes deco. (In this case, limit the bottom time to 45 min and apply 50 min bottom time @ 30 m for the decompression)
33 m	40 min	Not possible	Not possible	***Additional depth:*** 40 min. using Table 36 m = 42.15 minutes (In this case, limit the bottom time to 35 minutes) ***Additional bottom time***: 45 min. using Table 33 m = 40 minutes (This is equal time. The best is to limit the bottom time to 35 minutes and apply 40 minutes for the decompression)

2.2.3.3 - In-water or in-bell oxygen decompression table 6 m MT92

2.2.3.3 - In-water or in-bell oxygen decompression table 6 m MT92

Actual depth	IOGP/HSE limit	Safety procedure applied (reinforcement)		Comments
		1 additional depth	1 additional bottom time	
27 m	60 min	Possible	Possible	***Additional depth:*** 60 min. using Table 30 m = 34.45 minutes decompression. ***Additional bottom time***: 70 min. Table 27 m = 29.30 minutes decompression.
30 m	50 min	Possible	Possible	***Additional depth:*** 50 min. Using Table 33 m = 37 minutes deco. ***Additional bottom time***: 60 min. using Table 30 m = 34.45 minutes deco.
33 m	40 min	Possible	Possible	***Additional depth:*** 40 min. using Table 36 m = 25.15 minutes. ***Additional bottom time***: 45 min. using Table 33 m = 25 minutes
36 m	35 min	Possible	Possible	***Additional depth:*** 35 min. using Table 39 m = 27.30 minutes. ***Additional bottom time***: 40 min. using Table 36 m = 25.15 minutes
39 m	30 min	Possible	Possible	***Additional depth:*** 30 min. using Table 42 m = 27.45 minutes. (Nevertheless, we have only 2:15 min margin) ***Additional bottom time***: 35 min. using Table 39 m = 27.30 minutes (same scenario as above)
42 m	30 min	Not possible	Not possible	***Additional depth:*** 30 min. using Table 45 m = 30.45 minutes. (In this case limit the bottom time to 25 minutes) ***Additional bottom time***: 35 min. using Table 42 m = 37.30 minutes (In this case, limit the bottom time to 25 minutes and apply 30 minutes for the decompression)

Note that in water oxygen decompression allows to exploit the operational limits IOGP/UK. HSE fully until 39 m instead of 27 m with the other methods.

2.2.4 - Comparison using DCIEM tables

2.2.4.1 - In-chamber decompression using surface oxygen decompression table DCIEM

Actual depth	IOGP/HSE limit	Safety procedure applied (reinforcement)		Comments
		1 additional depth	1 additional bottom time	
27 m	60 min	Possible	Possible	***Additional depth:*** 60 min. using Table 30 m = 56 minutes deco. ***Additional bottom time***: 70 min. Table 27 m = 53 minutes deco.
30 m	50 min	Not possible	Possible	***Additional depth:*** 50 min. Using Table 33 m = 55 minutes deco. (In this case, limit the bottom time to 45 minutes - but you will have only 1 min margin -). ***Additional bottom time***: 55 min. using Table 30 m= 49 minutes deco. (But only 1 minute margin).
33 m	40 min	Not possible	Not possible	***Additional depth:*** 40 min. using Table 36 m = 51 minutes (In this case, limit your bottom time to 30 minutes) ***Additional bottom time***: 45 min. using Table 33 m = 49 minutes (In this case, limit the bottom time to 30 minutes and apply 35 minutes for the decompression as 35 minutes gives 40 minutes decompression)

2.2.4.2 - In-water decompression using standard air table DCIEM

Actual depth	IOGP/HSE limit	Safety procedure applied (reinforcement)		Comments
		1 additional depth	1 additional bottom time	
27 m	60 min	Possible	Possible	***Additional depth:*** 60 min. using Table 30 m = 55 minutes deco. ***Additional bottom time***: 65 min. Table 27 m = 47 minutes deco.
30 m	50 min	Not possible	Possible	***Additional depth:*** 50 min. Using Table 33 m = 54 minutes deco. (In this case, limit the bottom time to 45 minutes) ***Additional bottom time***: 55 min. using Table 30 m = 48 minutes deco. (But only 1 minute margin).
33 m	40 min	Not possible	Not possible	***Additional depth:*** 40 min. using Table 36 m = 48 minutes (In this case, limit the bottom time to 35 minutes, but there is only 2 min. margin) ***Additional bottom time***: 45 min. using Table 33 m = 46 minutes (In this case, limit the bottom time to 35 minutes and apply 40 minutes for the decompression)

2.2.4.3 - In-water or in-bell oxygen decompression table 6 m DCIEM

Actual depth	IOGP/HSE limit	Safety procedure applied (reinforcement)		Comments
		1 additional depth	1 additional bottom time	
27 m	60 min	Possible	Possible	***Additional depth:*** 60 min. using Table 30 m = 39 minutes decompression. ***Additional bottom time***: 70 min. Table 27 m = 35 minutes decompression.
30 m	50 min	Possible	Possible	***Additional depth:*** 50 min. Using Table 33 m = 40 minutes deco. ***Additional bottom time***: 55 min. using Table 30 m = 35 minutes deco.
33 m	40 min	Possible	Possible	***Additional depth:*** 40 min. using Table 36 m = 37 minutes. ***Additional bottom time***: 45 min. using Table 33 m = 34 minutes
36 m	35 min	Not possible	Not possible	***Additional depth:*** 35 min. using Table 39 m = 38 minutes. (In this case limit the bottom time to 30 minutes) ***Additional bottom time***: 40 min. using Table 36 m = 37 minutes (In this case, limit the bottom time to 30 minutes and apply 35 minutes for the decompression)

Note that the maximum depth with in-water oxygen decompression is limited to 33 m with DCIEM

2.3 - Use of Nitrox

Nitrox can be used to reduce the decompression times. The gains will be approximately one table.
Nevertheless, because IMCA and the DMAC recommend a maximum oxygen partial pressure of 1.4 bar at depth, this procedure is limited to depths equal and above 36 m using a mix 30/70, and less if using richer mixes.

If using Table #7 “Equivalent air depths” from Tables MT92/2012 with a mix 30/70, at 33 m, the Equivalent Air Depth (EAD) indicated is 30 m. At 36 m the Equivalent Air Depth with the same mix is 33 m.
Thus, if using a reinforcement of one additional depth, the table to apply for a dive at 36 m is the actual depth.

Table 1(N) “DCIEM Equivalent Air Depth for nitrox” promotes a mix 32/68 and in this case the limit indicated is 33 m.
Note that nitrox mixes below 30% are beneficial but do not reduce the decompression times significantly.

Also, note that using nitrox does not give gains regarding the operational depth compared to the Table MT92/2012 with oxygen in-water decompression at 6 m that allows applying in full the operational bottom time IOGP/UK. HSE at 39 m where the operational limit of a nitrox 30/70 is 36 m.

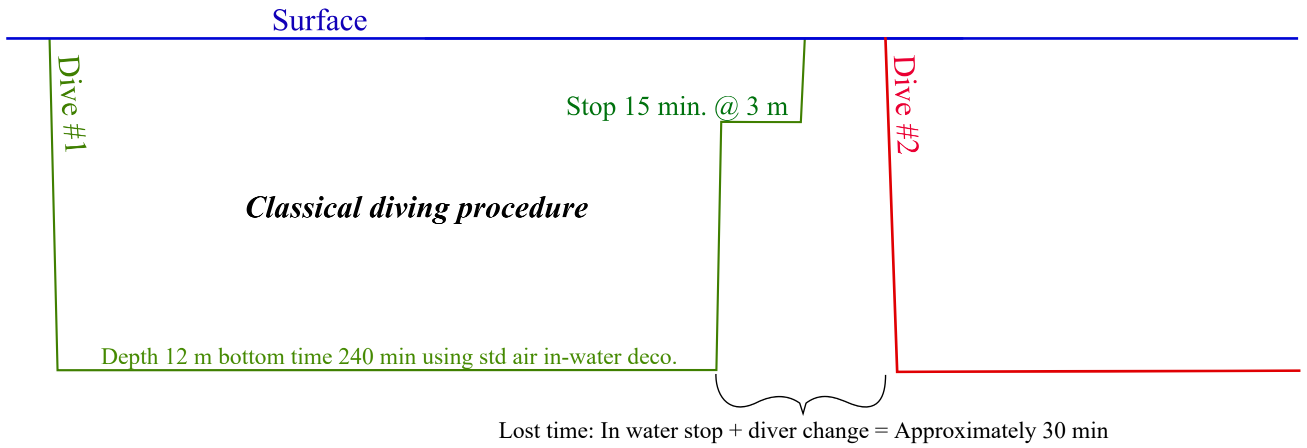
2.4 - Use of Heliox

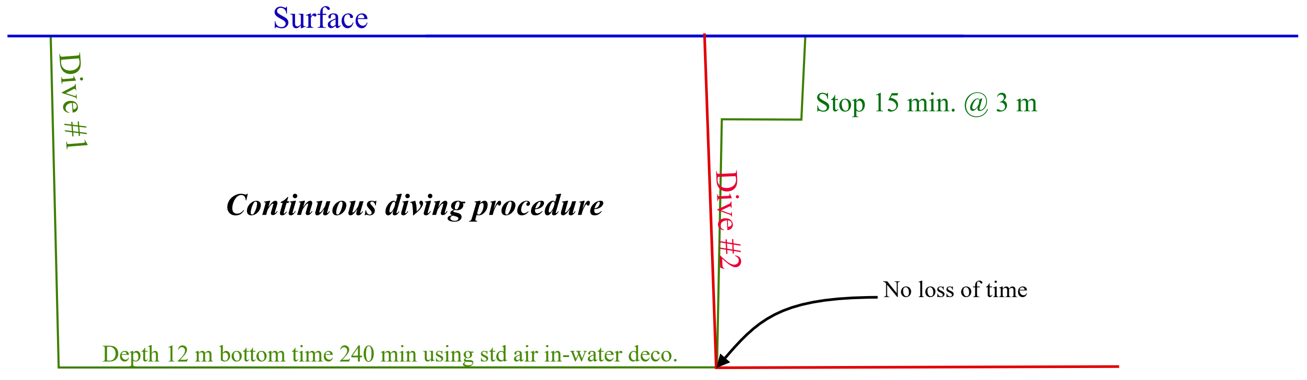
There is no heliox surface decompression procedure with MT92 tables.
For this reason, CCO Ltd has not retained the in-water decompression procedures heliox MT92 (6 m & 12 m) because for jobs in the offshore industry; there must be a surface decompression table that can be used as a backup table in case that the in-water decompression procedures become impractical.
Note that these tables can be efficiently used for other diving operations but not for IOGP/IMCA diving operations.

At the opposite, DCIEM has edited heliox in-water and in-chamber decompression procedures that can be used.
Note that the 1st depth available is 36 m and that the decompression times for 30 minutes at 39 m are 61 minutes for the surface decompression procedure and 46 minutes using in-water decompression.
As a result, surface decompression cannot be used as main procedures as the decompression times are the double of the bottom times.
For the in-water decompression procedure, real continuous dives cannot be organized because the supervisor will have to make sure that the remaining decompression time of the diver in decompression is less than the bottom time planned before launching the next dive.
Using three teams with two teams in decompression when the third team is on the job is probably possible, but that implies a very complex organization where the equipment and personnel will need to be increased. Thus, in this case, saturation is probably preferable in term of cost, efficiency, and safety.

2.5 - Possible gains using continuous diving procedures at shallow and very shallow depths

The previous points demonstrate that continuous diving is possible with all types of decompression and reinforcement procedures at 27 m and shallower. Also, organize continuous diving operations can be beneficial at shallow depths as it allows to have continuous work during the stops (even minimized compared to the bottom times) but also during the time where the team is preparing to launch the next diver.
A diver change takes approximately 10 to 15 minutes, this loss of time is added to the time lost due to the decompression if using the classical diving procedure.
As an example, using Tables MT92/2012, a dive at 12 m applying the maximum IOGP/UK. HSE bottom time, so 240 minutes, requires 20 minutes deco time using the surface decompression procedure, 15.45 minutes using the in-water decompression procedure, and 10.30 minutes using the in-water (or in-bell) 6 m decompression procedure.
Thus 20 to 35 minutes of bottom time can be saved each dive, depending on the decompression procedure used if continuous diving is implemented. That can be between 60 and 105 minutes, bottom time saved each day.



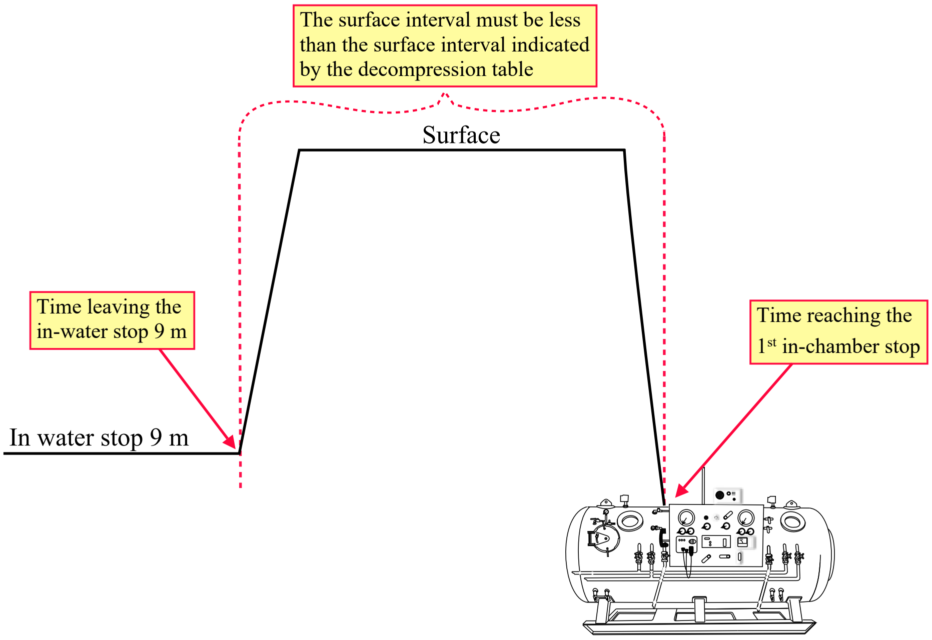


Note that as said previously, there must be a comparison of costs and gains with the standard diving operation to make sure that implementing a continuous diving procedure at a shallow depth will be really profitable.

2.6 - Safety considerations

2.6.1 - Surface oxygen decompression

Surface decompression procedures reduce the in-water exposure time with most of the decompression being carried out in a deck decompression chamber. In-water decompression is carried out normally as for standard air until the end of the 9 m stop. At the end of the 9 m stop, the diver goes directly to the surface and then returns to 12 m in the deck decompression chamber to complete the decompression requirements on O_2. Note that the interval from leaving the 9 m in-water stop to the 12 m stop in chamber is 7 minutes with Tables DCIEM and 4 minutes with Tables MT92/2012.



With this procedure, the diver is transferred to the surface without having completed his decompression. It is based on the fact that, generally, a decompression accident is not detectable immediately after surfacing and that a short period is necessary for the process to develop and symptoms becoming visible. Thus, the diver is transferred to the chamber and recompressed during this very short period. It is obvious that the diver must be transferred to the chamber as quickly as possible.
During the seventies, these tables were considered the first choice because it was said that the diver is removed from the water and under control into the chamber. Nevertheless, studies started during this period and continued until now have demonstrated that despite some advantages, this procedure is not the safest and has a lot of inconveniences.
Among the inconveniences, we can highlight the following points:

- Decompression stress during the surface interval (diver experiencing DCS symptoms):

  DCIEM says:
  During the surface interval, the diver is exposed to a higher level of decompression stress than would be encountered if in-water decompression only had been executed. Therefore, the diver may experience signs and/or symptoms of decompression stress.
  Manned validation has indicated that when symptoms do occur during the surface interval, they are almost always very mild and late into the surface interval. In addition, the symptoms usually completely resolve during the pressurization to 12 m in the chamber. Experimental dives have demonstrated that the divers who experienced surface interval symptoms had the same incidence of decompression sickness after the completion of the dive as those divers who did not experience signs or symptoms during the surface interval. Therefore, during surface oxygen decompression diving, when all signs and symptoms of surface interval stress have been completely resolved by the time, the diver is confirmed on oxygen at 12 m in the chamber and the decompression profile is to be completed as planned.
  When the signs and symptoms of the surface interval stress have not been completely resolved by the time the diver is confirmed on oxygen at 40 feet (12 m), it should be treated as decompression sickness. The diver must be immediately pressed to 60 feet (18m) , a Treatment table 6 initiated, and the Diving Medical Officer contacted.

- Interval from in water stop 9 m to in-chamber stop 12 m can exceed the allocated time:

  If the surface interval exceeds the allocated time, the dive is considered as a shortened decompression, and a medical table for decompression accidents must be applied. Also, considering the possibility of complex decompression illness involving, for instance, the central nervous system, the diving medical specialist must be contacted and his recommendations applied. The surface decompression dives have to be stopped for the duration of the treatment. To finish on this point, this incident must be reported to the client.

- The diver may be unable to reach the 12 m (40 ft) stop

  The problem is generally linked to divers who cannot equalize their ears during the recompression in the

chamber. This problem is common and, unfortunately, sometimes ignored by diving managers or client representatives who consider that surface decompression is the sole efficient decompression procedure. Note that the efforts resulting from Vasalva manoeuvre which might be performed by the diver could increase the intra-thoracic pressure and ease the transfer of small bubbles from the right heart atrium to the left heart atrium in case of presence of patent foramen ovale (PFO) or through intra-pulmonary shunts.
CCO Ltd manuals propose two "safe way out procedures" that are based on the US Navy procedures to solve this problem. Nevertheless applying such procedure is equivalent to applying a medical table: The dives must be stopped during the treatment, and the incident reported.

- According to studies, the risk of type 2 decompression accidents is higher with surface decompression.

During the 70's and the 80's doctor T. Shields, COMEX, and other teams made investigations to find solutions to lower the frequency of the too numerous decompression accidents in the north sea. These studies have initiated the implementation of reinforcement procedures, the generalization of techniques such as saturation, and the publication of safer decompression tables than those that were in service. COMEX tables MT74 and MT92 are examples of the decompression models studied and published .
Comparisons between in-water and surface oxygen decompression techniques were made to determine the impact of the techniques of decompressions regarding decompression accidents.
In an article entitled "Decompression in surface-based diving", that was the safety analysis of MT74 air decompression tables, explained by J.P. Imbert and M. Bontoux (COMEX) in a workshop in Tokyo in 1986 it is said:
In order to detect possible advantages of in-water decompression over surface decompression, the performances of the air/oxy tables were compared to the surface decompression tables from report to DOE. Once again, such a comparison is reasonable because the tables were used over similar exposures. The results of table n° 8 (see below) indicate that, although the overall DCS incidence appeared similar :

- *in-water decompressions tend to produce type I accidents only,*
- *surface decompressions tend to produce a large proportion of type II accidents, and <u>thus in-water decompression should be preferred to surface decompression, at least for the tables considered.</u>*

	Surface decompression	***In water Air Oxy tables***
Number of dives	14691	10063
Type 1 DCS	39	67
Type 2 DCS	34	1
Total DCS	73	68
% DCS	0.0049	0.0068
% type 2 / Total DCS	0.46585	0.0147

In another article entitled " Decompression safety" published in 1993 J.P. Imbert (COMEX) said:
The comparison of the type I DCS occurrences does not allow differentiating between the two techniques of decompression. However, the comparison of the type II DCS occurrences shows that their incidence becomes significantly much higher with the surface decompression than with in-water decompression (see below)…

Exposures	***Prt ≤ 25*** *(Dr T. Shields)* ***Moderate***		***Prt < 25 ≤ 35*** *(Dr T. Shields)* ***Standard***		***Prt > 35*** *(Dr T. Shields)* ***Severe***	
Method	***In-water deco.***	***Surface O2 deco.***	***In-water deco.***	***Surface O2 deco.***	***In-water deco.***	***Surface O2 deco.***
Number of dives	37551	10674	22643	54230	8349	9323
Number of Type 1 DCS %	30 0.08%	4 0.04%	78 0.34%	118 0.22%	77 0.92%	87 0.93%
Number of Type 2 DCS %	5 0.01%	1 0.01%	3 0.01%	74 0.14%	12 0.14%	35 0.38%

- The diver breathes oxygen at 2.2 bar in the chamber.

High partial pressure of oxygen can trigger acute oxygen poisoning. The procedure for managing such incident is explained in the manuals designed by CCO Ltd. Nevertheless it is an undesirable event .

In the case of a loss of oxygen supply, the procedure promoted by COMEX and DCIEM is to apply a Std air table with additional reinforcements. Nevertheless, that will have the effect of delaying the deco time.

Despite these inconveniences, surface decompression tables offer some advantages that must be considered:

- The diver is dry and not exposed to cold water, strong currents, and the effects of the waves during the decompression in the chamber.
- In the case of an incident such as acute O_2 poisoning or decompression accident, the diver medic can easily intervene.
- Decompression using surface decompression is possible if the decompression in the water becomes impractical.
- Decompression is possible when the vessel is retrieving anchors or sailing.
- Change of decompression procedure from in-water deco to surface decompression is possible any time when the 9 m stop has been completed (or if it is not scheduled).

A common assumption should be reconsidered:

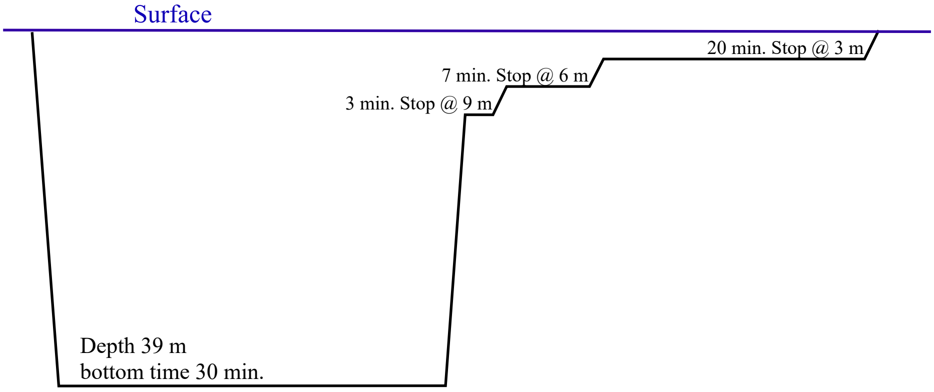
A lot of people think that diving operations using surface decompression are possible when they are not possible using in-water decompression.
This assumption must be reconsidered, because if it is true that surface decompression should be used to complete an in-water decompression that becomes difficult or impossible due to suddenly degraded conditions, it must be remembered that the in-water decompression procedure is the recovery table of the surface decompression procedure. In the case that the chamber is not available, or the transfer to the deck is not possible using the basket/bell for technical reasons or an incident, the decompression will have to be completed in the water.
For these reasons, decompression using oxygen is not a substitute for in-water decompression when the pre-dive assessment shows that in-water decompression cannot be performed.

Cleanliness of the chambers:

Long hyperbaric treatments may be carried out in the chambers on injured casualties. For this reason, the chambers must be cleaned and disinfected before and during the diving operations to avoid any risk of contamination (see in manuals CCO Ltd and DMAC 26). The frequency of disinfection of the chambers should be increased because they are in use every day.

2.6.2 - Standard air in water decompression

This type of decompression is the most common and is considered very safe. With this procedure the diver gradually ascends, performing scheduled stops until the moment he can be recovered to the surface.



The main advantages of this technique are that:

- There is no rupture of the decompression process
- There is less risk of decompression accidents type 2 than with surface decompression.
- No oxygen. Thus, no risk of O2 poisoning, O2 supply break down,
- It is simple to implement

This technique has of course some inconveniences:

- The diver may be exposed to cold water, strong currents, and the effects of the waves during the decompression.
- As explained in the previous point this technique does not remove the risk of decompression accident.
- The decompression must be completed before retrieving the anchors and sailing.
- The recovery table of the in-water decompression is the surface decompression. Thus, even the in-water decompression procedure is more simple to implement, the team must be ready to shift to surface decompression at all times.

2.6.3 - In-water or in-bell oxygen decompression at 6 m

With this procedure the in-water decompression stops are performed on air until 6 m where they are performed using oxygen. There is no 3 m stop. Note that in-water oxygen decompression. 12 m (MT92) and 9 m (DCIEM) can be used with wet bells. Nevertheless, these procedures do not give any reduction of the decompression times for the exposures indicated in the IOGP/UK. HSE bottom time limits.

The main advantages of this technique are that:

- There is no interruption of the decompression process
- There is less risk of decompression accidents type 2 than with surface decompression.
- The last stop is at 6 m: That allows more comfortable decompressions than the “standard air” procedure particularly in the case of waves
- It is the most efficient technique and it allows to apply additional safety margins
- Oxygen decompression at 6 m is considered safe regarding acute oxygen poisoning

The inconveniences are similar to those of air in-water decompression plus those linked to oxygen

- The diver may be confronted to cold water, strong currents, and the effects of the waves during the decompression.
- As explained previously, this technique does not completely remove the risk of decompression accident.
- There must be specific equipment and the team must be familiar with oxygen handling.
- There is a very low possibility of oxygen poisoning of extremely sensitive people
- The decompression must be completed before retrieving the anchors and sailing.
- The backup procedure of the in-water decompression is the surface decompression. Thus, even though the in-water decompression procedure is more simple to implement, the team must be ready to shift to surface decompression at all times.

2.7 - Summary regarding the efficiency and safety of the decompression techniques that may be used.

The comparisons of dive profiles demonstrate that surface decompression procedures are not the safest and the most efficient techniques of decompression.
In term of efficiency, the oxygen in-water or in-wet-bell decompression procedures are the only procedures that allow continuous diving operations deeper than 30 m (39 m using MT92).
Regarding the safety points that have been highlighted, there is less risk of type 2 decompression accident with water or in-wet-bell decompression procedures. Also, in water decompression procedures don’t have the inconveniences that are linked to the surface transfer that is a very risky phase of the surface decompression procedures.
On the other hand, it is true that performing oxygen stops in the water requires that strict oxygen handling and management procedures are in place. Nevertheless, these procedures that are detailed in the corresponding manuals CCO Ltd are not so complex, and there are fewer reports of incidents with in-water oxygen decompression than with surface decompression procedures, where they often happen during the transfer to the chamber.
For those who consider that oxygen breathed in the helmet and delivered through the panel is dangerous, wet-bells where oxygen is delivered through a separate panel and breathed using masks that can be easily removed are the best tools. Note that oxygen decompression using a wet bell is explained in the surface supplied diving manuals CCO Ltd.
For these reasons, the recommendation regarding the selection of the decompression techniques is the one indicated by COMEX: In-water decompression should be preferred to surface decompression, at least for the tables considered.

The fact that surface oxygen decompression procedures are not the best techniques regarding efficiency and safety does not mean that they must not be used. Surface oxygen decompression procedures remain the backup for in-water and in-wet-bell decompression procedures. It must be remembered that in addition to the 90 m^3 of oxygen, IMCA D 050 requires at a minimum sufficient gas for two surface decompressions.
Note that surface oxygen decompression can be used if continuous diving operations using in-water decompression cannot be implemented. But because it is a 2nd choice, the reason for using it as main procedure should be explained and argued in details. Also, additional reinforcements should be implemented to keep the divers away from type 2 decompression accidents.

3) Assess the additional equipment that is necessary.

The implementation of real continuous diving operations requires increasing the equipment. The additional items will depend on the number of divers planned in the water, and the method of decompression selected.
In most cases, the items will have to be multiplied by two because a real continuous diving operation is an operation where two teams are working at the same time: One team performing a dive and one team decompressing the divers who were previously at work and preparing for the next dive.

3.1 - Diving panels, helmets and umbilicals

When in-water decompression is used, there must be two separate panels. The reason is that when a diver is on stops (in-water stops), another diver is on the job. Also the pre-dive check lists are performed during the previous dive.
Depending on whether one or two divers are planned, the number of helmets and umbilicals must be multiplied by two. In most cases it is better to keep the possibility to have two divers in the water. Thus, two helmets + umbilical and 1 mask + umbilical connected to each panel.

A common procedure for back-to-back diving is implementing surface decompression procedures using only one dive panel with the umbilicals and helmets that are connected to this panel. This technique has the advantage to limit the equipment involved. Nevertheless, in addition to the inconveniences linked to the use of surface decompression procedures that has been previously highlighted, note that back-to-back operations organized in this manner are not continuous diving operations, but "Pseudo continuous" diving operations as the work at depth is interrupted to:

- Recover the diver to the surface
- Transfer the diver into the chamber
- Check the panel and the dive station
- Check the divers
- Contact the bridge
- Launch the dive

If a 2nd panel is in use, such preparation can be done during the previous diving operation and approximately 15 minutes (or more) can be saved each dive as the diver change can be organized when the diver at work is recovered to the surface.
Note that in the case of the break down of one panel, the operations can continue using the 2nd panel.
Also, having a 2nd panel gives sufficient time to make sure that the pre-dive checklists have been done correctly. Note that teams in a hurry may become casual regarding the checklists. Checklists incorrectly performed because the personnel becomes casual is highlighted in IMCA D 022 chapter 12/ point 3.5 where it is said: *"After a period, when the team has become completely familiar with procedures, there is sometimes a tendency to become casual. This is typically seen in the use of checklists. Items are ticked off without being properly checked. It is at this stage that accidents may happen."*.

Thus, for organizational and safety reasons, the recommendation is to use two diving panels whatever the procedure of decompression selected.

3.2 - Communications

When using two separate panels (recommended) there must be wired hands free communications between the dive controls #1 and #2 if they are installed in separate rooms. Also, there must be a video combo where the supervisor preparing the next dive can see and hear what happen during the previous dive. For a better communication, the best is to install the dive panels in the same room as it is often the case with twin bell saturation vessels *(see photo below)*. Such arrangement allows the supervisors to work together more efficiently.
Note that each supervisor should have the communications that must normally be in a dive control to communicate with the divers, the deck, the bridge, crane operator, and every personnel involved in the diving operation.

3.3 - Baskets or Wet-bells

The ideal organization for in-water decompression is two baskets/bells for each team. Thus, four baskets. Nevertheless, there is sometimes not enough space for four baskets/bells. In this case, the basket of the standby diver can be shared between the two teams (but there must be two standby diver: One for the diver on stops and one for the diver at work). This solution can be considered acceptable as there is a very low likelihood that the diver at work is in trouble the same time as the diver at stops. The deck and the personnel must be organized to have a quick and dedicated response in the case of the intervention of one standby diver.

For continuous diving using surface decompression, the best procedure is to have at least three baskets. The reasons are the same as those explained before. Note that if the diver change is to be performed on the bottom, the basket of the 2nd diver is launched when the 1st diver is recovered to the surface. Some teams prefer launching the 2nd dive when the 1st diver is performing his stops. In this case the basket is launched when the diver is on the stop at 9 m or, if there is no stop at 9 m, when the diver arrives on deck.

Also note that this 3rd basket allows continuing the operations if one basket is in breakdown.

Another procedure that is often used with surface decompression is to use only two baskets and to launch the next diver when the previous diver is at 12 m in the chamber.
As explained before regarding the additional panel, in addition to the inconveniences linked to the use of surface decompression, this procedure is not a real continuous diving operation as a lot of time will be lost to:

- Recover the diver to the surface
- Transfer the diver into the chamber
- Check the panel and the dive station
- Check the divers
- Contact the bridge
- Launch the dive

Mistakes can be made during the preparation of the dive for the reasons explained before.

For these reasons, the recommendation is to use an additional basket/bell even using a surface decompression procedure.

The table below indicates the decompression tables where in-water stops are necessary using standard air with surface oxygen decompression table MT92 & standard air with surface oxygen decompression table DCIEM:

Table air std - surface oxygen decompression MT92

Depth	Bottom time (min)	Deco time at 9 m
36 m	15	0
36 m	20	0
36 m	25	0
36 m	30	0
36 m	35	3
39 m	10	0
39 m	15	0
39 m	20	0
39 m	25	0
39 m	30	3
42 m	10	0
42 m	15	0
42 m	20	0
42 m	25	3
42 m	30	5

Table air std - surface oxygen decompression DCIEM

Depth	Bottom time (min)	Deco time at 9 m
27 m	50	0
27 m	55	1
27 m	60	2
30 m	30	0
30 m	35	0
30 m	40	2
30 m	45	3
30 m	50	4
33 m	25	0
33 m	30	2
33 m	35	3
33 m	40	5
36 m	20	0
36 m	25	2
36 m	30	4
36 m	35	6
39 m	20	0
39 m	25	5
39 m	30	7
42 m	15	0
42 m	20	4
42 m	25	7
42 m	30	6 (+ 4 @ 12 m)

3.4 - Chamber availability

The following texts must be taken into account:

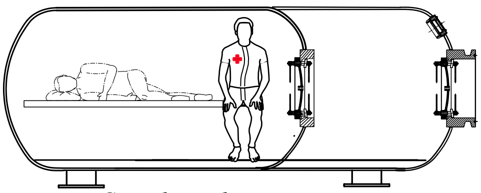
- IMCA 14 says, "No surface supplied diving operation within the scope of this code is to be carried out unless a two compartment chamber is at the work site to provide suitable therapeutic recompression treatment."
- IOGP 411 appendix 10 says that there must be at least one decompression chamber. It is also said that additional DDCs may be required where treating a DCI incident may stop diving operations if only one DDC is available.
- Sufficient divers should have received additional first aid training to ensure that one trained diver can accompany the injured diver during treatment inside the chamber. Their training should be at diver medic level. There should be another diver medic outside the chamber to act as a communication link to remote medical advice (DMAC 11).

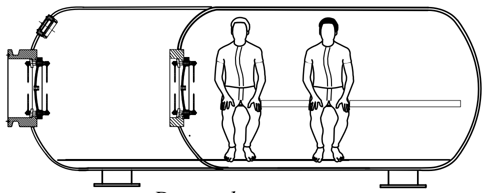
Note that for the situations explained in the next pages, it is considered that the divers at work are not diver medic. This is to take into account the worse scenarios.

3.4.1 - When carrying out surface decompression:

The recommendation is to have two decompression chambers in the case that surface oxygen decompression is the method of decompression selected.
The reasons that are agreed by most superintendents, diving managers, and diving medical specialists are that:

- If only one chamber is on site, it will be intensively used for the decompressions and may not be immediately available for the casualty.
- The casualty can be injured and on a stretcher. If the chamber is in use, the stretcher cannot be introduced into the chamber and the casualty cannot be properly transferred.
- Note that, as indicated previously, the frequency of Type 2 decompression accidents is higher with surface decompression than in-water decompression and the chamber must be immediately available for the casualty and the diver medic.
- Having a diver medic in the chamber is required, because the assessment and the assistance of the casualty must be performed by qualified people and a diver who has not this qualification cannot do it. The fact that one diver in decompression who is qualified could act as diver medic is not taken into account as it may not be the case when the accident happens, or the diver may not be in condition to act as diver medic.
- The treatments for decompression accidents are long treatments, particularly in the case of Type 2 accidents, and the tender and the casualty must be comfortably installed: Small chambers are not originally designed to welcome more than 2 people.
- If there is only one deck chamber available on the worksite, the rule is to stop the operations whenever the recompression chamber is no longer available.
- If two chambers are used, in the case of any unplanned occurrence, the diving operations can continue using the second chamber as a back-up.


Casualty under treatment


Divers decompressing

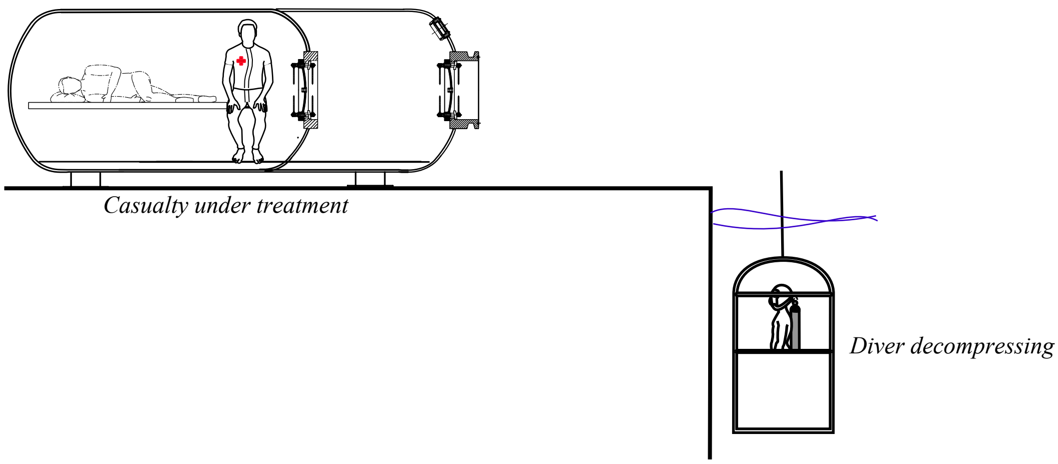
3.4.2 - When carrying out in-water decompression:

The recommendation is to have two decompression chambers for most the reasons indicated above.
Nevertheless, because the decompression of the divers is not carried out in the chamber, one decompression chamber can be considered acceptable if the diver at work can be recovered on free time (without decompression stops).
This point has to be explained and accessed.

3.4.2.1 - Assess what is commonly considered acceptable by IOGP and IMCA members for diving teams performing air/nitrox diving with only one chamber available on the worksite.

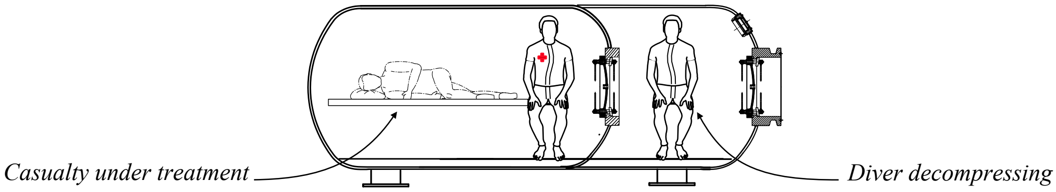
- 3.4.2.1.1 - If the diver is in the water and a decompression accident has to be treated:

- If in water decompression is possible (as planned), the casualty is transferred into the chamber with a diver medic. The diver returns to the basket /bell and is decompressed in-water as it is planned in the original procedure.

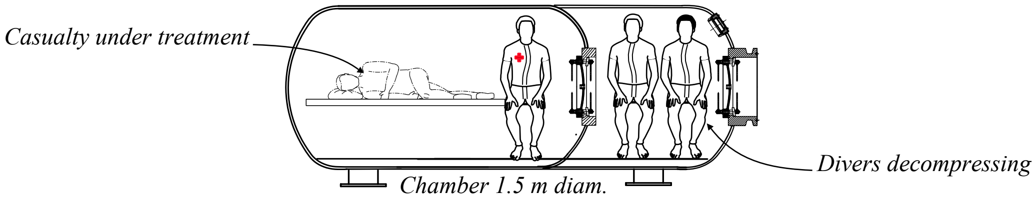


  Note that in this case the diving operations are stopped until the treatment in the chamber is completed and the chamber returned ready for use.

- If in-water decompression is not possible, and the casualty is under treatment in the chamber, the diver is transferred into the entry lock and decompressed accordingly to the corresponding surface oxygen decompression table. This procedure is common and the likelihood that difficult in-water decompression happens at the same time the chamber is already used is considered low. Nevertheless, it may happen. Hence, from a legal perspective , it is a foreseeable risk which should be prevented.



- 3.4.2.1.2 - If two divers are in the water and a decompression accident has to be treated:
  - If in water decompression is possible (as planned), the casualty is transferred into the chamber with a diver medic, and the divers return to the basket /bell. They are decompressed in the water as it is planned in the original procedure.
  - If in-water decompression is not possible, and the casualty is under treatment in the chamber, the divers are transferred into the entry lock and decompressed accordingly to the corresponding surface oxygen decompression table. This procedure is common and the likelihood that difficult in-water decompression happens at the same time the chamber is already in use is, as indicated before, considered low. Note that two divers who are decompressing in the entry lock of a small chamber are not comfortable.

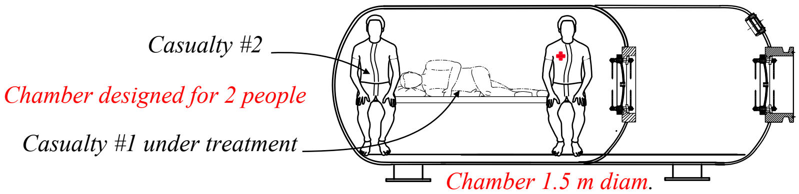


- 3.4.2.1.3 - Case of a diver injured who needs to be transferred into the chamber:

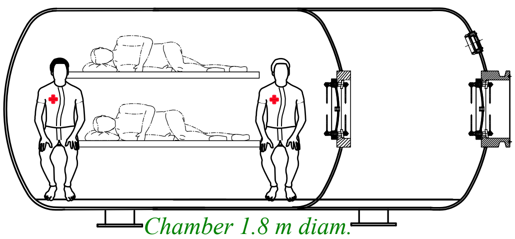
Because the chamber is not in use the casualty can be transferred into the chamber any time. Also, because the dives must be interrupted if the chamber is in use, there is normally no risk to have a diver injured the same time as there is no diver at work on the bottom. The likelihood that another undesirable event happens the same time the casualty is transferred into the chamber is considered low (but it is possible).

- 3.4.2.1.4 - Case of a decompression accident that needs to be treated when a chamber 1.5 m diameter is already in use for another treatment.

In this case the system arrives at the end of its limits as there is already two people in the chamber. The only solution will be to transfer the 2nd casualty into the chamber and apply the longer treatment table to all occupants.
But, the chamber is originally designed for 2 people and not for 3 occupants. That will oblige the tender to work in a very congested environment and rest on the floor as there is only 2 bunks. Also the third oxygen mask is normally a back up in the case of a breakdown. Thus the decompression of the tender will not be comfortable. Note that when a medical treatment is started, it can last for a very long time that can be more than 2 days.



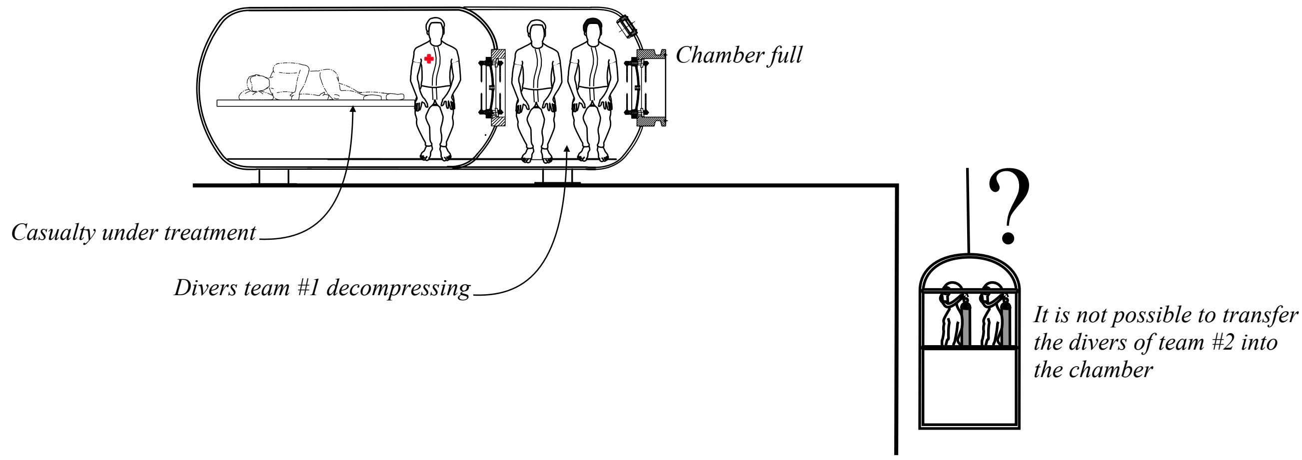
Such a problem can be solved more comfortably if the chamber is 1.8 m diameter and above as these chambers are normally designed with four bunks. In this case another diver medic can be transferred into the chamber with the 2nd casualty and act rotationally with the 1st diver medic.



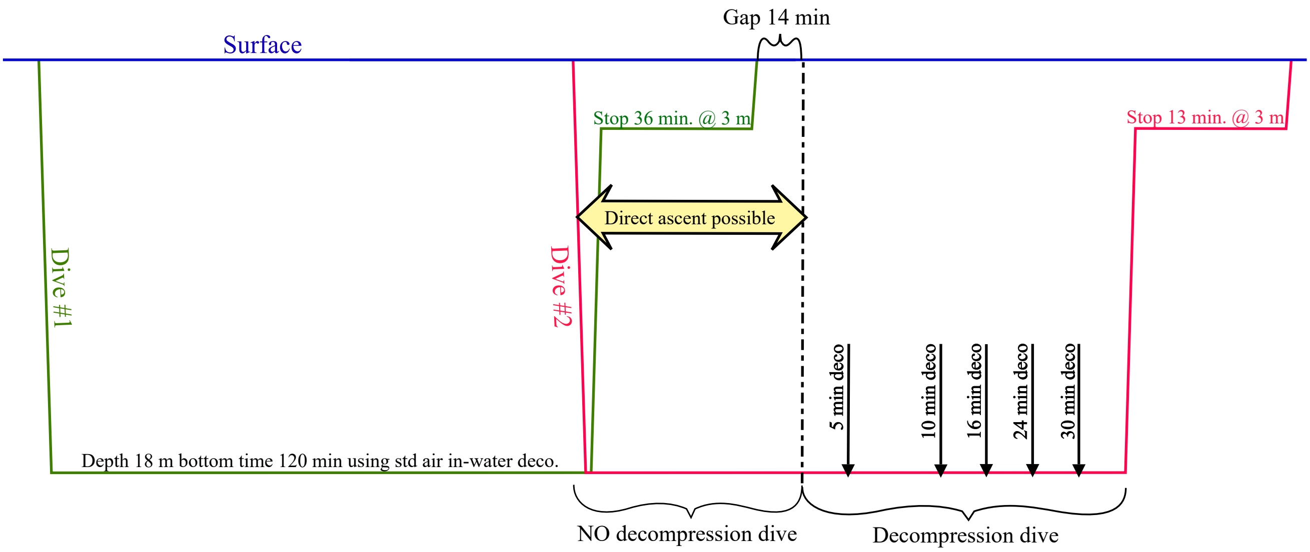
Note that the best solution to solve such problems is to have two chambers.
Nevertheless, this organization of the worksite with only one chamber is considered the “standard organization” for air diving using in-water decompression by most IOGP and IMCA members. For this reason, we can consider that the safety measures that are in place are acceptable, although we can see that this configuration has its limitations and cannot cover all scenarios. It is right that the likelihood that these extreme scenarios happen is considered low.

3.4.2.2 - Assess whether continuous diving using one chamber, offer safety conditions that are at least similar to the conditions described above (that are agreed by IOGP and IMCA members).

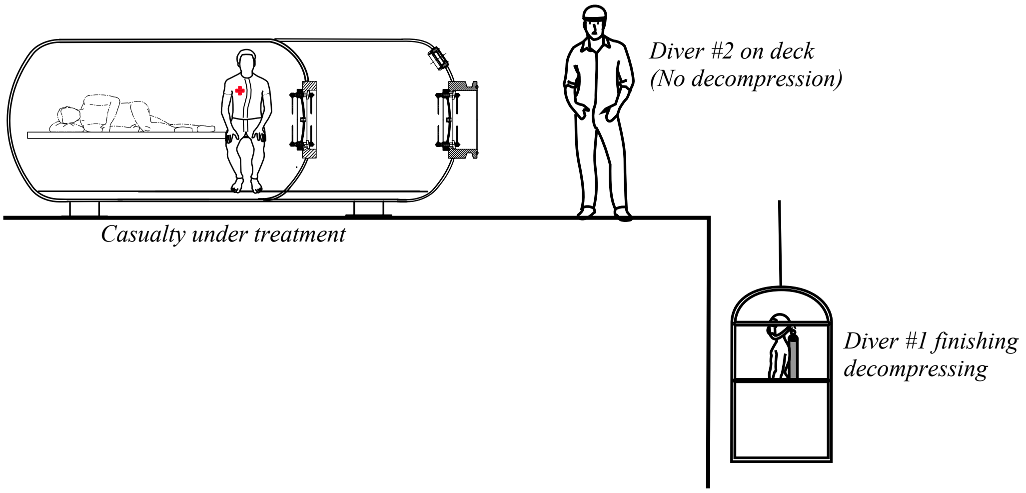
It is not possible to perform continuous diving with one chamber if the divers at work have to perform decompression stops before being recovered when the divers who were previously at work have not yet completed their decompression. In this case, if the chamber is activated and if due to an unplanned reason the decompression in not possible in the water, one team can be in a situation where the divers cannot be recovered to the surface as the chamber is already full *(see drawing below).*



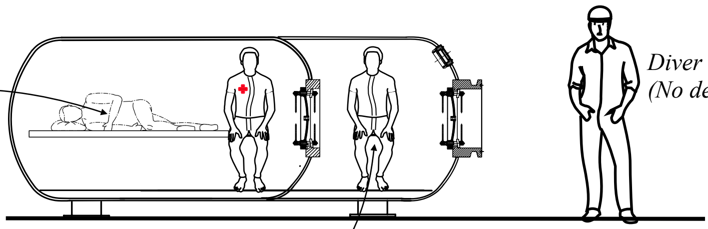
To be in the same condition as what is considered acceptable for "non continuous air diving" the divers at work on the bottom must not have any decompression stop to perform during the time the previous divers are performing their decompression. Thus, the divers at work can be immediately recovered to the deck.



- 3.4.2.2.1 - In the case that a treatment has to be performed in the chamber during a dive:
  If the dive is organized as explained above, the casualty and the diver medic transfer into the chamber. The divers in decompression are finishing their stops while the divers at work are immediately recovered to the deck as they have no decompression stop to perform. It is the same scenario than the one explained point 3.5.2.1.1, and this scenario is considered safe by most IOGP & IMCA members.

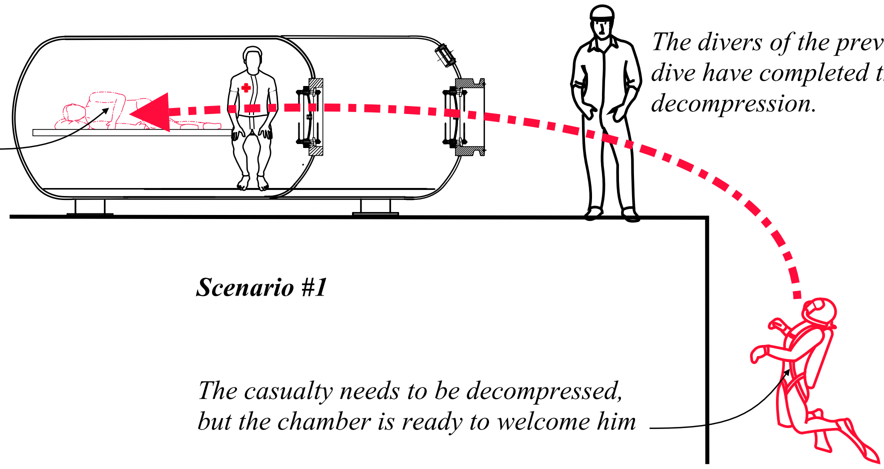


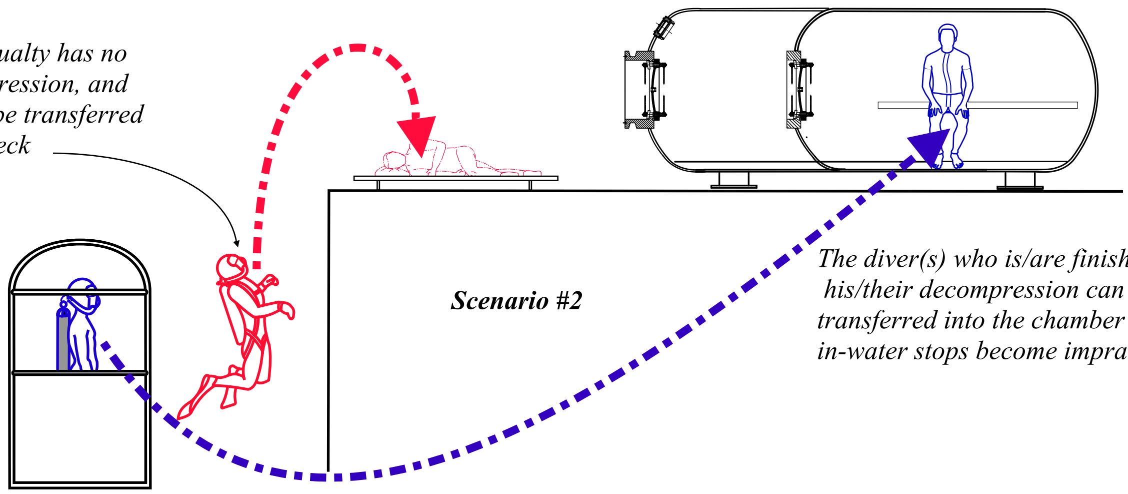
If due to unpredictable reasons the divers decompressing need to be transferred into the chamber, they can perform their stops in the entry lock as with the procedure agreed for "normal" air diving procedure. Because the divers at work have no decompression they can be recovered immediately on deck. It is a condition similar to the one commonly agreed for "normal" in-water decompression diving operations.



- 3.4.2.2.3 - Case of an injured diver who needs to be transferred into the chamber:

Similarly to point 3.5.2.1.3, because the chamber is not used, if the casualty has some stops he can be transferred into the chamber without delays even if a stretcher must be used *(see scenario #1 below)*. Also, because there should not be decompression stop for the divers at work when other divers are decompressing, they can be recovered on deck immediately without decompression stops *(see scenario #2 below)*. Thus, there is a very low likelihood of having conflicts between the divers in decompression and the casualty during the diving operations, even if the divers decompressing have to be recovered into the chamber.
This configuration is considered acceptable for "normal air diving operations", so it is acceptable for continuous operations if the dives are organised within the limits described.

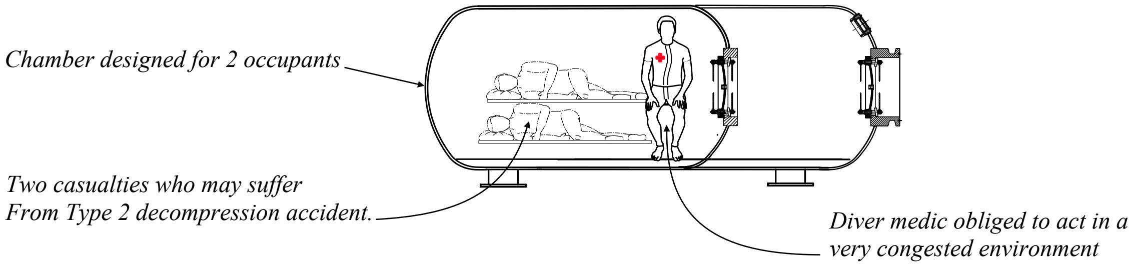




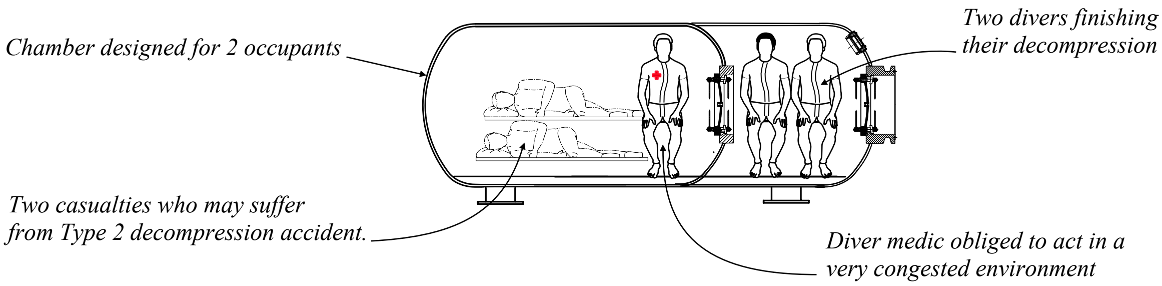
- 3.4.2.2.4 - Case of a decompression accident that needs to be treated when a chamber 1.5 m diameter is already in use for another treatment.:

As explained in point 3.5.2.1.4, in this case, the safety procedures in place arrive at the end of their limits:
There are already two people in the chamber. The only solution is to transfer the 2nd casualty into the chamber and apply the longer treatment table to all occupants. But, the chamber is originally designed for 2 people and not for 3 occupants. That will oblige the tender to rest on the floor as there are only 2 bunks. Also, he will have to act in a very

congested environment which is not an ideal condition to monitor casualties, and he will have to take care of two casualties.
Note that the third oxygen mask that he will have to use if he stays for the duration of the treatment is normally a back up in the case of a breakdown. Thus, depending on the system and whether quick connectors are in place, another line may have to be installed or one mask of the entry lock should be used in the case of a problem.
Note that when a medical treatment is started, it can last for a very long time that can be more than 2 days. A rotation of diver medics can be organized. Nevertheless, if the treatment is long, the team can be quickly short of qualified personnel, and the recommendation is that the diver medic should not have decompression penalties. For this reason, in the case of long treatments, it is preferable to keep the diver medic inside the chamber for the duration of the treatment as recommended by the US Navy.



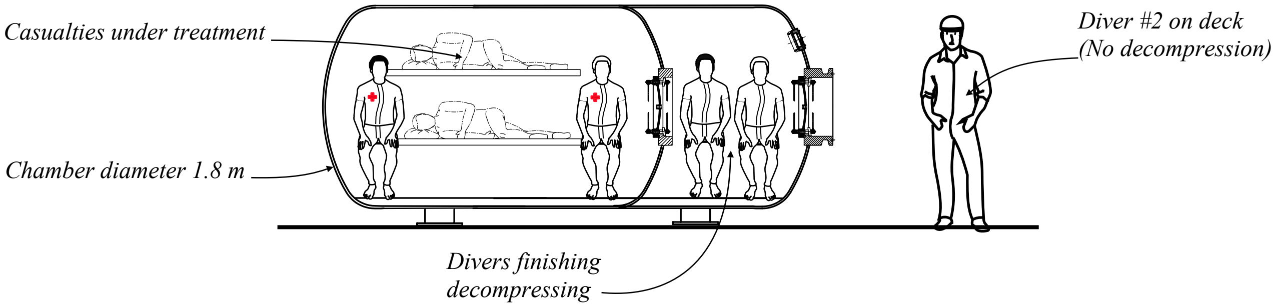
Another extreme scenario is that the divers in decompression cannot perform their stop in the water when the chamber is already occupied by two casualties and the diver medic. In this case, they will have to be transferred into the entry lock and perform their decompression in it. There is a low likelihood that this scenario happens, but it may happen due to this special rule that makes an undesirable event often happen with another one.



Note that such scenarios can happen when performing continuous, and non continuous diving operations as this safety organization is considered sufficient by most IOGP and IMCA members for non continuous diving operations with in-water stops:

- There is one, or several casualties under treatment,
- the diving operations have been stopped,
- divers are finishing their decompression in the water.
- there is no problem for the divers who were at work on the bottom as they have no decompression stop.

As explained in point 3.5.2.1.4, the problems linked to the number of occupants can be solved if the chamber is 1.8 m diameter and above because these chambers are normally designed with four bunks. In this case, another diver medic can be transferred into the chamber with the 2nd casualty and acts rotationally with the 1st diver medic. The two divers finishing their decompression in the entry lock will be more comfortable.



3.4.2.3 - Make sure when continuous diving with one chamber is applicable within the limits indicated:

The scenarios above demonstrate that continuous diving operations with in-water decompression and only one chamber offer the same level of safety as classical diving operations with one chamber if the dives are performed within the limits explained before. This configuration is, of course, more limited than continuous diving operation with two chambers because the decompression times must be inferiors to the no-decompression time instead of the bottom time of the diver at work. The list of depths and bottom times that are applicable using the MT92 or DCIEM standard air in-water decompression procedures are displayed on the next pages.

Elements indicated in the tables:

- The depths and bottom times are strictly those of the tables MT92 and DCIEM.
- The column "Gap no decompression time minus stops" indicates the remaining time the diver can be recovered to the deck without performing decompression stops when the decompression of the previous team is completed. Passed this time, the diver will have to perform some stops before being recovered to the deck.
- The column "Continuous dive with 1 chamber" indicates whether the dive is "Possible" or "Impossible". A safety margin of 10 minutes between the end of the decompression of the previous team and the end of the no decompression time of the diver is recommended. For this reason, when the difference between the two times is less than 10 minutes it is indicated "Possible < 10min"

Table standard air - MT92/2012 - In-water decompression

Depth	Bottom time (min)	No deco time	Total stop time (minutes)	Gap no deco. time minus stops	Continuous dive with 1 chamber
12 m	165	165	1	164	Possible
12 m	170	165	4	161	Possible
12 m	180	165	6	159	Possible
12 m	210	165	11	165	Possible
12 m	240	165	16	149	Possible
15 m	80	80	2	78	Possible
15 m	90	80	4	76	Possible
15 m	100	80	6	74	Possible
15 m	110	80	8	72	Possible
15 m	120	80	13	67	Possible
15 m	130	80	16	64	Possible
15 m	140	80	21	59	Possible
15 m	150	80	26	54	Possible
15 m	160	80	26	54	Possible
15 m	170	80	31	49	Possible
15 m	180	80	35	45	Possible
15 m	210	80	45	35	Possible
15 m	240	80	60	20	Possible
18 m	50	50	2	48	Possible
18 m	55	50	5	45	Possible
18 m	60	50	7	43	Possible
18 m	70	50	9	41	Possible
18 m	80	50	17	33	Possible
18 m	90	50	22	28	Possible
18 m	100	50	27	23	Possible
18 m	110	50	32	18	Possible
18 m	120	50	37	13	Possible
18 m	130	50	44	6	Possible < 10 min
18 m	140	50	51	-1	IMPOSSIBLE

Depth	Bottom time (min)	No deco time	Total stop time (minutes)	Gap no deco. time minus stops	Continuous dive with 1 chamber
21 m	35	35	2	33	Possible
21 m	40	35	5	30	Possible
21 m	45	35	7	28	Possible
21 m	50	35	9	26	Possible
21 m	60	35	17	18	Possible
21 m	70	35	22	13	Possible
21 m	80	35	30	5	Possible < 10 min
21 m	90	35	37	-2	IMPOSSIBLE
24 m	25	25	2	23	Possible
24 m	30	25	5	20	Possible
24 m	35	25	7	18	Possible
24 m	40	25	9	16	Possible
24 m	45	25	12	13	Possible
24 m	50	25	17	8	Possible < 10 min
24 m	60	25	25	0	NOT POSSIBLE
27 m	20	20	3	17	Possible
27 m	25	20	5	15	Possible
27 m	30	20	7	13	Possible
27 m	35	20	12	8	Possible < 10 min
27 m	40	20	17	3	Possible < 10 min
27 m	45	20	20	0	NOT POSSIBLE
30 m	15	15	3	12	Possible
30 m	20	15	6	9	Possible < 10 min
30 m	25	15	8	7	Possible < 10 min
30 m	30	15	13	2	Possible < 10 min
30 m	35	15	17	-2	IMPOSSIBLE
33 m	12	12	3	9	Possible < 10 min
33 m	15	12	6	6	Possible < 10 min
33 m	20	12	8	4	Possible < 10 min
33 m	25	12	13	-1	IMPOSSIBLE

Standard air table DCIEM →

Standard air table - DCIEM - In-water decompression

Depth	Bottom time (min)	No deco time	Total stop time (minutes)	Gap no deco. time minus stops	Continuous dive with 1 chamber
15 m	75	75	1	74	Possible
15 m	100	75	5	70	Possible
15 m	120	75	10	65	Possible
15 m	125	75	13	62	Possible
15 m	130	75	16	59	Possible
15 m	140	75	21	54	Possible
15 m	150	75	26	49	Possible
15 m	160	75	31	44	Possible
15 m	170	75	35	40	Possible
15 m	180	75	40	35	Possible
15 m	200	75	50	25	Possible
15 m	220	75	59	16	Possible
15 m	240	75	70	5	Possible < 10 min
18m	50	50	1	49	Possible
18m	60	50	5	45	Possible
18 m	80	50	10	40	Possible
18 m	90	50	16	34	Possible
18 m	100	50	24	26	Possible
18 m	110	50	30	20	Possible
18 m	120	50	36	14	Possible
18 m	130	50	42	8	Possible < 10 min
18 m	140	50	46	4	Possible < 10 min
18 m	150	50	52	-2	IMPOSSIBLE
21 m	35	35	1	34	Possible
21 m	40	35	5	30	Possible
21 m	50	35	10	25	Possible
21 m	60	35	12	23	Possible
21 m	70	35	20	15	Possible
21 m	80	35	29	6	Possible < 10 min
21 m	90	35	37	-2	IMPOSSIBLE
24 m	25	25	2	23	Possible
24 m	30	25	5	20	Possible
24 m	40	25	11	14	Possible
24 m	50	25	15	10	Possible

Depth	Bottom time (min)	No deco time	Total stop time (minutes)	Gap no deco. time minus stops	Continuous dive with 1 chamber
24 m	55	25	20	5	Possible < 10 min
24 m	60	25	27	-2	IMPOSSIBLE
27 m	20	20	2	18	Possible
27 m	25	20	7	13	Possible
27 m	30	20	11	9	Possible < 10 min
27 m	40	20	16	4	Possible < 10 min
27 m	45	20	21	-1	IMPOSSIBLE
30 m	15	15	2	13	Possible
30 m	20	15	8	7	Possible < 10 min
30 m	25	15	12	3	Possible < 10 min
30 m	30	15	15	0	IMPOSSIBLE
33 m	12	12	2	10	Possible < 10 min
33 m	15	12	5	7	Possible < 10 min
33 m	20	12	12	0	IMPOSSIBLE

Table in-water oxygen decompression 6 m - MT92/2012 -

Depth	Bottom time (min)	No deco time	Total stop time (minutes)	Gap no deco. time minus stops	Continuous dive with 1 chamber
12 m	180	165	4	161	Possible
12 m	210	165	6	159	Possible
12 m	240	165	11	154	Possible
15 m	80	80	2	78	Possible
15 m	90	80	4	76	Possible
15 m	100	80	4	76	Possible
15 m	110	80	6	74	Possible
15 m	120	80	8	72	Possible
15 m	130	80	8	72	Possible
15 m	140	80	11	69	Possible
15 m	150	80	16	64	Possible
15 m	180	80	21	59	Possible
15 m	210	80	26	54	Possible
15 m	240	80	31	49	Possible

Depth	Bottom time (min)	No deco time	Total stop time (minutes)	Gap no deco. time minus stops	Continuous dive with 1 chamber
18 m	50	50	2	48	Possible
18 m	60	50	4	46	Possible
18 m	70	50	6	44	Possible
18 m	80	50	8	42	Possible
18 m	90	50	11	39	Possible
18 m	100	50	16	34	Possible
18 m	110	50	16	34	Possible
18 m	120	50	21	29	Possible
18 m	130	50	26	24	Possible
18 m	140	50	31	19	Possible
18 m	150	50	36	14	Possible
18 m	180	50	41	9	Not recommended
21 m	35	35	2	33	Possible
21 m	40	35	5	30	Possible
21 m	45	35	5	30	Possible
21 m	50	35	7	28	Possible
21 m	60	35	9	26	Possible
21 m	70	35	12	23	Possible
21 m	80	35	17	18	Possible
21 m	90	35	22	13	Possible
21 m	100	35	27	8	Possible < 10 min
21 m	110	35	27	8	Possible < 10 min
21 m	120	35	32	3	Possible < 10 min
24 m	25	25	2	23	Possible
24 m	30	25	5	20	Possible
24 m	35	25	5	20	Possible
24 m	40	25	7	18	Possible
24 m	45	25	7	18	Possible
24 m	50	25	9	16	Possible
24 m	60	25	17	8	Possible < 10 min
24 m	70	25	22	3	Possible < 10 min
24 m	80	25	27	-2	IMPOSSIBLE
27 m	20	20	3	17	Possible
27 m	25	20	5	15	Possible

Depth	Bottom time (min)	No deco time	Total stop time (minutes)	Gap no deco. time minus stops	Continuous dive with 1 chamber
27 m	30	20	5	15	Possible
27 m	35	20	7	13	Possible
27 m	40	20	9	11	Possible
27 m	45	20	12	8	Possible < 10 min
27 m	50	20	17	3	Possible < 10 min
27 m	60	20	22	-2	IMPOSSIBLE
30 m	15	15	3	12	Possible
30 m	20	15	5	10	Possible
30 m	25	15	5	10	Possible
30 m	30	15	7	8	Possible < 10 min
30 m	35	15	9	6	Possible < 10 min
30 m	40	15	17	-2	IMPOSSIBLE
33 m	12	12	3	9	Possible < 10 min
33 m	15	12	6	6	Possible < 10 min
33 m	20	12	6	6	Possible < 10 min
33 m	25	12	8	4	Possible < 10 min
33 m	30	12	10	2	Possible < 10 min
33 m	35	12	13	-1	IMPOSSIBLE

Table in-water oxygen decompression 6 m - DCIEM

Depth	Bottom time (min)	No deco time	Total stop time (minutes)	Gap no deco. time minus stops	Continuous dive with 1 chamber
15 m	75	75	1	74	Possible
15 m	120	75	10	65	Possible
15 m	130	75	16	59	Possible
15 m	140	75	21	54	Possible
15 m	160	75	31	44	Possible
15 m	170	75	35	40	Possible
15 m	180	75	40	35	Possible
15 m	200	75	28	47	Possible
15 m	220	75	32	43	Possible
15 m	240	75	36	39	Possible

Depth	Bottom time (min)	No deco time	Total stop time (minutes)	Gap no deco. time minus stops	Continuous dive with 1 chamber
18m	50	50	1	49	Possible
18 m	80	50	7	43	Possible
18 m	90	50	12	38	Possible
18 m	100	50	17	33	Possible
18 m	110	50	21	29	Possible
18 m	120	50	24	26	Possible
18 m	140	50	30	20	Possible
18 m	160	50	35	15	Possible
18 m	180	50	40	10	Possible
21 m	35	35	1	34	Possible
21 m	50	35	8	27	Possible
21 m	70	35	14	21	Possible
21 m	80	35	20	15	Possible
21 m	90	35	25	10	Possible
21 m	100	35	29	6	Possible < 10 min
21 m	110	35	32	3	Possible < 10 min
21 m	120	35	36	-1	IMPOSSIBLE
24 m	25	25	2	23	Possible
24 m	35	25	8	17	Possible
24 m	50	25	10	15	Possible
24 m	55	25	14	11	Possible
24 m	60	25	18	7	Possible < 10 min
24 m	70	25	25	0	IMPOSSIBLE
27 m	20	20	2	18	Possible
27 m	25	20	7	13	Possible
27 m	40	20	11	9	Possible < 10 min
27 m	45	20	13	7	Possible < 10 min
27 m	50	20	19	1	Possible < 10 min
27 m	55	20	24	-4	IMPOSSIBLE
30 m	15	15	2	13	Possible
30 m	20	15	7	8	Possible < 10 min
30 m	30	15	11	4	Possible < 10 min
30 m	35	15	12	3	Possible < 10 min
30 m	40	15	16	-1	IMPOSSIBLE

Depth	Bottom time (min)	No deco time	Total stop time (minutes)	Gap no deco. time minus stops	Continuous dive with 1 chamber
33 m	12	12	2	10	Possible < 10 min
33 m	20	12	9	3	Possible < 10 min
33 m	25	12	11	1	Possible < 10 min
33 m	30	12	13	-1	IMPOSSIBLE

3.4.2.4 - Why are divers decompressed in the entry lock and not in the chamber when a treatment is ongoing?

As explained before, what was considered acceptable a few years ago, is not acceptable today.
When a diver is under treatment, he must be monitored by a diver medic who is qualified to perform the appropriate actions and report to the Diving Medical Specialist of the company who is generally remote. A diver who is not qualified can miss important details and the diagnostic of the Diving Medical Specialist can be incorrect if any important information is missing.
For the extreme cases where divers are decompressing in the chamber instead of in the water, they are not supposed to be acting as diver medic during their decompression, and it is impossible to predict whether these divers are diver medic or not. In addition, these divers are finishing a dive, and nothing can ensure us that they will not be affected by decompression sickness. Such events have already happened in the past, and for this reason, procedures to treat decompression accidents during the decompressions have been published. Thus, the diver medic should not have decompression penalties when he is entering into the chamber.

This study recommends to decompress the divers in the entry lock instead of the main chamber for the following reasons:

- To perform the assessment of the casualty, the diver medic needs sufficient space and to be in a calm environment.
- Also, the diver medic needs the same conditions if he has to intervene to treat the casualty.
- Most chambers in service with air diving teams are small chambers 1.5 m diameter that are designed for two occupants.
- If the divers are transferred into the main chamber, they will be decompressed on the treatment table.
  The duration of treatment tables can be very long: Depending on the complications that may happen, it is difficult to predict how long a treatment will last ***see #3 in Notes**.
  Also, during the final decompression the tender may have to breathe oxygen. If there is more that one diver in addition to the casualty and the diver medic in a small chamber, one of them has to use a BIB's that is in the entry lock as most small chambers have only the minimum, so 2 masks + a backup. During this time, the entry lock cannot be used.
  The minimum duration of treatment tables that may be used must be kept in mind:
    - USN Table 5 = 2 hours & 15 minutes
    - COMEX Cx 12 = 2 hours & 30 minutes
    - USN Table 6 = 4 hours & 45 minutes
    - COMEX Cx 18 = 5 hours
    - USN Table 6A = 5 hours & 50 minutes
    - COMEX Cx 30 = 7 hours & 30 minutes
    - USN Table 4 = 39 hours & 6 minutes
    - USN Table 7 = 48 hours
    - COMEX CX 30 saturation = 54 hours
- If a diver is decompressed using a medical table he will not be available for the duration of the table plus the surface interval necessary to be able to dive with no decompression penalty.
- Because IOGP/HSE bottom time limits must be applied, the decompression times are reduced accordingly. Thus, if MT92/2012 or DCIEM tables are used within the recommended limits, the maximum decompression time in the entry lock should not be more than 61 minutes. Passed this time the divers can be recovered on deck and the treatment in the chamber can continue normally.
  Because most decompression times are approximately of the same duration as the decompression of a tender who is recovered after an intervention inside the chamber, they can be considered acceptable. Nevertheless, because the entry lock must be available as soon as possible, a decompression time of approximately 30 minutes, should be considered a wise limit if, due to an exceptional situation, the divers finishing their dive have to be decompressed in the entry lock.
  Note that the occupation of the entry lock can be reduced by selecting a bottom time that requires less decompression. Of course, that will have an additional impact on the working time. The table that is displayed on the next page can be used for this purpose. For each depth and bottom time it shows:
    - The maximum decompression time in the column "Deco. Time"
    - The decompression that is required in the entry lock in the column "Time in entry lock"
    - The percentage of the treatment Table 5 USN the entry lock will be unavailable (in the last column). Note that Table 5 is selected for this calculation because it is the shorter medical table proposed.

Table standard air with surface oxygen decompression MT92/2012

Depth	Bottom time (min)	Deco time	Time in entry lock	% Table 5 USN in the entry lock
12 m	180	20	16	0.12
12 m	210	20	16	0.12
12 m	240	20	16	0.12
15 m	90	21	16	0.12
15 m	100	21	16	0.12
15 m	110	21	16	0.12
15 m	120	21	16	0.12
15 m	130	21	16	0.12
15 m	140	26	21	0.16
15 m	150	31	26	0.19
15 m	180	36	31	0.23
18 m	60	21	16	0.12
18 m	70	21	16	0.12
18 m	80	21	16	0.12
18 m	90	26	21	0.16
18 m	100	31	26	0.19
18 m	110	36	31	0.23
18 m	120	36	31	0.23
18 m	130	41	36	0.27
18 m	140	51	46	0.34
18 m	150	51	46	0.34
21 m	40	21	16	0.12
21 m	45	21	16	0.12
21 m	50	21	16	0.12
21 m	60	21	16	0.12
21 m	70	26	21	0.16
21 m	80	31	26	0.19
21 m	90	36	31	0.234
21 m	100	46	41	0.31
21 m	110	51	46	0.34

Depth	Bottom time (min)	Deco time	Time in entry lock	% Table 5 USN in the entry lock
21 m	120	56	51	0.38
24 m	30	21	16	0.12
24 m	35	21	16	0.12
24 m	40	21	16	0.12
24 m	45	21	16	0.12
24 m	50	21	16	0.12
24 m	60	26	21	0.16
27 m	25	22	16	0.12
27 m	30	22	16	0.12
27 m	35	22	16	0.12
27 m	40	22	16	0.12
27 m	45	27	21	0.16
27 m	50	32	26	0.2
27 m	60	42	36	0.27
30 m	20	22	16	0.12
30 m	25	22	16	0.12
30 m	30	22	16	0.12
30 m	35	27	21	0.16
30 m	40	32	31	0.23
33 m	15	22	16	0.12
33 m	20	22	16	0.12
33 m	25	22	16	0.12
33 m	30	27	21	0.16
33 m	35	32	26	0.2

Note: The values written in red are not applicable with only one chamber

Table standard air with surface oxygen decompression DCIEM

Table standard air with surface oxygen decompression DCIEM

Depth	Bottom time (min)	Deco time	Time in entry lock	% Table 5 USN in the entry lock
18m	70	18	11	0.08
18 m	80	24	17	0.13
18 m	90	28	21	0.16
18 m	100	32	25	0.18
18 m	110	36	29	0.21
18 m	120	38	31	0.22
18 m	130	45	38	0.29
18 m	140	51	44	0.33
18 m	150	55	48	0.36
18 m	160	59	52	0.39
18 m	170	65	56	0.41
18 m	180	68	61	0.45
21 m	50	14	7	0.05
21 m	60	23	16	0.12
21 m	70	29	22	0.16
21 m	80	34	27	0.2
21 m	90	38	31	0.23
21 m	100	47	40	0.3
21 m	110	53	46	0.34
21 m	120	58	56	0.41
24 m	45	20	13	0.1
24 m	50	25	18	0.13
24 m	55	29	22	0.16
24 m	60	32	25	0.19
24 m	70	38	31	0.23
27 m	35	16	8	0.06
27 m	40	24	16	0.12
27 m	45	29	21	0.16
27 m	50	33	25	0.19
27 m	55	37	28	0.21

Depth	Bottom time (min)	Deco time	Time in entry lock	% Table 5 USN in the entry lock
30 m	30	16	9	0.07
30 m	35	25	18	0.13
30 m	40	32	23	0.17
33 m	25	15	8	0.06
33 m	30	28	17	0.17

Note: The values written in red are not applicable with only one chamber

3.4.2.5 - Conclusion regarding the possibility to organize continuous diving with in-water decompression with only one chamber on the jobsite:

Continuous diving operations with in-water decompression and using only one chamber offer the same level of safety as "normal" air diving operations that are commonly agreed by IOGP and IMCA members if the divers at work on the bottom have no decompression stops to perform during the time the previous divers are performing their decompression. Thus, the divers at work can be immediately recovered to the deck.
Note that this procedure is efficient for shallow depths no deeper than 24 m using oxygen decompression. Passed this depth the bottom times proposed are very limited. Nevertheless, it can be implemented for operations where the maximum depths are limited to 12 - 20 m, and the surface supports available have a limited deck space.

Note that this procedure is not the best, but it is acceptable because it is of an equivalent level of safety of what is considered the "standard procedure" for air diving by the IOGP and IMCA members.
The best procedure for continuous diving, but also, for standard diving operations with in-water decompression is to have two decompression chambers available instead of one.
Having two chambers allows solving extreme cases when there is more than one casualty to treat. Regarding the size of the chambers, vessels of 1.8 m diameter and above are preferable, especially if the dives are frequently organized with two divers, as they can welcome four people instead of two.

Regarding some scenarios described in this discussion, it is true that the likelihood they happen is low, but as explained, such incidents may happen, and the magnitude of the risk they represent is often high. For this reason, they must be considered.

Regarding the operational point of view, remember that if there is only one chamber on site, the operations must be stopped as soon as it is activated. Having a second chamber is insurance to continue the operations and not being stuck for hours.

3.5 - Gases and electrical supplies:

They must be organized according to the additional items that are installed.

3.5.1 - Regarding the gases:

IMCA D 050 provides guidance on the absolute minimum levels of gases to be carried onboard for surface orientated air. Nitrox and heliox diving. This guidance says:

1) Sufficient compressed gas always needs to be available for two emergency dives to the full intended diving depth and time. 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.
2) 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 ***see #3 in Notes**.

   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.
3) 90 m3 (3200 cu ft) of breathing quality oxygen needs to be available for emergency treatment procedures.

Not indicated in IMCA D 050, but in the medical book COMEX, when heliox is used for therapeutic treatments, 90 m³ of 50/50 and 220 m³ of 20/80 must be available.

IMCA D 050 also says:

This document provides guidance to supervisors and others as to when diving operations should not be commenced due to inadequate gas or air 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.

Analysis and recommendations

There is nothing that indicates that there must be an additional reserve or supply system of gas in the case of continuous diving operations involving two chambers and diving panels.
Nevertheless, common sense must be the rule, and it is clear that if the operations are commenced with the absolute minimum, they must be stopped if a part of these gas has been used and the remaining quantities are below the absolute minimum recommended by IMCA D 050. The economic impact of equipment and personnel unemployed at sea for such reasons will be disastrous.

working offshore the operations can be stopped several days, and note that in the case that two chambers are used, there should be the minimum quantities of gas for each chamber because it is impossible to predict in which chamber a treatment will be started. Also, note that in the case that a chamber is used, the diving operation cannot be continued if the quantities of gas for the 2nd chamber are insufficient.

Regarding the calculation of the minimum quantities of gasses, the working conditions on the worksite must be taken into account. For example, the operations can be near a facility where the safety conditions may oblige to recover the divers in the chamber to quickly escape the area, or the operations can be organized in a period of the year where the weather condition may oblige to complete some decompressions in the chamber.

Regarding the air sources, some teams consider suitable to share them between the two dive stations. Nothing in IMCA D 050 says that the air sources of panels or chambers cannot be shared. In fact the main and the backup air sources can supply both stations. Nevertheless, this configuration can lead to problems if both dive stations are in use at the same time, and that will be inevitably the case. IMCA D 023 section 2/point 5 "Air supplies" says:

- *"Sufficient sources of air, of breathing quality, must be available and suitably arranged so that if the on line source to the diver fails, an alternative source can be immediately switched on."*
- *"Each of the sources should be able to provide adequate pressure and flow rates to all divers that they may be required to supply at the maximum depth of the intended diving operation."*
- *"There should be a primary air source for each working diver plus a secondary source."*
- *"For one diver working in the water this requires two sources, one connected as a primary source for the diver and the other as an independent and separate secondary source."*
- *"For two divers working in the water at the same time this requires three sources, connected either as a separate primary source for each diver with a common secondary or else a common primary source feeding both divers but with independent and separate secondary sources to each diver"*
- *"The air supply to each diver must be arranged such that if one line fails then this does not interfere with the supply to another diver"*
- *There must be a primary air source to the standby sufficient to allow him to rescue an injured diver and arranged to be separate from the main and secondary sources to the working diver(s)*

if the air sources are shared, what is said for the air sources of one diving station in IMCA D 023 should apply to supply two separated dive stations.

- There must be a primary and a secondary air source plus a separated air source for the standby diver of each dive station.
- The air supplies must be sufficiently powerful to supply the two dive stations at their maximum pressures and flow rates at the same time. Note that the fact that chambers can be used at the same time must be taken into account. Also, consider that the divers at work can be in an emergency. In this case, their breathing rate can be between 40 l/min (IMCA) and 62.5 l/min (NORSOK).
- The air sources should be arranged such that if a line supplying one station fails the 2nd station should not be deprived of air.

Please take into account that:

- Continuous diving operations means that there is no interruption of the dives. Thus, The air sources should be arranged in such way that it is possible to perform their maintenance without affecting the ongoing operations. The supervisor should be able to switch to the backup supply at all times, and the breakdown of an air source is not going to paralyse the operations.
- Most modern classified dive systems are supposed to be used in the conditions indicated in the classification file. They are generally composed of one diving panel for three divers plus one chamber that can be in the same or a separate container. Thus, they are designed for non-continuous diving operations if used alone or continuous diving operations if used in parallel with another system. Their compressors are sufficient to supply the items in use at their maximum working capacity, but these compressors are generally not sufficiently powerful to supply two dive systems at the same time. Powerful compressors able to supply comfortably two dive systems at the

- same time exist, but they are extremely expensive.
- A dive system that is specific for performing continuous diving operations can be created and classified.

3.5.1 - Regarding the other supplies:

Main and backup generators can be shared by the dive stations and other items, provided that the generators are sufficiently powerful to supply the two dive stations and the items they energize at the same time. As for the air sources, the generators should be arranged in such way that it is possible to perform their maintenance without affecting the ongoing operations . The supervisor should be able to switch to the backup generator at all times, and the breakdown of a generator is not going to paralyse the operations.
The same rule should apply for the hydraulic power packs and the industrial air compressors that may be used for the launch and recovery systems.

4) Assess the additional personnel.

Regarding the working hours, AODC 048 “Offshore dive team manning levels” says:

- 1 - Diving activities should normally be planned on the basis that the diving team, with the exception of divers in saturation, will work for a maximum of twelve hours in any period of twenty-four hours. A rest period of a minimum of eight hours continuous duration must be allocated in each twenty-four hour period.
- 2 - If the guidance given above cannot be adhered to, and it is necessary to work for longer than twelve hours in any twenty four hour period, manning levels should be increased so as to allow either the cyclic replacement of part of the diving team or to provide sufficient personnel to work in two shifts, each of twelve hours duration.
- 3 - When diving in areas of strong tidal current, where diving is limited to those periods of slack water which occur when the tide turns, the timing and duration of operations will be dictated by a mixture of astronomical and environmental conditions. If three periods of slack water are required to be worked in each day, it will not be possible to follow the guidance -1- above and the procedure to be followed should then be:
  - Where manning levels are planned so as to allow working for two periods of slack water in each day. This may very occasionally be extended to three periods of slack water in each day, for up to a maximum of three days as a single exercise, provided that a rest period of a minimum of eight hours continuous duration be allocated in each twenty-four hour period and that on completion the diving team is rested for a minimum of twelve consecutive hours.
  - Where it is planned that working for three periods of slack water in each day should be sustained for longer than three days, manning levels should be arranged to meet the guidance -2- above.
- 4 - No person will be expected to work for more than 12 hours without an intermediate meal break taken away from their place of work. Personnel also need toilet and refreshment breaks during their shifts. (IMCA 14)

The implementation of continuous diving operations requires that the number of personnel is adjusted according to the number of dives that must be performed each day.

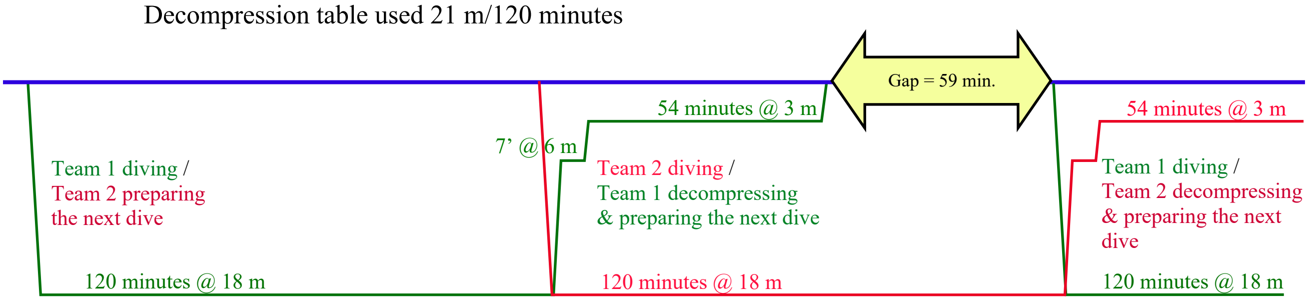
For continuous diving operations it is necessary to appoint at least two diving supervisors each shift because it is impossible for a supervisor to prepare and manage a dive at the same time. Note that IMCA 14/point 3.5 says:

- The supervisor with responsibility for the operation is the only person who can order to start a dive.
- Supervisors can only supervise as much of a diving operation as they can personally control, both during routine operations and if an emergency should occur.
- A diving supervisor should only hand over control to another supervisor appointed in writing by the diving contractor
- Note that in the case that life support technicians or chamber operators are employed to manage the decompressions, they work under the responsibility of the diving supervisor *(IMCA 14 point 5.2.4).*

Based on what is said above, in the case of intensive operations it can be necessary to appoint a third supervisor.

What is said above can be illustrated by the examples below:

1st scenario: Continuous diving operations at 18 m /120 minutes bottom time (IOGP/HSE operational limit).
Decompression table used 21 m/120 minutes



Number of dives using continuous diving operations @ 18 m

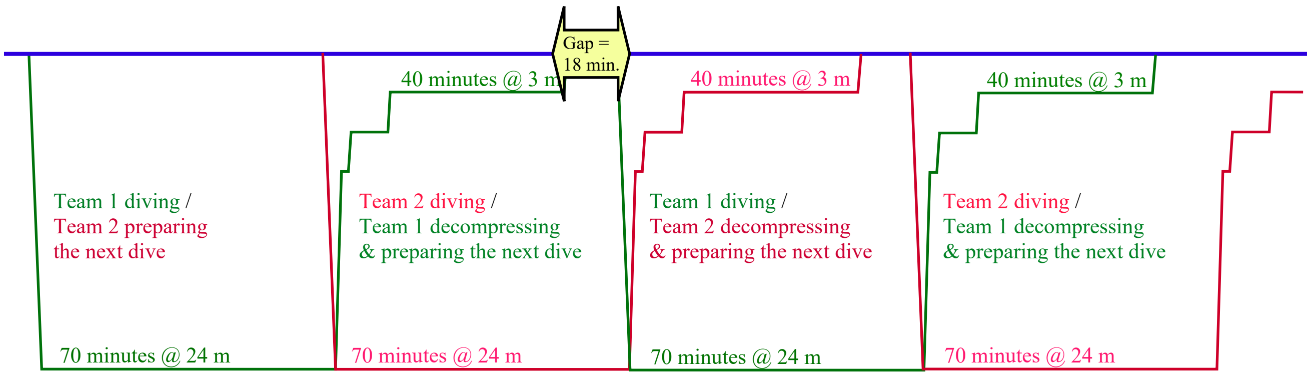
Action	Duration main activity in minutes	Remaining duration of the shift in minutes
Divers on deck	0 min (Starting shift)	720 minutes
Tool box talk and preparation of the dive station (check lists, certificates , permits to work & dive)	60 minutes	660 minutes
Dive #1	120 min bottom (61 min deco performed during the next dive)	540 minutes
Dive #2	120 min bottom (61 min deco performed during the next dive)	420 minutes
Dive #3	120 min bottom (61 min deco performed during the next dive)	300 minutes

Action	Duration main activity in minutes	Remaining duration of the shift in minutes
Dive #4	120 min bottom (61 min deco performed during the next dive)	180 minutes
Dive #5	120 min bottom (61 min deco performed during the next dive)	60 minutes
Dive #6	50 min bottom (10 min deco)	0 minutes

Number of dives using non-continuous diving operation @ 18 m (for comparison)

Action	Duration main activity in minutes	Remaining duration of the shift in minutes
Divers on deck	0 min (Starting shift)	720 minutes
Tool box talk and preparation of the dive station (check lists, certificates , permits to work & dive)	60 minutes	660 minutes
Dive #1	196 min (181 minutes dive time + 15 min for launching the next dive.)	464 minutes
Dive #2	196 min (181 minutes dive time + 15 min for launching the next dive.)	268 minutes
Meal diving supervisor	60 min	208 minutes
Dive #3	196 min (181 minutes dive time + 15 min for launching the next dive.)	12 minutes
Dive #4	12 min. dive time	0 minutes

2nd scenario: Continuous diving operations at 24 m /70 minutes bottom time (IOGP/HSE bottom time limit). Decompression table used 27 m/70 min minutes



Number of dives using continuous diving operations @ 24 m

Action	Duration	Remaining time in minutes
Divers on deck	0 min (Starting shift)	720 min
Tool box talk and preparation of the dive station (check lists, certificates , permits to work & dive)	60 min	590 min
Dive #1	70 min bottom (52 min deco performed during the next dive)	520 min
Dive #2	70 min bottom (52 min deco performed during the next dive)	450 min
Dive #3	70 min bottom (52 min deco performed during the next dive)	380 min

Action	Duration	Remaining time in minutes
Cumulated meals diving supervisors	60 min	320 min
Dive #4	70 min bottom (52 min deco performed during the next dive)	250 min
Dive #5	70 min bottom (52 min deco performed during the next dive)	180 min
Dive #6	70 min bottom (52 min deco performed during the next dive)	110 min
Dive #7	70 min bottom (52 min deco performed during the next dive)	40 min
Dive #8	29 min bottom (11 min deco)	0 min

Number of dives using non-continuous diving operation @ 14 m (for comparison)

Action	Duration	Remaining time in minutes
Divers on deck	0 min (Starting shift)	720 min
Tool box talk and preparation of the dive station (check lists, certificates , permits to work & dive)	60 min	590 min
Dive #1	137 min (122 minutes dive time + 15 min for launching the next dive.)	453 min
Dive #2	137 min (122 minutes dive time + 15 min for launching the next dive.)	316 min
Meal diving supervisor	60 min	256 min
Dive #3	137 min (122 minutes dive time + 15 min for launching the next dive.)	119 min
Dive #4	119 min dive time	0 min

Due to the difference of maximum bottom times that are possible, fewer divers are necessary at 18m.
The comparison with non-continuous diving operations shows that two additional dives can be done at 18 m and four additional dives at 24 m. Thus, between two and four additional divers will be necessary at 18 m and between four and eight additional divers at 24 m, depending on the number of divers planned each dive.
Continuous diving has a multiplying effect as the number of divers with non-continuous diving operations of these examples are similar.
Because the tasks on deck remain the same (tenders for the divers, standby diver + his tender, winch man, lead diver), more personnel will be available to prepare the next dives with continuous diving operations than with non-continuous diving operations where the divers are longer time on duty.

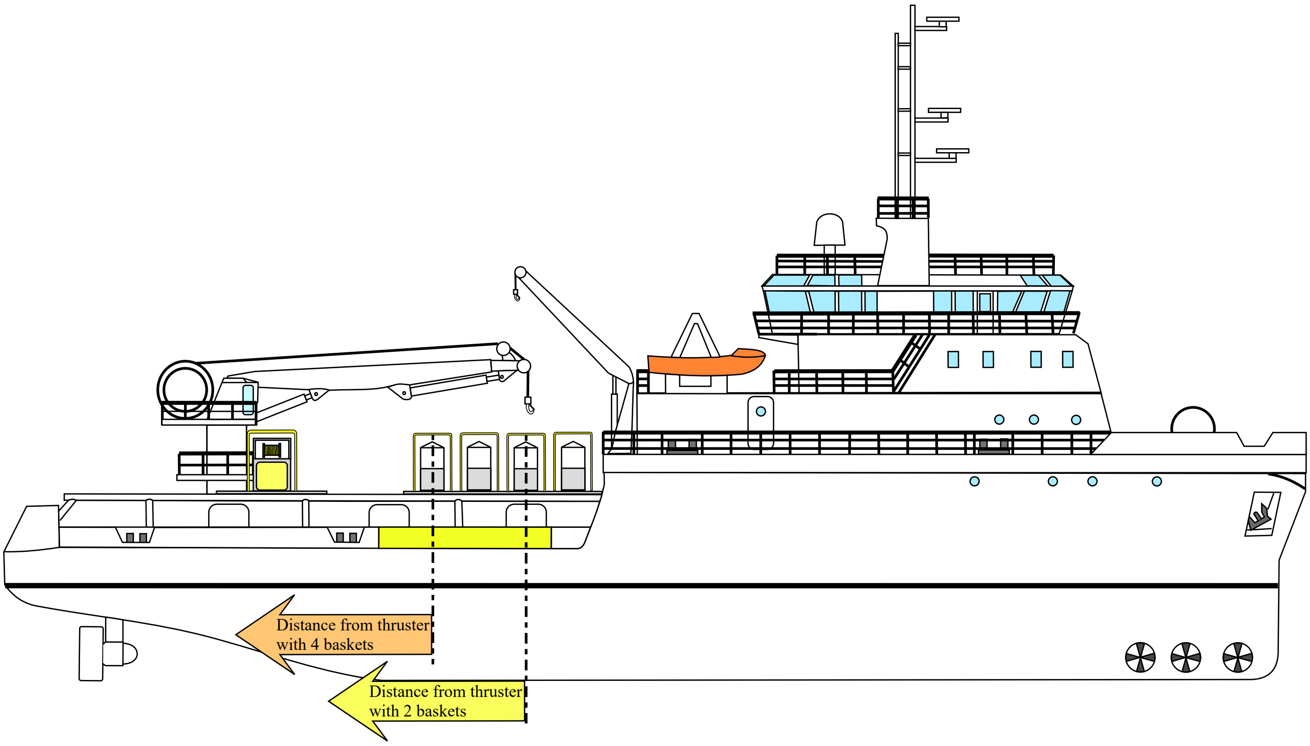
Another point to consider is that the gap between two dives at 18 m is 59 minutes instead of only 18 minutes for dives at 24 m. Fifty-nine minutes gap allows the supervisor to relax or have his meal between two dives. It is less feasible at 24 metres as there is only 18 minutes gap between two dives.
Eighteen minutes does not give much time to relax as the supervisor must prepare to launch the next dive at the end of the previous decompression. Also, the time between two dives is too short for having a meal. As a result, the operations must be stopped because the supervisor is not available on site during this time.
This loss of time can be avoided if a third supervisor is on duty. Also, the fatigue of key personnel is often the cause of incidents and when the frequency of dives is high, the best manner to prevent such incidents is to have a third supervisor and additional key personnel on shift. Note that:

- IMCA R004 says point 9.3 *"The maximum number of hours that a member of the ROV team pilots an ROV should not exceed six hours in every 24 hour period under normal circumstances".*
- NORSOK standard U-100 says point 8.4.6: *"The diving supervisor shall have a rest period from the direct communication control after a period of 4 h. The rest period shall be at least 30 min. The total time for this function shall be limited to 8 h in the course of a 12 h period. The workload should determine the length of the rest periods. Inside a 24 h period supervisory personnel should normally have a 12 h period of continuous rest."*

What is already in force to control machines or in Norway should be considered and discussed with the client.

5) Assess whether the personnel and equipment can be accommodated on the surface support.

Before implementing the continuous diving operation, it is necessary to make sure that the necessary equipment, divers, and key personnel can be accommodated on board the vessel that is selected for the project. Also, if the operation is planned from a Dynamic Positioning vessel, the additional baskets may be too close to the propeller to allow the diver sufficient length of umbilical to reach the planned job site safely. As a result, even though the vessel can accommodate the diving system and the personnel, a longer vessel will be necessary to have sufficient distance between the basket/bell and the propellers or thrusters.



When the surface support is limited by its' size, which is often the case with the vessels used for inspection projects, the team preparing the vessel may be obliged to install additional platforms to secure the items. It is often the case with the boats of opportunity that are designed for another purpose than diving. These platforms must be checked and agreed by a classification society.

5.1 - Make sure that the totality of the equipment can be accommodated according to the rules for the organization and the housekeeping of the dive station:

The deck layout of the planned vessel should be studied before starting the mobilization, and if it appears that the vessel cannot accommodate the equipment, the team must look for another vessel. The following elements that are more detailed in the diving manuals should be assessed:

- Access and safe circulation

- The access of any area in the dive station must be easy and secured: Tripping hazards must be removed, and those that cannot be must be highlighted with caution signs displayed around (yellow background with red or black stripes are commonly used); differences of level on deck must be indicated too. Low beams that people may face must be indicated with caution signs and wrapped with materials absorbing shocks such as neoprene, plastic foam, or similar.
- Additional LARS platform, additional working platforms and stairs must be fitted with hand rails and/or barriers to prevent the personnel from falling down on deck or into the sea. Also, the winches and drums must be protected with guards and there must be sufficient space to avoid the personnel at work not to be at too close proximity during the operations.
- Except for the operations planned only by day light, there must be sufficient lighting to erase shadow areas on deck during the night, and the light in the working areas must be sufficient to allow people to read documents and/or instrument's gauges easily.
- There must be access to the gas banks, the compressors, the chamber, the dive control, the power supplies.

- Protection of/from pressure hoses and electrical wires:

- Hoses, electrical and communication cables of the temporary installation must be arranged to pass at least 2.2 m above the deck using one inch (1") diameter ropes, metallic cables, rigid pipes or cable trays as support, and secured on these supports every 20 cm.
- Hoses and cables running on deck without protection are prohibited. If, for an operational reason, the installation

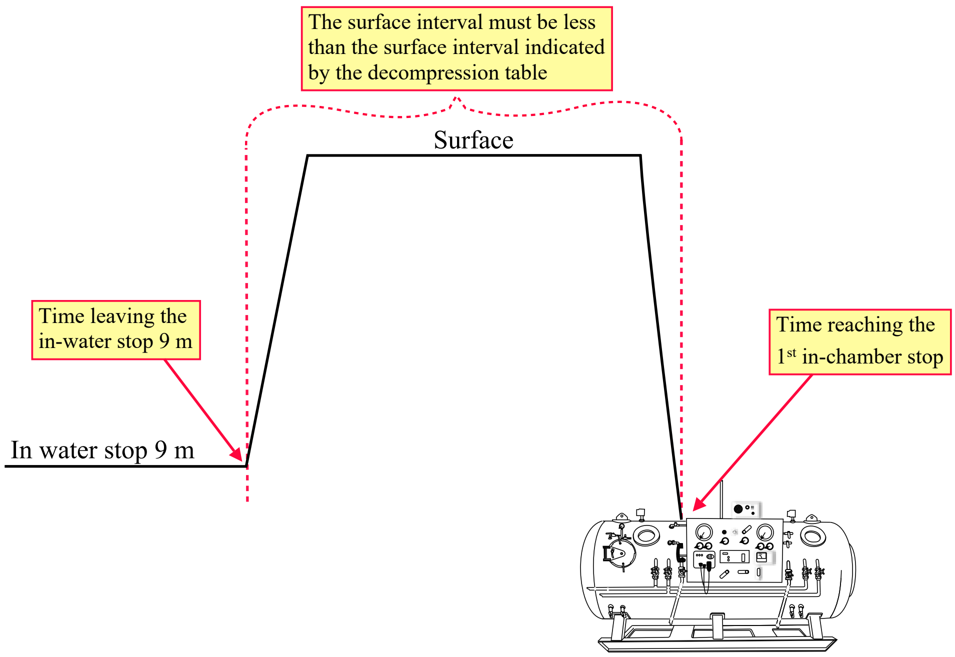
must be organized this way, the hoses must be fully enclosed, protected from shocks and not create a tripping hazard.

- Protection from weather conditions and from falling into the sea:
  - The electrical panels and devices installed outside must be waterproof with dedicated sockets and connectors agreed for works in wet and salted environments.
  - In the case that the free-board of the surface support is less or equal to two (2) meters, containers, control rooms, stores, and electrical equipment must have been installed on welded iron legs of at least 40 cm high, allowing waves to pass freely underneath.
  - There must be a workshop to do the maintenance of sensitive systems, store the tools, protect the spare parts and sensitive systems from the weather.
  - The standby diver must be ready to intervene quickly at any moment. There must be a well protected shelter with a chair on which he can sit comfortably fully dressed, and a screen with sound showing him what is happening on the bottom during the dive.
  - There must be chain guards, doors or any suitable means to close the openings to sea when the diving operations are completed.
- Air compressor and thermal engines
  - The intakes of all compressors must be sited in an area where they are not exposed to any pollution – particularly exhaust fumes. The recommendation is that they should be at more than 2 m above the floor. Because there will be more items on board, having this point satisfactory fulfilled is more difficult, but essential.
  - Machines that are driven by thermal engines should be installed on the open deck, far from any air intake and in an area where their fumes are evacuated by the wind without affecting the personnel working in the surrounding. Because the boat is more congested than with only one dive system, this point is often difficult to organize. Note that electrically driven machines are more appropriate on congested decks.

5.2 - Make sure that decompression dives can be performed safely

A suddenly degraded status may oblige to terminate the dive and recover the diver(s) as soon as possible. For this reason, the surface oxygen decompression table and the chamber must always be ready, even if the method of decompression selected is in-water decompression.
The distance of the chamber from the launching station must be as close as possible, and the time to reach it must be less than the "Surface interval" indicated by the table selected *(7 minutes from leaving the stop at 9 m to the stop at 12 m into the chamber using the DCIEM table, & 4 minutes with MT92/2012 table)*. Note that the time lost to undress the diver(s), unexpected delays, and the fact that the diver(s) must not run on deck have to be taken into account for the calculation. It is also important to make sure that the doors of the chamber can be quickly closed and sealed.
Trip hazards should be removed where possible or highlighted to secure the path between the launching station and the chamber. During his transfer on deck, the diver must be accompanied by a tender who takes care of him. This is to avoid falls and injuries. Note that the diver must wear shoes during this transfer: Walking on deck barefoot is prohibited.

If the conditions indicated above cannot be fulfilled, dives with decompression cannot be undertaken.



5.3 - Make sure that the vessel can accommodate the additional personnel.

Accommodating the additional personnel is often a problem with small boats, but also on barges that are often already

of equipment and passengers.
As an example, a multipurpose vessel 60 m long can accommodate approximately 45 people. Nevertheless, the vessel crew has to be removed from the number of passengers that will be at work. If the vessel is planned to work 24 hours the crew can be approximately 20 people. That let 25 beds for the diving team. If the diving team is working at 18 m as explained in the scenario #1 explained in the previous point, the minimum diving team will be as follows:

- 16 divers
- 4 supervisors
- 4 technicians
- 1 diving superintendent

There is no bed available with this organization of the work. Thus the vessel cannot accommodate the inspectors 3.4U, ROV team, engineers, client representatives, visitors, and other people.
The solution can be the installation of portable cabins. This solution is commonly used when the vessels are too small. Such portable cabins can be organized to welcome up to six passengers
Please, note that cabins are considered as rest area. For this reason these cabins must be away from noisy areas, isolated, and be protected from the waves as most are not equipped with marine doors.
In addition, convenient bathrooms and toilets must be organised and not too far. Toilets are sometimes included in the cabins, and in this case hoses for the supply of water and evacuation of faeces and dirty water must be installed. Depending on the characteristics of the vessel that can lead to technical complications and additional expenses. Also consider that the number of portable cabins that can be installed is often limited on vessels or barges that are often congested.

Another system can be the organization of a hot bunks system similar to what was done in war vessels, particularly in submarines. Nevertheless, the hot bunks system is not popular and can be the source of complaints and bad ambiance. For these reasons this procedure should be avoided, or organized with extreme precautions and only with well known personnel.

Note that in the case of additional passengers; there must be sufficient life rafts to rescue all crews in the case of an abandon ship. Thus, the installation of additional accommodations should conform with the rules and may lead to the installation of additional life rafts.

If the installation of additional cabins is not possible, or too expensive, a boat that is designed to carry more passengers must be selected.

6) Assess whether the continuous diving operation is economically realistic:

Continuous diving operations are more efficient but more expensive than classical non-continuous diving operations. The fact that such operations are accepted by the client may depends on the priority of the mission to be performed. As an example, In the case of a facility that is stopped and must be returned in service as soon as possible, there are some chances that the client will invest in such operation even in the case that a non-continuous diving operation is less expensive.
Nevertheless, depending on the work to perform, passed a depth of 30 m, the costs can be compared with those of a saturation diving operation, as the bottom times will be reduced and a lot of divers may be necessary to perform the planned task. Also, for very shallow depths, the time lost for the diver change is limited if the diver can stay in the water more than 3 hours with very short decompression stops.

The cost of the continuous and non-continuous diving operations must be compared to see which procedure is the most profitable. Note that costs can be impacted by numerous variables such as, but not limited to:

- The additional items that are planned (as an example, the number of chambers)
- Whether the additional equipment is rented or not, and the cost of renting (there are differences between the suppliers)
- The size of the surface support and its consumption (the price commonly indicated is 1$ for 1 Hp.)
- The personnel necessary to perform the operation and their level of competency
- The meals and laundry
- The fees for the mobilization
- The personnel for the mobilization
- The flights and fees for custom
- Travel from flight to the point of mobilization
- Insurances for personnel and equipment
- The depth(s) and bottom times planned for the operation
- The duration planned for the work. Thus, the number of hours necessary to complete the task.
- The distance of the worksite from the port where the mobilization is planned
- The weather conditions that are planned on the worksite. Thus, whether the season is favourable or not.

Note that the additional costs of continuous diving operations can be absorbed with long operations requiring numerous dives. At the opposite projects of short duration can be more profitable with non-continuous diving operations.
As an example, we can make a comparison between non-continuous and continuous diving operation for a project requiring 600 hrs work with two divers in the water at 24 m, using the dive profiles described in point #3. Thus, 70 minutes bottom time and 52 minutes decompression using one additional depth as reinforcement procedure.
- The worksite is at 3 days sailing from the port where the equipment is mobilized
- The dive team is mobilized in another port that is at 1 day sailing from the worksite. Thus, the vessel will sail to this port and transfer the team before sailing to the worksite.
- The weather conditions are normally perfect (favourable seasonal period)
- Diving system and vessels are supposed rented

- Using non continuous diving operations:
  - 560 minutes bottom time are possible every day. Thus, 64 days are necessary to complete the 600 hours
  - The duration of the mobilization of the diving team plus the transit to the job site is planned for 2 days, and the duration of the demobilization is planned for the same time as the mobilization. So a total of four days
  - Thus, the diving team is employed for approximately 68 days
  - The mobilisation of the equipment is planned for two (2) days and the demobilization is planned for the same time. Thus, four days
  - Transit time of the vessel to and from the worksite is 6 days
  - Thus, the time the vessel and the equipment are on hire is 74 days
- Using non continuous diving operations:
  - 1200 minutes bottom time are possible every day. Thus, 30 days are necessary to complete the 600 hours
  - The duration of the mobilization of the diving team plus the transit to the job site is planned for 2 days, and the duration of the demobilization is planned for the same time as the mobilization. So a total of four days
  - Thus, the diving team is employed for approximately 34 days
  - The mobilisation of the equipment is planned for four (4) days and the demobilization is planned for the same time. Thus, eight (8) days
  - Transit time of the vessel to and from the worksite is 6 days
  - Thus, the time the vessel and the equipment are on hire is 44 days

Cost non continuous diving operation @ 24 m - 600 hrs work - 70 min bottom time each dive

Main Item	Detail	Number of items	price /day $	Number of days	Total price $
Dive control	10 ft container Dive panel 3 divers Radios CCTVs	1	600	74	44400
Gas sources	20 ft container LP compressor (30 Hp) HP compressor (7 Hp)	1	390	74	28860
	Air quad 16 bottles D1 +D2	1	150	74	11100
	Air quad 16 bottles D3	1	150	74	11100
	Air quad 16 bottles DDC	1	150	74	11100
	oxygen quad 16 bottles DDC	2	600	74	44400
LARS	Frame + basket driven by hydraulic D1 + D2	1	230	74	17020
	Frame + basket driven by hydraulic D3	1	230	74	17020
DDC	DDC 1.8 m diameter	1	450	74	33300
Divers umbilicals + helmets	Umbilical D1	1	100	74	7400
	Umbilical D2	1	100	74	7400
	Umbilical D3	1	100	74	7400
	KMB 37 D1	1	185	74	13690
	KMB 37 D2	1	185	74	13690
	KMB 18 D3	1	80	74	5920
Tools & Workshop	Tools + workshop container	1	700	74	51800
Boat	Boat 5000 Hp / 25 passengers with full crew + food	1	5000	74	370000
ROV	Observation ROV	1	2000	74	148000
Fuel consumption	In port (2800 litres x 0.7$)	(2800 litres x 0.7 $)	1960	4	7840
	At work (10000 litres x 0.7 $)	(10000 litres x 0.7 $)	7000	64	448000
	Cruising (15500 litres x 0.7 $)	(15500 litres x 0.7 $)	10850	6	65100
Food	Food 15$/ pass.)	35	525	68	35700
Insurances	Equipment		1100	72	79200
	Personnel		1540	68	104720
Diving team	Superintendent	1	1000	68	68000
	Supervisors	2	1600	68	108800
	Divers	12	4800	68	326400
	Technicians	2	600	68	40800
	ROV	6	1140	68	77520
Mobilisation team	Superintendent	3	1000	4	4000
	Tech	3	900	4	3600
	welders	2	60	4	240
Flights	Flights (200$)	23			4600
				TOTAL	2218120

Continuous diving operation @ 24 m - 600 hrs work time - 70 min. Bottom time each dive.

Main Item	Detail	Number of items	price /day $	Number of days	Total price $
Dive control	10 ft container Dive panel 3 divers Radios CCTVs	2	1200	44	52800
Gas sources	20 ft container LP compressor (30 Hp) HP compressor (7 Hp)	2	780	44	34320
	Air quad 16 bottles D1 + D2	2	600	44	26400
	Air quad 16 bottles D3	2	600	44	26400
	Air quad 16 bottles DDC	2	600	44	26400
	oxygen quad 16 bottles DDC	4	1200	44	52800
LARS	Frame + basket driven by hydraulic D1 + D2	2	460	44	20240
	Frame + basket driven by hydraulic D3	2	460	44	20240
DDC	DDC 1.8 m diameter	2	900	44	39600
Divers umbilicals + helmets	Umbilical D1	2	200	44	8800
	Umbilical D2	2	200	44	8800
	Umbilical D3	2	200	44	8800
	KMB 37 D1	2	370	44	16280
	KMB 37 D2	2	370	44	16280
	KMB 18 D3	2	160	44	7040
Tools & workshop	Tools + workshop container	1	700	44	30800
Boat	Boat 7000 Hp / 40 passengers with full crew + food	1	7000	44	308000
ROV	Observation ROV	1	2000	44	88000
Fuel consumption	In port (2800 litres x 0.7$)	(2800 litres x 0.7 $)	1960	8	15680
	At work (10000 litres x 0.7 $)	(10000 litres x 0.7 $)	7000	30	210000
	Cruising (15500 litres x 0.7 $)	(15500 litres x 0.7 $)	10850	6	65100
Food /laundry	Food (15$/ day)	56	840	34	28560
Insurances	Equipment		1700	44	74800
	Personnel (44$/ pax)		2464	34	83776
Diving team	Superintendent	1	1000	34	34000
	Supervisors	6	4800	34	163200
	Divers	20	8000	34	272000
	Technicians	3	1140	34	38760
	ROV	6	1140	34	38760
Mobilisation team	Superintendent	1	1000	8	8000
	Tech	4	1200	8	9600
	Welders	4	1200	8	9600
Flights & custom	Flights + custom(200$)	36			7200
				TOTAL	1851036

Note that for continuous diving operations with this scenario, the diving equipment is doubled, six supervisors are planned, the mobilization time of the system is also doubled. the vessel is upgraded to 7000 hp / 40 passengers, and insurances and other fees are upgraded accordingly.

With this theoretical scenario for this depth and the bottom times planned, 367084 $ could be saved if continuous diving is implemented. The difference is sufficiently high to consider that even playing on variables such as another bottom time, continuous diving operation remain cheaper as it allows to exploit the dive times in full. As example, if applying 40 min bottom times with non-continuous diving, it allows cumulated bottom times of 597 minutes /day, so the work can be done in 61 days instead of 64, but the result is impacted by the increased number of dives that are necessary to perform the task *(note that in the chart below, the cost the diving system is summarized in one row)*:

Cost diving operation @ 24m - Non continuous diving operation - 40 min bottom time

Main Item	Detail	Number of items	price /day $	Number of days	Total price $
Equipment	Diving system + workshop	17 elements	4400	71	312400
	Boat 6000 Hp / 35 passengers	1	6000	71	426000
	Observation ROV	1	2000	71	142000
Fuel consumption	In port (2800 litres x 0.7$)	2800 litres	1960	4	7840
	At work (10000 litres x 0.7 $)	10000 litres	7000	65	455000
	Cruising (15500 litres x 0.7 $)	(5500 litres	10850	6	65100
Food	Food 15$/ pass.)	35	525	65	34125
Insurances	Equipment		1100	71	78100
	Personnel		1540	65	100100
Diving team	Superintendent	1	1000	65	65000
	Supervisors	2	1600	65	104000
	Divers	20	8000	65	520000
	Technicians	2	600	65	39000
	ROV	6	1140	65	74100
Mobilisation team	Superintendent	3	1000	4	4000
	Tech	3	900	4	3600
	welders	2	60	4	240
Flights	Flights (200$)	31			6200
				TOTAL	2436805

The result can be completely different if the planned working time is reduced. For example 150 hours instead of 600 hours.

- Using non continuous diving operations:
  - 560 minutes bottom time are possible every day. Thus, 16 days are necessary to complete the planned 150 hours
  - The duration of the mobilization of the diving team plus the transit to the job site is planned for 2 days, and the duration of the demobilization is planned for the same time as the mobilization. So a total of four days
  - Thus, the diving team is employed for approximately 20 days
  - The mobilisation of the equipment is planned for two (2) days and the demobilization is planned for the same time. Thus, four days
  - Transit time of the vessel to and from the worksite is 6 days
  - Thus, the time the vessel and the equipment are on hire is 26 days
- Using non continuous diving operations:
  - 1200 minutes bottom time are possible every day. Thus, 7.5 days are necessary to complete the planned 150 hours
  - The duration of the mobilization of the diving team plus the transit to the job site is planned for 2 days, and the duration of the demobilization is planned for the same time as the mobilization. So a total of four days
  - Thus, the diving team is employed for approximately 12 days as a started day is supposed to be paid
  - The mobilisation of the equipment is planned for four (4) days and the demobilization is planned for the same time. Thus, eight (8) days
  - Transit time of the vessel to and from the worksite is 6 days
  - Thus, the time the vessel and the equipment are on hire is 21.5 days

Cost non-continuous diving operation @ 24m - work time 150 hrs - 70 min bottom time each dive

Main Item	Detail	Number of items	price /day $	Number of days	Total price $
Dive control	10 ft container Dive panel 3 divers Radios CCTVs	1	600	26	15600
Gas sources	20 ft container LP compressor (30 Hp) HP compressor (7 Hp)	1	390	26	10140
	Air quad 16 bottles D1 + D2	1	150	26	3900
	Air quad 16 bottles D3	1	150	26	3900
	Air quad 16 bottles DDC	1	150	26	3900
	oxygen quad 16 bottles DDC	2	600	26	15600
LARS	Frame + basket driven by hydraulic D1 + D2	1	230	26	5980
	Frame + basket driven by hydraulic D3	1	230	26	5980
DDC	DDC 1.8 m diameter	1	450	26	11700
Divers umbilicals + helmets	Umbilical D1	1	100	26	2600
	Umbilical D2	1	100	26	2600
	Umbilical D3	1	100	26	2600
	KMB 37 D1	1	185	26	4810
	KMB 37 D2	1	185	26	4810
	KMB 18 D3	1	80	26	2080
Tools & Workshop	Tools + workshop container	1	700	26	18200
Boat	Boat 6000 Hp / 35 passengers with full crew + food	1	6000	26	156000
ROV	Observation ROV	1	2000	26	52000
Fuel consumption	In port (2800 litres x 0.7$)	(2800 litres x 0.7 $)	1960	4	7840
	At work (10000 litres x 0.7 $)	(10000 litres x 0.7 $)	7000	16	112000
	Cruising (15500 litres x 0.7 $)	(15500 litres x 0.7 $)	10850	6	65100
Food	Food 15$/ pass.)	35	525	20	10500
Insurances	Equipment		1100	42	46200
	Personnel		1540	20	30800
Diving team	Superintendent	1	1000	20	20000
	Supervisors	2	1600	20	32000
	Divers	12	4800	20	96000
	Technicians	2	600	20	12000
	ROV	6	1140	20	22800
Mobilisation team	Superintendent	3	1000	4	4000
	Tech	3	900	4	3600
	welders	2	60	4	240
Flights	Flights + custom & taxi (200$)	23			4600
				TOTAL	790080

Cost continuous diving operation @ 24m - work time 150 hrs - 70 min bottom time each dive

Main Item	Detail	Number of items	price /day $	Number of days	Total price $
Dive control	10 ft container Dive panel 3 divers Radios CCTVs	2	1200	21.5	25800
Gas sources	20 ft container LP compressor (30 Hp) HP compressor (7 Hp)	2	780	21.5	16770
	Air quad 16 bottles D1 + D2	2	600	21.5	12900
	Air quad 16 bottles D3	2	600	21.5	12900
	Air quad 16 bottles DDC	2	600	21.5	12900
	oxygen quad 16 bottles DDC	4	1200	21.5	25800
LARS	Frame + basket driven by hydraulic D1 + D2	2	460	21.5	9890
	Frame + basket driven by hydraulic D3	2	460	21.5	9890
DDC	DDC 1.8 m diameter	2	900	21.5	19350
Divers umbilicals + helmets	Umbilical D1	2	200	21.5	4300
	Umbilical D2	2	200	21.5	4300
	Umbilical D3	2	200	21.5	4300
	KMB 37 D1	2	370	21.5	7955
	KMB 37 D2	2	370	21.5	7955
	KMB 18 D3	2	160	21.5	3440
Tools & workshop	Tools + workshop container	1	700	21.5	15050
Boat	Boat 8000 Hp / 60 passengers with full crew + food	1	8000	21.5	172000
ROV	Observation ROV	1	2000	21.5	43000
Fuel consumption	In port (2800 litres x 0.7$)	(2800 litres x 0.7 $)	1960	8	15680
	At work (10000 litres x 0.7 $)	(10000 litres x 0.7 $)	7000	7.5	52500
	Cruising (15500 litres x 0.7 $)	(15500 litres x 0.7 $)	10850	6	65100
Food /laundry	Food (15$/ day)	56	840	12	10080
Insurances	Equipment		1700	21.5	36550
	Personnel (44$/ pax)		2464	12	29568
Diving team	Superintendent	1	1000	12	12000
	Supervisors	6	4800	12	57600
	Divers	20	16000	12	192000
	Technicians	3	1140	12	13680
	ROV	6	1140	12	13680
Mobilisation team	Superintendent	1	1000	8	8000
	Tech	4	1200	8	9600
	Welders	4	1200	8	9600
Flights & custom	Flights + custom & taxi (200$)	36			7200
				TOTAL	941338

In this case the result, is 151258 $ in favour of the non-continuous diving procedure.
It highlights the fact that because more equipment and personnel are necessary, jobs of small duration are not profitable with continuous diving. At the opposite continuous diving operations can be more efficient and less expensive for jobs of long duration.

Another element that has some influence on the cost is, as indicated previously, the depth. As an example, for a dive at 15 m with 180 min bottom time and reinforcement procedure of 1 table (180 min bottom time and 77 min decompression) for a total planned bottom time of 600 hrs.

Planning continuous diving operation 180 minutes @ 15 m

Action	Duration	Remaining time in minutes
Divers on deck	0 min (Starting shift)	720 min
Tool box talk and preparation of the dive station (check lists, certificates , permits to work & dive)	60 min	660 min
Dive #1	180 min bottom (77 min deco performed during the next dive)	480 min
Dive #2	180 min bottom (77 min deco performed during the next dive)	300 min
Dive #3	180 min bottom (77 min deco performed during the next dive)	120 min
Dive #4	84 min bottom time + 36 min deco.	0 min

Planning non-continuous diving operation 180 minutes @ 15 m

Action	Duration	Remaining time in minutes
Divers on deck	0 min (Starting shift)	720 min
Tool box talk and preparation of the dive station (check lists, certificates , permits to work & dive)	60 min	660 min
Dive #1	272 min (257 min. Dive + 15 min to prepare the next dive)	388 min
Meal	60 min	328 min
Dive #2	272 min (257 min. Dive + 15 min to prepare the next dive)	56 min
Dive #3	56 min	0 min

- Using non continuous diving operations:
  - 832 minutes of bottom time are possible every day. Thus, 44 days are necessary to complete the planned 600 hours
  - The duration of the mobilization of the diving team plus the transit to the job site is planned for 2 days, and the duration of the demobilization is planned for the same time as the mobilization. So a total of four days
  - Thus, the diving team is employed for approximately 48 days
  - The mobilisation of the equipment is planned for two (2) days and the demobilization is planned for the same time. Thus, four days
  - Transit time of the vessel to and from the worksite is 6 days
  - Thus, the time the vessel and the equipment are on hire is 54 days
- Using continuous diving operations:
  - 1248 minutes bottom time are possible every day. Thus, 29 days are necessary to complete the planned 600 hours
  - The duration of the mobilization of the diving team plus the transit to the job site is planned for 2 days, and the duration of the demobilization is planned for the same time as the mobilization. So a total of four days
  - Thus, the diving team is employed for approximately 33 days as a started day is supposed to be paid
  - The mobilisation of the equipment is planned for four (4) days and the demobilization is planned for the same time. Thus, eight (8) days
  - Transit time of the vessel to and from the worksite is 6 days
  - Thus, the time the vessel and the equipment are on hire is 43 days

Cost diving operation @ 15 m - Non continuous diving operation - 600 hrs bottom time

Main Item	Detail	Number of items	price /day $	Number of days	Total price $
Dive control	10 ft container Dive panel 3 divers Radios CCTVs	1	600	54	32400
Gas sources	20 ft container LP compressor (30 Hp) HP compressor (7 Hp)	1	390	54	21060
	Air quad 16 bottles D1 + D2	1	150	54	8100
	Air quad 16 bottles D3	1	150	54	8100
	Air quad 16 bottles DDC	1	150	54	8100
	oxygen quad 16 bottles DDC	2	600	54	32400
LARS	Frame + basket driven by hydraulic D1 + D2	1	230	54	12420
	Frame + basket driven by hydraulic D3	1	230	54	12420
DDC	DDC 1.8 m diameter	1	450	54	24300
Divers umbilicals + helmets	Umbilical D1	1	100	54	5400
	Umbilical D2	1	100	54	5400
	Umbilical D3	1	100	54	5400
	KMB 37 D1	1	185	54	9990
	KMB 37 D2	1	185	54	9990
	KMB 18 D3	1	80	54	4320
Tools & Workshop	Tools + workshop container	1	700	54	37800
Boat	Boat 6000 Hp / 35 passengers with full crew + food	1	6000	54	324000
ROV	Observation ROV	1	2000	54	108000
Fuel consumption	In port (2800 litres x 0.7$)	(2800 litres x 0.7 $)	1960	4	7840
	At work (10000 litres x 0.7 $)	(10000 litres x 0.7 $)	7000	44	308000
	Cruising (15500 litres x 0.7 $)	(15500 litres x 0.7 $)	10850	6	65100
Food	Food 15$/ pass.)	21	315	48	15120
Insurances	Equipment		1100	54	59400
	Personnel		1540	48	73920
Diving team	Superintendent	1	1000	48	48000
	Supervisors	2	1600	48	76800
	Divers	10	9600	48	460800
	Technicians	2	600	48	28800
	ROV	6	1140	48	54720
Mobilisation team	Superintendent	3	1000	4	4000
	Tech	3	900	4	3600
	welders	2	60	4	240
Flights	Flights (200$)	21	7000	0	4200
				TOTAL	1880140

Cost diving operation @ 15 m - Continuous diving operation - 600 hrs bottom time

Main Item	Detail	Number of items	price /day $	Number of days	Total price $
Dive control	10 ft container Dive panel 3 divers Radios CCTVs	2	1200	43	51600
Gas sources	20 ft container LP compressor (30 Hp) HP compressor (7 Hp)	2	780	43	33540
	Air quad 16 bottles D1 + D2	2	600	43	25800
	Air quad 16 bottles D3	2	600	43	25800
	Air quad 16 bottles DDC	2	600	43	25800
	oxygen quad 16 bottles DDC	4	1200	43	51600
LARS	Frame + basket driven by hydraulic D1 + D2	2	460	43	19780
	Frame + basket driven by hydraulic D3	2	460	43	19780
DDC	DDC 1.8 m diameter	2	900	43	38700
Divers umbilicals + helmets	Umbilical D1	2	200	43	8600
	Umbilical D2	2	200	43	8600
	Umbilical D3	2	200	43	8600
	KMB 37 D1	2	370	43	15910
	KMB 37 D2	2	370	43	15910
	KMB 18 D3	2	160	43	6880
Tools & workshop	Tools + workshop container	1	700	43	30100
Boat	Boat 8000 Hp / 60 passengers with full crew + food	1	8000	43	344000
ROV	Observation ROV	1	2000	43	86000
Fuel consumption	In port (2800 litres x 0.7$)	(2800 litres x 0.7 $)	1960	8	15680
	At work (10000 litres x 0.7 $)	(10000 litres x 0.7 $)	7000	29	203000
	Cruising (15500 litres x 0.7 $)	(15500 litres x 0.7 $)	10850	6	65100
Food /laundry	Food (15$/ day)	56	840	33	27720
Insurances	Equipment		1700	43	73100
	Personnel (44$/ pax)		2464	33	81312
Diving team	Superintendent	1	1000	33	33000
	Supervisors	6	4800	33	158400
	Divers	40	16000	33	528000
	Technicians	3	1140	33	37620
	ROV	6	1140	33	37620
Mobilisation team	Superintendent	1	1000	8	8000
	Tech	4	1200	8	9600
	Welders	4	1200	8	9600
Flights & custom	Flights + custom(200$)	56			11200
				TOTAL	2115952

In this case, the result which can be checked in the previous two pages is 235812 $ in favour of the non-continuous diving procedure.
It highlights the fact that the depth has an influence on the profitability of continuous diving operations and that non-continuous diving is often cheaper when it is shallow. Note that the table selected for the non-continuous dives in this example is not the most favourable.
These examples demonstrate the effect of variables such as the depth and the duration of a project on the profitability of diving operations.
That means that diving procedures must not be chosen according to beliefs, but after a precise study of all the variables of a selected work. It is true that such process of comparison takes time, but it is the only efficient method to select the most profitable diving procedure for a project.

Also, even in the case that continuous diving operation can save costs, it does not mean that it will be the best solution:

- If the project is a lump sum contract it may be the case.
- If the project is based on day rates, it may be advantageous for the contractor not to propose this solution.

Thus, when the cost have been calculated, it is important to check how the operation is sold.

7) Summary of acceptable and not acceptable solutions

The previous chapter describes the procedures that are acceptable for organizing continuous diving operations.
Note that as explained in the presentation, continuous diving operations must offer, at a minimum, the level of safety of standard diving operations.
Nevertheless, as explained in the chapters #4 & #5, the procedures that are selected may be open to discussions due to technical or economical reasons. For this reason, the elements selected for the organization of the diving operation must be assessed, and the level of safety proposed must comply at a minimum to what is considered safe by IOGP and IMCA members. The purpose of this chapter is to summarize the evaluation of elements that are the most discussed.

An equipment can be safe if used in a certain manner and not if used in another manner. For this reason, the word "solution" is used to describe the equipment and the method of utilization that is planned. Four levels of acceptability that can be considered in a hazard identification and a risk assessment are described:

- Unacceptable: The solution does not offer what is considered the minimum level of safety.
- Acceptable: The solution is considered acceptable by competent bodies. Some risks may not be covered in the best manner if extreme scenarios happen, but it is considered that the likelihood that these scenarios happen is low. Note that some solutions considered acceptable are not recommended by this study.
- Compliant: The solution offers what is considered safe. The risks of the scenarios considered are covered.
- Optimum: The solution proposed offers a level of safety that is beyond what is considered "compliant".

Topics	Solution proposed	Level of safety	Explanations
Launch and recovery system	Ladders and in-water decompression	Unacceptable	- A ladder does not allow a controlled transfer of the diver to the chamber if he needs to perform surface decompression. Also, transfer to the chamber using a ladder obliges the diver to do efforts while the decompression is not completed. - Ladders are acceptable in the case of no decompression dives. - Ladders are limited to only calm sea and current conditions: 0.6 m waves at the ladder & 0.8 knots current
	In water decompression with two baskets and a ladder for the standby diver	Acceptable *Not recommended for jobs where a very calm sea is not guarantee, and not applicable with Dynamic Positioning (DP) vessels.*	- A ladder can be used to launch the stand by diver provided that the stand by diver is recovered with the diver rescued. - Using a ladder limits the launching conditions of the divers to the conditions required for the ladder. Thus the dives must not be launched if the waves are above 0.6 m at the ladder and the current above 0.8 knots - Launching of the standby diver is not possible if the diver is in trouble and the sea conditions become rough - <u>This solution is inapplicable with DP vessels</u>
	In water decompression with 3 baskets	Acceptable	- The 3rd basket is shared by the standby diver of the team decompressing the diver who has performed the previous dive and the standby diver of team commencing the next dive. This solution is considered acceptable because the likelihood of having the diver at work in trouble at the same time as the diver on stops is extremely low. - Nevertheless, if the situation described above happens when diving from a DP vessel, the rescue of one of the two divers will be difficult. Note that if the vessel is not a DP vessel one standby diver can be launched using a ladder.
	In chamber decompression with 2 baskets	Acceptable *Continuous diving impossible & Deco. procedure not recommended.*	- <u>Continuous diving is impossible</u> as the diver finishing his dive must be transferred into the chamber before launching the 2nd dive. Thus only "pseudo continuous" diving is applicable. - <u>Surface decompression</u> has a lot of inconveniences that are described in chapter 2 and <u>should not be the 1st choice for decompression</u>
	In water decompression with 4 baskets	Optimum	- The standby divers do not need to share the basket and simultaneous rescue can be launched (even though it is true that the likelihood that two rescue happens at the same time is low) - In the case of a problem with one basket, the dives can be temporarily reorganised with 3 baskets.

Topics	Solution proposed	Level of safety	Explanations
Launch and recovery system	In chamber decompression with 3 baskets	Acceptable *Deco. Procedure not recommended*	- Continuous diving is possible - Surface decompression has a lot of inconveniences that are described in chapter 2 and should not be the 1st choice for decompression
Chambers	1 chamber with surface decompression or in-water decompression outside the limits indicated chapter 2	Unacceptable	- If only one chamber is on site, it will be intensively used for the decompressions and may not be immediately available for the casualty. - The casualty can be injured and on a stretcher. If the chamber is in use, the stretcher cannot be introduced into the chamber and the casualty cannot be properly transferred.
	1 chamber 1.5 m diameter used with in-water decompression and used within the limits indicated chapter 2 with 2 divers in the water.	Acceptable	- The chamber is available for a casualty or the diver(s) at all times. - Nevertheless, chapter 2 shows that some cases such as 2 casualties to treat at the same time can be difficult to manage.
	1 chamber 1.5 m diameter used with in-water decompression and used within the limits indicated chapter 2 with 1 divers in the water.	Acceptable *Nearly compliant*	- The chamber is available for a casualty or the diver(s) at all times. - This condition is more comfortable than the previous as only one diver is in decompression. - Nevertheless, chapter 2 shows that some cases such as 2 casualties to treat at the same time can be difficult to manage.
	1 chamber 1.8 m diameter and above used with in-water decompression and used within the limits indicated chapter 2 (1 or 2 divers in the water)	Compliant	- The chamber is available for a casualty or the diver(s) at all times. - It is possible to treat 2 casualties and decompress two divers at the same - Long treatments (Type 2 deco accidents) are performed more comfortably than in chambers 1.5 m diameter. - The only limit of the system is that in case that the chamber is activated, the operations have to be Stopped.
	2 chambers with surface decompression (1 or 2 divers)	Acceptable *Deco. Procedure not recommended*	- One chamber is available for a casualty or the diver(s) at all times. - It is possible to treat 2 casualties and decompress two divers at the same - Surface decompression has a lot of inconveniences that are described in chapter 2 and should not be the 1st choice for decompression
	2 chambers 1.5 m diameter and above used with in-water decompression (1 or 2 divers)	Compliant	- Two chambers are available for casualties or the diver(s) at all times. - it is possible to treat 2 casualties and decompress two divers at the same time
	2 chambers 1.8 m diameter and above used with in-water decompression	Optimum	- Two chambers are available for casualties or the diver(s) at all times. - Long treatments (Type 2 deco accidents) are performed more comfortably than in chambers 1.5 m diameter. - Eight bunks are available
Diving panels	1 panel 3 divers with 1 diver at work, 1 diver in deco, and 1 standby diver	Unacceptable	- The panel cannot be properly checked during 2 dives as it should be the rule. - The standby diver change must be done during the dive: It is not a good practice. - Because the panel cannot be properly checked, the supervisor and the divers may become casual regarding the checklists and the overall safety.
	2 panels 2 divers with 1 diver at work and 1 diver decompressing in the water	Compliant	- The panels can be properly checked. - The standby diver change is done between 2 dives and the standby diver properly checked. - The panels limit the dives to 1 diver at work
	2 panels 3 divers with 2 divers at work and 2 divers decompressing in the water	Compliant	- The panels can be properly checked. - The standby diver change is done between 2 dives and the standby diver properly checked. - There is no additional line in the case of a breakdown.

Topics	Solution proposed	Level of safety	Explanations
Diving panels	1 panel 3 divers with 1 or 2 divers at work and 1 or 2 divers decompressing in chamber *(considering that there are 2 chambers)*	Acceptable *Continuous diving impossible & Deco. procedure not recommended*	- Continuous diving is impossible as the diver finishing his dive must be transferred into the chamber before launching the 2nd dive. Thus only "pseudo continuous" diving is applicable. - Time will be lost to perform the pre-dive check lists before launching the dives. - Surface decompression has a lot of inconveniences that are described in chapter 2 and should not be the 1st choice for decompression
	2 panels 3 divers with 1 or 2 divers at work and 1 or 2 divers decompressing in chamber	Acceptable *Deco. procedure not recommended*	- Continuous diving is possible if there are 2 chambers and 3 baskets - Surface decompression has several inconveniences described in chapter 2 and should not be the 1st choice for decompression
	2 panels 3 divers with 1 diver at work and 1 diver decompressing in the water	Optimum	- The panels can be properly checked. - The standby diver change is done between 2 dives and the standby diver properly checked. - There are additional lines in the case of a breakdown.
Diving supervisors	1 diving supervisor managing in-water decompression and a dive at the same time	Unacceptable	- It is impossible for a supervisor to prepare a dive, control a decompression, and manage a dive at the same time.
	1 diving supervisor/shift managing the dives and 1 assistant managing in-water decompression	Unacceptable	- When divers are in the water they are supposed diving: IMCA 14 says that only an appointed diving supervisor can launch and manage a dive. - IMCA 14 says: *"A diving supervisor should only hand over control to another supervisor appointed in writing by the diving contractor"*
	1 diving supervisor/shift managing the dives and 1 chamber operator or a LST (Life Surface Technician) managing the decompressions in chamber	Acceptable *Continuous diving impossible & Deco. procedure not recommended.*	- Operations will need to be interrupted to prepare the next dive and to let the supervisor have his meal. - The LST or the chamber operator works under the responsibility of the diving supervisor. Thus, the diving supervisor must be at direct proximity and cannot have rest or take his meal during this period - The scope of work of the diving supervisor is high and that can lead to fatigue and mistakes. - Surface decompression has a lot of inconveniences that are described in chapter 2 and should not be the 1st choice for decompression NOTE: Such organization is often practiced, but it is not recommended.
	2 diving supervisors/shift managing the dives and chamber operators (or LST) managing the decompressions in chamber (gap between 2 dives < 30 min)	Acceptable *Deco. procedure not recommended*	- Continuous operations can be organised, but it will be necessary to stop the operations to let the supervisors have their meals. - The LST or chamber operator works under the responsibility of the diving supervisor. Thus, the diving supervisor must be at direct proximity and cannot have rest or take his meal during this period - The scope of work of the diving supervisor is more comfortable than with only one supervisor, but still high. - Surface decompression has a lot of inconveniences that are described in chapter 2 and should not be the 1st choice for decompression
	2 diving supervisors/shift managing the dives and chamber operators (or LST) managing the decompressions in chamber (gap between 2 dives > 30 min)	Acceptable *Deco. procedure not recommended*	- Continuous operations can be organised; the supervisors can have time to have their meals and relax a bit during two dives. - The LST or chamber operator works under the responsibility of the diving supervisor. Thus, the diving supervisor must be at direct proximity and cannot have rest or take his meals during this period - The scope of work of the diving supervisor is more comfortable than with only one supervisor. - Surface decompression has a lot of inconveniences that are described in chapter 2 and should not be the 1st choice for decompression

Topics	Solution proposed	Level of safety	Explanations
Diving supervisors	2 diving supervisors/shift managing the dives and decompressions in the water (gap between 2 dives < 30 min)	Acceptable	- Operations will need to be interrupted to let the supervisors have their meals. - The scope of work of the diving supervisors is high and that can lead to fatigue and mistakes as a result.
	2 diving supervisors/shift managing the dives and decompressions in the water (gap between 2 dives >30 min)	Compliant	- Operations should not be interrupted if the supervisors have sufficient time for their meals. - Supervisors should have time to relax depending on the gap between two dives. - The scope of work of the diving supervisors is more comfortable as in the scenario above.
	3 diving supervisors/shift managing the dives and decompressions in the water	Optimum	- Operations should not be interrupted as the supervisors have sufficient time to have their meals. - Supervisors should have time to relax. - The scope of work of the diving supervisors is normally comfortable. - The recommendation from NORSOK standard U-100/ point 8.4.6 that is explained in chapter #3 can be applied in full.

NOTE:
When organising the project, the solutions classified "Compliant" and "Optimum" should be selected in priority.

8) Notes

Note #1:

In Kirby Morgan manuals "Light work" is 10-20 RMV (10 to 20 litres/minutes). It is roughly the efforts made by a person walking at speed between 3 and 4 km/h.

Note #2:

Discussing reinforcement procedures is not the main purpose of this document, as the principles explained will remain similar if the operator is not to apply any reinforcement of the decompression model he uses.
MT 92 and DCIEM decompression tables have been designed by competent bodies. However, offshore experience based upon actual facts encountered on diving work sites justifies to enhance these procedures. Among these operational justifications, the main ones are presented below:

- It can be difficult, even for an experienced diving supervisor, to accurately evaluate the dive profile and the actual constraints generated from the dive's scope of work which acts on diver's physiology during the dive. For instance:
  - The actual depth may not be accurately captured due to faulty gauges. Audits and function checks might not detect a loss of accuracy which may affect mechanical "Bourdon types" gauges which are still used on the majority of the diving systems. Note that electronic gauges may sometimes have a failure.
  - Due to contributing factors such as working environment and fatigue, a human error from the diving supervisor may happen.
- The unpredictability of the level of fitness of the diver when the dive is being performed. The medical certificate for fitness to dive does not reflect the actual current level of fitness of the Diver. A medical condition and/or a medical treatment might not be declared by the diver during the pre-dive checks, intentionally or non-intentionally. Hence, the current level of the diver's individual susceptibility to decompression illness when the dive is being performed.
- Human factors related to employment and commercial constraints. Reluctance to report past occurrences of decompression illness signs and / or symptoms is a very common fact.

In addition to the above which are tightly inter-related together, it has to be noted that the "cost" of enhancing the decompression by adding safety margins is negligible. The additional time spent on implementing the safety procedures is not "lost" as it prevents both diver, diving Supervisor, and diving company from considerable financial, legal and reputational impact which would certainly occur following the event of a decompression illness case.

Last but not least, the effectiveness of all the existing decompression procedures (either provided by mean of printed decompression tables, or by diving computers) have been being evaluated by performing and monitoring statistics on decompression illness. Indeed, the reliability of these statistics is linked to the reliability of the clinical data which have been gathered. Review of the medical and scientific literature highlight the fact that that the diagnosis of decompression illness is, in many cases, difficult for both Diver and Diving Supervisor to establish. Hence, underreporting of actual decompression illness cases might be most likely substantial.

Note #3:

The full sets of medical tables USN and COMEX are published in the manuals CCO Ltd.
Note that the selection of the medical tables to be applied in the case of an emergency is the responsibility of the diving medical specialist. It is also his responsibility to explain how these tables must be applied in the emergency response plan.
Also, note that the diving medical specialist must be consulted for each medical case that may happen.

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