The effects of underwater currents on divers' performance and safety

IMCA D067 – Rev. 0.1
January 2023

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IMCA D067 – Rev. 0.1

Document designation: This document is categorised as **Recommended Practice**

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Version history

Date	Reason	Revision
December 2023	Quality check; headers, footers & bookmarking updated; no change to content	Rev. 0.1
June 2021	Revised to become IMCA D document	
July 1987	Initial publication as AODC document	

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1 Background

Underwater currents can produce considerable forces which affect not only divers themselves, but also their diving umbilicals, together with any hoses and cables running from the surface to equipment and tools the divers may have at working depth. Tides and currents also affect the diving vessel or platform from which the diving is being conducted.

For many years the offshore diving industry has relied on the information and guidance on underwater currents contained in AODC 047 *The effects of underwater currents on divers' performance and safety* to help keep its divers safe and productive. This document updates and supersedes AODC 047 which is withdrawn.

2 Aims

The main aims of this document are to provide information and guidance to IMCA Diving Division members and their clients in order to:

- ensure the safety of divers when operating in currents
- describe the factors which should be considered when planning, managing, and conducting diving operations in areas subject to the effects of underwater currents, and
- recommend suitable operating limits for diving in currents.

3 Application

This guidance is intended to apply internationally, but it is recognised that some countries will have legislation that requires different standards or practices to be followed. Where local or national laws are more stringent than the advice contained herein, they will always take precedence over this guidance.

4 Definition of currents

Currents are flowing masses of water within a body of water and can be divided into the following groups:

- **Ocean currents** – continuous, predictable, directional movements of seawater driven by gravity, wind and water density.
- **Tidal currents** – the horizontal movement of water caused by the vertical rise and fall of the tide.
- **Rip currents** – strong, fast and localised water movements closer to shore caused by breaking waves.
- **River currents** – occur in the proximity of an estuary when a river discharges into the sea depositing silt and debris, often compromising visibility and altering the density as fresh water mixes with salt water.

All of the above can be influenced by a number of additional environmental factors, including wind strength, changes in barometric pressure, and abnormal meteorological conditions.

In many parts of the world a phenomenon known as *soliton waves* might be encountered. These are solitary internal wavelike distortions of the boundary layer between a warm upper layer of sea water and cold lower depths and have strong associated currents. Diving in areas of known solitons requires constant monitoring. Soliton waves create eddies or whirlpools which may occur at any depth. On the surface they are identified by circular disturbances on the water with fast moving unpredictability.

The direction and speed of a current can vary with water depth, salinity, tide and bottom contours. Current readings near the surface may not reflect the actual speed and direction of a current in deeper water.

5 Effects of currents on divers and diving operations

The effects of currents on divers varies with the individual, the work being done, the diver's position in the water and the diving method used. Currents produce forces which affect not only divers' bodies but also their umbilicals, together with any hoses and cables from the surface to equipment and tools the divers may have at the working depth. Currents can also have an adverse effect on diver deployment devices, for example cages, bells and/or bell umbilicals.

A proportion of a diver's energy is devoted to overcoming the forces generated by currents until the point is reached when the diver will become unproductive. As an increasing amount of energy is devoted to combating the effects of current as well as carrying out productive operations, it follows that the greater the speed of the current, the shorter will be the period during which the diver will be effective before the onset of significant fatigue.

As noted above, currents have a major impact on diver umbilicals. The forces exerted on diver umbilicals by flowing water may give divers the impression that they are being tended too tightly, making it difficult for them to remain on the worksite. In such circumstances divers may request more 'slack'. This can worsen the situation by creating more force on an umbilical, and therefore make it harder for the diver to remain on location. Tenders and diving supervisors must be aware of this risk. If more umbilical is paid out it will create a greater 'arc' or 'bight' of umbilical in the water, thus increasing the surface area available for the current to act upon, and ultimately causing greater drag for the diver to struggle against.

A diver operating from a closed bell or wet bell is better able to operate in currents than a diver tended from the surface. In most cases the umbilical from the bell to the worksite is shorter and is deployed at a shallower angle than an umbilical tended from the surface. This means that umbilicals deployed from bells attract much less resistance to water movement and so cause less drag on the diver during operations.

Currents are usually stronger from near the surface to a depth of around 30 m (100 ft). Most saturation diving operations are conducted below this depth range, although some saturation diving operations can be as shallow as -15 msw (-49 ft). Underwater currents can adversely affect bell umbilicals that pass close to vessel hulls or through moon pools. Chafing of the bell umbilical on the side of the hull or moonpool should be a consideration if operating in strong currents. If a bell is deployed over the side of the vessel, the main bell wire or clump weight wires can be deflected to an angle that is out of specification for the sheaves. Currents can also deflect the clump weight and wires to a position where the recovery of the bell and/or clump weight could be compromised.

5.1 Drag forces

The force exerted on a diver by a current is proportional to the water velocity squared, i.e. if the current doubles, the force against the diver increases four times.

Table 1 below shows approximate drag forces exerted on the "average" diver in both a vertical and horizontal position.

Table 1 – Approximate drag forces exerted on an average diver in the vertical and horizontal position

Current speed (knots)	Force on diver vertical facing current (max profile)		Force on diver horizontal facing current (min profile)	
	lb-f	kg-f	lb-f	kg-f
0.5	6	3	1	0.5
1	23	10	4	2
1.5	52	23	9	4
2	92	41	15	7
3	207	94	36	16
4	369	167	61	28
5	567	260	96	44

1 knot normal operating limit

5.2 Major factors to consider when planning to dive in the presence of underwater currents

How much current, or force, a diver can withstand while still continuing to work safely and effectively depends on various factors, such as:

- the ability of the standby diver or bellman to be deployed and recovered safely in the event of an emergency, considering the potential increase in drag that will be experienced should the standby be required to assist an incapacitated diver
- whether the current trend is increasing or decreasing
- how quickly the current speed is likely to increase or decrease (largely dependent on whether the planned work will take place during spring or neap tides)
- the individual fitness of the diver(s)
- the type of equipment being used, (surface supplied, wet bell, or closed bell)
- the length of diver umbilical, its deployment plane (vertical or horizontal), orientation in the current, and whether floating or negatively buoyant
- whether the work is being carried out on the seabed or in mid-water
- the nature of the work being carried out and the tools used to do it
- whether the use of both hands is required to perform a task
- current fluctuation and changes of direction (these may be caused by the presence of other structures in the dive location for example)
- the possible use of aids such as underwater tend points, swim lines and downlines
- the effects of current on equipment such as lift bags, or on the deployment of crane loads and positioning of structures
- whether or not the work site location somehow creates a lee for the diver (for example, the diver may be sheltered from the current by an underwater structure).

In such circumstances, thought must be given as to how easy or difficult it will be for the diver to leave the sheltered worksite and return safely to the surface or bell through the force of the current. In parallel with this factor, the ability of the standby diver or bellman to go to the aid of a sheltered diver in the event of an emergency must also be considered (see the first bullet above).

6 Effects of currents on the safety of diving operations

Table 2 below indicates the type of diving operations that might be possible in various current speeds. It also indicates the added restrictions placed on diving operations by increasing current strength, and facilitates identification of certain conditions beyond which it would be unwise to continue routine operations.

Table 2 – Effects of current speeds on types of diving operations

Current (knots)	0.0	0.7	1.0	1.2	1.5	1.8	2.0 & beyond
Surface supply in mid water	Normal Work	Light work	See Notes	No Diving			
Surface supply on bottom	Normal Work	Normal work	See Notes	No Diving			
Bell or wet bell in mid water	Normal work	Light work	See Notes	No Diving			
Bell or wet bell on bottom	Normal work		See Notes	No Diving			

Notes

Diving in currents between 1 and 1.2 knots should not be considered as a normal operation.

Prior to deciding whether or not to conduct a diving operation in the 1 to 1.2 knot range, the diving supervisor should ensure a suitable and sufficient risk assessment has been carried out, and appropriate risk control measures implemented, if diving is to be authorised.

The assessment should carefully consider:

- *the feasibility and practicability of being able to safely deploy and then recover a standby diver, along with the working diver(s), should an incident occur during such operations; and*
- *all other factors listed in Section 5.2 above.*

When diving in the 1 to 1.2 knot range a method of constantly monitoring the current speed should be available to the diving supervisor. Diving activities should be aborted if the current is seen to be increasing above safe limits.

The diving supervisor with responsibility for the operation is the only person who can order the start of a dive. Before making the decision to commence a dive the supervisor will need to determine the actual current strength at the time and place of the proposed diving operation, and then evaluate its likely effects on diver performance and safety. When doing so, perhaps the most critical questions for the diving supervisor to consider are:

- Given the strength of the current, in an emergency, could the standby diver/bellman be safely deployed and then recovered along with the working diver(s)?
- Given the strength of the current, would the standby diver/bellman be able to get to the worksite and provide effective assistance to a distressed, trapped, unconscious or otherwise incapacitated diver?

The decision to commence, or indeed to continue, a diving operation will often strongly depend on the diving supervisor's judgement on these questions. Dive teams must always be in a position to be able to respond effectively to an emergency involving the working diver(s).

The major factors to consider when considering how much current, or force, a diver can withstand while still continuing to work safely and effectively are listed in Section 5.2 of this document.

Subject to the work activity being undertaken, diving operations can usually be considered if the current is 0.7 knots or less, or can commence above that rate of flow (up to a maximum normal operating limit of 1 knot) if the current is showing a decreasing trend. Diving in a current of 0.7 knots should not commence if the current meter is showing an increasing trend.

If available, an ROV should be used to monitor the effect of any current on the diver deployment device and umbilicals. It should be noted that an ROV can also be adversely affected by currents.

Diving in currents above 1 knot should only be considered in exceptional circumstances and only when the operation has been pre-planned taking account of the presence of strong currents (see Table 2 above). Special solutions and arrangements will need to be put in place to protect the working and standby divers from the effects of such strong currents and to provide contingencies for emergencies.

7 Special devices for operating in high currents

For operations in high currents, the employment of special devices and arrangements may be considered – for example, a device may be used to clip a diver's umbilical to a downline or to the worksite in order to reduce drag on the diver. However, any fixings must be capable of being released quickly in the event of an emergency. Rope, twisted wire or cable ties should never be used to tie off a diver's umbilical to a downline or to the worksite.

Additionally, when planning such special operations, consideration should be given to the consequences for the diver if such a special device fails, is released unexpectedly, or if a standby diver is required to intervene (see IMCA D058 *Diver attachment to structures by means of a weak link*).

8 Current meters

Current meters help diving supervisors to make well-informed decisions that improve the safety of the diving operations under their control.

In tidal diving operations, the correct identification of slack water periods is essential and the accuracy of tidal charts cannot be relied upon for precise planning purposes. It is recommended that current meters are used to provide diving supervisors with accurate information about the true speed and direction of currents in real time wherever tidal diving operations are conducted. They can also be usefully used to plot current trends.

Current meters may be easily deployed through a moonpool, or over the side or stern of a vessel. Care must be taken to ensure that any current meter cables are free and will not present a hazard to the vessel or its propulsion system.

Current readings from a vessel's bridge should not be relied upon to determine the feasibility of diving operations commencing.

9 Summary

The diving supervisor with responsibility for the operation is the only person who can order the start of a dive.

- Before making the decision to commence a dive the supervisor will need to determine the actual current strength at the time and place of the proposed diving operation, and then evaluate its likely effects on diver performance and safety.
- It is recommended that in tidal waters current meters should be deployed to provide diving supervisors with accurate information about the true speed and direction of currents in real time.
- Diving operations can usually be considered if the current is 0.7 knots or less.
- Diving in a current of 0.7 knots should not commence if the current meter is showing an increasing trend.
- Subject to the judgement of the diving supervisor, diving operations may commence in currents above 0.7 knots (up to a maximum normal operating limit of 1 knot) if the current is showing a decreasing trend.
- The normal operating limit for diving operations is a current speed of 1 knot.
- Diving in currents between 1 and 1.2 knots should not be considered as a normal operation.
- Diving in currents above 1 knot should only be considered in exceptional circumstances and only when the diving operation has been pre-planned taking account of the presence of strong currents.
- Diving operations should not take place in currents above 1.2 knots.

10 References

- IMCA D058 *Diver attachment to structures by means of a weak link*

10.1 Further reading

- IMCA D014 *International code of practice for offshore diving*
- IMCA D022 *Guidance for diving supervisors*