Rescue of an Incapacitated Surface-Supplied Air Diver:

A review of practices and equipment

Rev 5.9.4

4SeasSafety@gmail.com

Revision History		
Rev	Date	Change
00	May 2021	Originally developed
01	August 2023	Review, tidy up, no change to content
02	September 2024	Changed ‘Bailout’ to ‘personal gas reserve’ Changed ‘Emergency cylinders’ to ‘Basket carried reserve gas supply’
03	February 2025	Added Surface Swimmer Amended text for gender neutral where possible
04	August 2025	Added Circum-Rescue Collapse
05	April 2026	Review, tidy up, Grammarly check. Added Extended Umbilical

Acronyms, Initialisms, & Brief Explanations	
AHC	Active Heave Compensation
ALARP	As Low As Reasonably Practicable: The reduction must be made in such a way that the sacrifice of time, effort and money is not grossly disproportionate to the benefit arising from the risk reduction measure.
ASOG	Activity Specific Operating Guidelines are generally presented in tabulated format and state the operational, environmental and equipment performance limits necessary for safe Dynamic Positioning operations while carrying out a specific activity at sea.
AVPU	A rapid four-level scale used in emergency medicine to assess an IPs level of consciousness and responsiveness. Alert, Verbal, Pain and Unresponsive.
Beacon	A colloquial term for a transponder or other seabed unit that transmits acoustic ranges or data.
BA	Breathing Apparatus. This refers to any breathing apparatus the diver is wearing: helmet, BandMask©/full face mask.
CCTV	Closed Circuit Television
CPR	Cardiopulmonary Resuscitation: An emergency treatment that's done when someone's breathing or heartbeat has stopped. CPR is a combination of the Chest Compression procedure and Expired Air Resuscitation (EAR)
CO	Carbon Monoxide: Gas typically found in the air supply from a faulty compressor or a compressor with a badly placed air intake A partial pressure that would be safe on the surface may be lethal at 30 msw, where the partial pressure is four times greater.
CO_2	Carbon Dioxide.
CoG	Centre of Gravity (When lifting a load): The point within an object where its weight is evenly balanced in all directions
DAF	Dynamic Amplification Factor, where the forces acting on a load amplify the force exerted by its own weight .
Daughter Craft	A workboat deployed from and/or operating in conjunction with a diving platform, the workboat is used to deploy divers into and recover them from the water.
Deployment device	The device or method used to deploy (and recover) the diver to depth and recover the diver to the surface. This will be either or a combination of wet bell, basket, ladder or in some cases a davit.
DCS/DCI	Decompression Sickness & Decompression Illness. DSC and DCI are related but distinct terms. DSC refers specifically to the condition caused by dissolved gases coming out of solution and forming bubbles in the tissues and bloodstream due to a reduction in ambient pressure. DCI is a broader term that encompasses both decompression sickness and arterial gas embolism (AGE), which is caused by gas bubbles entering the arterial circulation, usually due to lung overexpansion injuries.
DDC	Deck Decompression Chamber: A pressure vessel for human occupancy which does not go under water and used for diver decompression or treatment of decompression illness. Also called compression chamber, recompression chamber, deck chamber or surface compression chamber
DMAC001	Diving Medical Advisory Committee . Document 001

	Aide Mémoire for Recording and Transmission of Medical Data to Shore. Industry standard . Originally developed by United States Navy.
DMT	Diver Medical Technician: A member of the dive team who has undertaken advanced training in emergency care and the management of diving related illnesses .
DMP	Diving Medicine Physician: A Level 2D doctor who is competent to manage the treatment of diving accidents and illnesses
DPP	Diving Project Plan. Documents and information available on-site at a diving project and IMCA should include mobilisation and demobilisation plans, the diving technique/procedures to be used, step-by-step diver work procedures, identification of hazards and control and contingency procedures for any foreseeable emergency.
DSV	Diving Support Vessel .
EAR	Expired Air Resuscitation rescue breathing as part of CPR or by its self if there is a pulse.
EN	European Norm European Standard: technical standards drafted and maintained by CEN (European Committee for Standardization).
ERP	Emergency Response Plan.
FFM	Full Face Mask. Generic term- This includes BandMask© and other types and manufacturers.
FMEA	Failure Modes and Effects Analysis. This is a methodology used to identify potential failure modes, determine their effects and identify actions to mitigate the failures .
Hazard	An object, physical effect or condition with the potential to harm people, the environment or property.
HRF	Hyperbaric Reception Facility A DDC on shore (usually) to evacuate divers needing recompression if the dive site is compromised.
HP	High Pressure.
H_2S	Hydrogen Sulphide: A colourless, flammable, and highly toxic gas with a strong odour of rotten eggs. It occurs naturally in crude petroleum and natural gas.
IMO	International Maritime Organization: United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships.
Industry Accepted	Something that has gained recognition or acceptance and has been in common use for the relevant industry.
IP	Injured Person or Injured Party (Incapacitated Plongeur).
IWTP	In-Water Tending Point.
J-Bottle	HP gas cylinder of approximate 44.4 litres floodable volume. Weighs about 70kg.
JSA	Job Safety Analyses
LARS	Launch and Recovery System.

Line of Fire	Line of Fire (LoF): Being in the line of fire is being in harm's way. LoF injuries occur when the path of a moving object and an individual's body intersect. The moving object might be typical expected motions or might be the results of unexpected failures. LoF is an LSR.
LSR	Life Saving Rule: Nine rules set out by IOGP and adopted by most clients and contractors.
LP	Low Pressure.
MOB	Man overboard.
Mid-Water	Term used to describe any depth where the diver isn't diving near the surface or on the seabed.
MEWP	Mobile Elevated Work Platform
Nitrox	A breathing mixture of nitrogen and oxygen .
NORSOK	NORSOK standards were developed by the Norwegian petroleum industry to ensure safety, add value and promote cost effectiveness.
OBG	Onboard Gas. Emergency gas cylinders carried on a wet bell as a secondary supply in case of main umbilical failure or contaminated surface supply.
OM	Offshore Manager. Also known as an OCM-Offshore Construction Manager or OPM Offshore Project Manager.
Rescue Diver	The term 'rescue diver' is used throughout this review. The rescue diver is the diver tasked by the diving supervisor to carry out the rescue; this could be the surface standby diver, the IPs dive partner, an in-water tender, or, if utilising a wet bell, the bellman or surface contingency diver. The author believes that 'rescue' is positive, i.e. the IP is alive, and 'recovery' is negative, i.e. body recovery. The news media often use this, '…it is no longer a rescue but a recovery ..'
RIB	Rigid Inflatable Boat
Risk	The product of the chance that a specific adverse event will occur and the severity of the consequences of the event.
Risk assessment (RA)	The process by which every reasonably foreseeable risk is evaluated and assessed. As part of the process, control measures to be established to prevent harm before an operation commences should be identified. The findings and actions will be documented. A risk assessment is part of the risk management process .Risk assessment is a fundamental part to safe diving operations.
Safe Practice	A way to perform a task that minimizes risk.
SCE	Safety Critical Element: Part of a facility, plant or equipment that can cause or contribute to a major accident, or that prevents or limits the effect of a major accident. SCEs can include equipment or structures, and are important to identify to ensure system safety.
SRP	Scuba Replacement Package.
Standby diver	A diver other than the working diver(s) who is dressed and with equipment immediately available to provide assistance to the working diver(s) in an emergency .
SOLAS	Safety Of Life At Sea -International organisation overseeing maritime standards
Source and Supply	Source: The pressurised gas going to the control panel (Diving supervisors and DDC panel) Supply: The breathing or pressurised gas going to diver or DDC from the control panel.
SWL	Safe Working Load: The SWL may be the same as the WLL but may be of a lower value assigned by an independent competent person taking account of service conditions

PFD	Personal Flotation Device. ‘Life Jacket’ or ‘Buoyancy Aid’
PMS	Planned Maintenance System.
Portable diving system	Portable – also known as mobile – diving system. This is a diving system which is installed on a vessel or installation on a temporary basis, although this may be for a reasonably long period of time. It will often be situated on an open deck and is installed in such a way that would make it relatively easy to remove it to a different location or vessel.
PPE	Personal Protective Equipment.
PPO_2	Partial Pressure of Oxygen.
QC	Quick Connect. (Sometimes referred to as QD-Quick Disconnect) Fittings allowing quick connect and disconnect of LP hoses whilst under pressure.
ROV	Remotely Operated Vehicle
VOC	Volatile Organic Compound .
WLL	Working Load Limit WLL is the ultimate permissible load, assigned by the manufacturer of the item.

1 INTRODUCTION

The diving organisation should have a plan to recover an unconscious diver from working depth to a safe location for treatment. The organisation's emergency recovery or standby diver rescue procedures are generally similar. However, ALARP is not static. Practices and equipment should be reviewed. This review suggests ways to improve diver rescue by drawing on real incident experience and existing diving industry-recommended practices.

Diving Industry recommended practices acknowledge the lack of industry research: "*There has been little research or practice in handling an injured diver in the water. The priority is usually to get him quickly to the surface*."

The primary purpose of this review is to promote consistency and a systematic approach to rescuing unconscious divers across various surface-supplied diving techniques. However, it should be treated as guidance rather than definitive. The recommendations may differ depending on specific circumstances and vary from vessel to vessel, worksite to worksite, and LARS to LARS. Consequently, each diving organisation should assess how the guidance's considerations apply to the particular circumstances of each diving system and implement measures accordingly to ensure safety.

Diving organisations should develop rescue procedures for each foreseeable scenario within the rescue hierarchy. Many actions should remain consistent regardless of who performs the rescue. The procedures should include the following general guidance, which individual diving organisations should adapt to their specific circumstances, such as team size, available equipment, and the worksite.

Diver rescue procedures should guide dive teams and, where relevant, the ship's crew on the actions to be taken. Previous lessons-learned reports indicate that during an actual rescue, the ability of the entire vessel's crew to work collaboratively and to recognise the importance of acting quickly and professionally will ultimately influence the outcome.

An unconscious diver in the water is a high-impact / low-probability event.

1.1 Aim

It is hoped that this document will be used and referenced by diving organisations to assess the mitigations they have in place to prepare for and improve the rescue of an incapacitated diver.

This review, written by a human, aims to help diving organisations achieve ALARP in their surface-supplied diver rescue procedures by:

- Providing examples of best practices for diver rescue helps the diving organisation to develop and refine its rescue procedures and equipment choices, informed by risk assessments and safe practices.
- This review presents current industry-accepted practices, challenges them where appropriate, and offers practical advice and achievable controls for significant and credible hazards. The recommendations here do not constitute an exhaustive list of actions for diver rescue.

It should be noted that many divers are 'day-rate' contractors who move between companies. Diving industry influencers and enablers should aim to standardise best rescue practices, ensuring that rescue methodology remains consistent, or at least very similar, across diving organisations.

1.2 Scope and Exclusions

This review covers diver rescue during air and nitrox diving operations involving working divers. Although not specifically about diving, it also includes the rescue of a surface swimmer. The review considers the in-water rescue of the IPs until they return to the deployment area. It does not include surface medical first aid or treatment.

Omitted from its scope

- Surface-supplied mixed-gas diving, closed-bell diving, and surface standby during closed-bell diving.
- The rescue of a surface standby diver.
- Multi-casualty rescue.
- TUP diving

Note: Nitrox can be used instead of air in certain situations. If so, replace 'air' with 'nitrox' unless the text explicitly states otherwise.

2 TERMINOLOGY: UNCONSCIOUS/INCAPACITATED

Most diving organisations and industry-recommended practices refer to diver rescues as ‘unconscious diver recovery’, which, in the organisation’s diving or emergency manual, almost exclusively results in CPR. Using the correct terminology is vital, as an unconscious diver does not always require CPR.

- Unconscious: loss of awareness of oneself and one’s surroundings, and an inability to perceive or respond to environmental stimuli.
- Unconscious and not breathing: respiratory and cardiac arrest.
- Injured: a physical wound or shock resulting from sudden trauma.
- Incapacitated: lacking strength or power, ‘lying ill or helpless,’ ‘out of action.’

The diver may be unconscious, incapacitated, conscious, or semi-conscious. “Incapacitated” will refer to all these categories throughout this review unless explicitly stated otherwise.

Resuscitation is defined as “the act of reviving someone from apparent death or unconsciousness”. This can be achieved through EAR or CPR.

3 POTENTIAL CAUSES OF INCAPACITATION WHEN DIVING

A diver can become unconscious in the water for many reasons. It could be the result of a single cause or several causes, such as:

- Trauma
  - Physical
  - Impact
  - Exhaustion
  - Blast Injury
  - Marine Life
- Underlying Medical Conditions
  - Heart condition
  - Stroke
- Loss of Thermal Balance
  - Hypothermia
  - Hyperthermia
- Other
  - CNS Depressors
  - Drugs
  - Alcohol
- Incorrect Breathing Gas (or no gas)
  - Anoxia
  - Hypoxia
  - Hyperoxia
  - Hypercapnia
  - Carbon monoxide
- Electric Shock
- Chemical Contamination
- Allergic Reaction
- Noise
- Mental
  - Shock

4 DOCUMENT LAYOUT

This review layout is based on various diver deployment and rescue methods, assuming that the diving organisation already follows industry-recommended practices.

Each section provides an overview of industry-recommended practices, where applicable.

Before reviewing specific diving-technique rescues, a section covers general equipment and procedures applicable to all surface-supplied diving techniques.

Rescue of an IP when deployed by or employing the following techniques:

- Basket.
- Ladder.
- Wet bell.
- Surface Swimmer.

5 DIVER RESCUE PHILOSOPHY

This section outlines the general philosophy of rescuing an incapacitated diver and is applicable regardless of the diving technique employed.

As the commercial diving industry has progressed, the procedures, equipment, and mindset for rescuing incapacitated divers have largely remained unchanged and unchallenged. This review's considerations are based on experience and lessons learned from diver rescues.

Rescues generally fall into one of two categories:

1. A serious injury or an event that the supervisor considers requiring intervention by another person, such as a rescue. The supervisor believes that the IP’s condition is either life-threatening or could deteriorate to become life-threatening before reaching the surface. The primary objective is to recover the incapacitated diver to the deployment device as quickly and efficiently as practicable without exposing the rescue diver or IP to unacceptable risk.
2. A minor injury requiring assistance or precautionary measures. The supervisor is confident that the individual's condition will not deteriorate and that all emergency back-up systems are working effectively. The primary objective is to recover the IP to the deployment device without exacerbating the injury or placing any rescue diver at unacceptable risk.

The diving supervisor shall determine the rescue category based on the actual situation, considering the potential for escalation, in accordance with dynamic risk management principles.

6 DYNAMIC RISK MANAGEMENT & SITUATIONAL AWARENESS

The nature of the environment and equipment means that hazards will always be present. While it is impossible to prepare for every scenario, the supervisor should be familiar with the diving organisation’s risk assessment for foreseeable emergencies.

The diving supervisor must be familiar with the diving organisation’s documented emergency procedures. If an incident occurs, the supervisor must assess the situation and take immediate action in accordance with established procedures. Diving, by its very nature, is hazardous and carried out in a changing environment; there should be procedures, so far as reasonably practicable, to minimise the need for judgment calls by the supervisor during an emergency.

Rescue procedures for an incapacitated diver should be risk-assessed and evaluated. However, it is unlikely that all environmental conditions, competencies, work sites, and injury types can be fully risk-assessed and that realistic procedures can be developed for every situation and condition.

The supervisor should be aware of events occurring subsea. If a rescue is initiated and steps go beyond the organisation’s documented risk assessment and procedures, the supervisor should continue to manage risks using dynamic risk management techniques. When dealing with rapidly changing circumstances during an operational incident, the supervisor should implement control measures to ensure an acceptable level of safety and, above all, to preserve life. This is a continuous process of monitoring, reviewing, identifying hazards, and assessing risk during the diving operation.

During an emergency, the diving organisation has delegated responsibility for responding to dynamic elements to the diving supervisor, whom the organisation deems competent. The diving organisation should consider documenting this in the diving supervisor’s roles and responsibilities.

The situation may become dynamic, but the risks should remain predictable. Risk is an evaluation of hazard and likelihood; the only difference is whether the supervisor has evaluated it beforehand or during the rescue. The supervisor should no longer be concerned with in-water time. The focus of dynamic risk management should be on the divers involved in the incident, rather than being overly concerned with project risk assessment criteria and policies, such as equipment costs, vessel scheduling, environmental concerns, or company reputation. Preventing **further injury and preserving life should be the supervisor’s primary focus.**

The diving supervisor is considered competent and authorised by their employing company, as outlined in their Letter of Appointment, to ‘manage predictable risk in a dynamic situation’. The supervisor is also permitted to issue direct health and safety instructions to any person involved in or influencing the diving operation. These instructions take priority over any company hierarchy. The supervisor must utilise the skills and experience of other team members. The entire responsibility for dynamic risk management and actions should not rest solely with the supervisor. Instead, the supervisor will collaborate with and be supported by team members.

7 RESPONSIBILITIES BEFORE, DURING AND AFTER A DIVER RESCUE

The diving supervisor in charge is the person appointed by the employing diving organisation and recorded in the diving operation log. This supervisor holds single-point responsibility and accountability for each part of the operation under their control. Responsibility includes the team's competency, diver rescue, first aid, treatment, and aftercare, unless formally handed over to a medical centre or hospital.

The diving supervisor must be fully aware of the diving organisation’s documented contingency plans and emergency procedures, both general and specific to the diving operation and worksite. He must ensure that all dive team members are familiar with the task and emergency procedures. On an air diving site, these include safely removing the diver (including an incapacitated diver) from the water to a place of safety for treatment.

The diving supervisors must confirm that the equipment used for operations is suitable, safe, certified, and properly maintained. They can do this by ensuring the equipment complies with industry-recommended practices and the diving organisation’s Diving Management System. Supervisors should also ensure that the equipment is thoroughly checked by themselves or another competent person delegated by the supervisor before use. Checks should be documented, for example, on an approved pre-prepared checklist and recorded in the project's operations log.

Following a traumatic incident or event at the workplace, it may be appropriate to organise group or one-to-one psychological counselling for those who feel they would benefit from discussing the events.

GENERIC RESCUE PRACTICES & EQUIPMENT

8 GENERAL RESCUE PRACTICES & EQUIPMENT

This section outlines suggested rescue actions and their rationale. It offers good practices that the diving organisation may find helpful when choosing safe diving equipment and when developing diver rescue drills, exercises, procedures and their accompanying risk assessments.

Rescue procedures and the rescue risk assessment should take into account the design of rescue equipment and the methodology for rescuing an incapacitated diver (or divers). The following sections may be applicable regardless of the diving technique used.

This section describes and explains some critical safety elements used in diver rescue. Some of these SCEs should be more noticeable.

8.1 The Hierarchy of Rescue and Rescue Diver Selection

The diving organisation should consider the hierarchy and selection of rescue divers in their emergency procedures and risk assessments. The organisation's procedures for rescuing an incapacitated diver should provide the required actions for the full range of different foreseeable situations.

The findings of the rescue risk assessment may indicate the safest rescue option and the hierarchy of rescues. Each diving technique has a different rescue methodology and, therefore, a corresponding hierarchy of rescue. These are explained later in this review. However, the philosophy is the same:

- Avoid deploying another diver if possible to reduce diver exposure.
- If another diver is deployed, minimise the time spent in the water and out of the deployment device.

The diving organisation should not assume that the default rescue plan is to 'jump the standby', as is the case with most diving organisations. The diving supervisor should conduct a dynamic risk assessment: *Which diver is best suited to carry out the rescue immediately?* (Hierarchy of rescue).

8.2 The Safety of the Rescue Diver

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system.

The following safety precautions, lessons learnt and best working practices should be considered before any attempt to rescue a diver during a surface-supplied diving operation, and apply regardless of the diving technique used:

- A rescue diver should not be committed to a rescue if doing so puts them at an unacceptable risk.
- When approaching an incapacitated diver, as with any casualty, ensure that it is safe to do so.
- If the standby diver is deployed to assist an incapacitated diver, procedures must be in place to ensure that the standby diver and their umbilical remain clear of all hazards identified in the emergency procedure risk assessment and in the supervisor's dynamic risk assessment.
- Diver safety should always be the top priority, and divers must always have the strength and stamina to rescue themselves or their dive partners in the event of an incident.
- When at a contaminated worksite, the rescue diver should have the same level of personal protection against contamination as the working diver(s).
- The rescue diver must wear the PPE specified in the diving organisation's risk assessment. This protection should be provided to the working diver in all circumstances.
- Given the circumstances of the diving operation, appropriate procedures should be established to enable the rescue of a diver in an emergency.

8.3 The Selection of the Surface Standby Diver

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system for rescuing a diver during a surface-supplied diving operation, applicable regardless of the diving technique used.

There shall be one standby diver for every two divers in the water. The surface standby diver shall be immediately ready to provide necessary assistance to any diver in the water.*

Divers breathing a mixture of oxygen and nitrogen under pressure, whether compressed natural air or an artificial mixture, are at risk of oxygen toxicity and nitrogen narcosis as depth increases. National legislation generally sets specific requirements and depth limits for different types of diving.

Industry recommended practice limits:

> *"diving with natural air to a maximum allowable depth of 50msw."*
>
> *"Nitrox diving to a maximum allowable oxygen partial pressure of 1.4 bar absolute."*

The following recommendations, based on lessons learned and experience, are considered safe working practices and aim to reduce risks to ALARP. The diving organisations' procedures should identify the following, where practicable:

- When the maximum depth is at or near the maximum allowable depth for the breathing medium, the emphasis should be on the diver's experience and history of deep surface-supplied diving, as verified by logbook checks and the verification process.
- The diving organisation should not plan to undertake dives beyond the recognised safety limits or beyond the diver's formal training and experience.
    - Standby divers (and working divers) should be exposed to this depth only after a period of gradual acclimatisation.
    - A closed-bell diver is not necessarily competent to manage narcosis during a deep air dive and should undergo a series of gradual work-up dives.
- When working 'mid-water', the rescue procedure should consider a scenario in which the incapacitated diver has 'fallen' to the full extent of their deployed umbilical length and is at a depth exceeding the maximum allowable depth or PPO_2. 'Depth' includes the maximum allowable depth and depths with severe decompression penalties or exceptional exposure.
- The standby diver must be free from any decompression penalties that could hinder their ability to perform their role.
- The standby diver must be free from any medical conditions that hinder their ability to perform their role.
- The standby diver should be an experienced diver, not a trainee, unless competence has been established through prior experience, supplemented, where appropriate, with any additional training deemed necessary by the diving supervisor.

*During a wetbell diving operation where there is a bellman in the bell, the surface contingency standby diver does not have to be 'immediately ready'.

8.4 The Surface Standby Divers Breathing Apparatus

This section ensures that the diving organisation conducting surface-supplied diving operations has an effective diving safety management system for diver rescue. It applies regardless of the diving technique used.

The type of breathing apparatus worn by the surface standby diver should be formally risk-assessed and stated in the DPP. It is common for the surface standby diver to wear a full-face mask.

The following safety considerations should be discussed when preparing diver rescue documentation and apply regardless of the diving technique used. The diving organisations' risk assessment and procedures should identify the following, where practicable:

- If the standby divers' BA differs from the usual type used for work, consider the users' familiarity and skill level.
- BandMasks (a common type of full-face mask) come in various face-fit sizes: S/S, S/M, M/L, and L/L. The standby diver must know which size fits their face and ensure the correct one is fitted.
- If the standby diver is to wear a full-face mask, the diving manufacturer's 'hard shell' protection (Photograph 3) may be inadequate for the risks the standby diver might face. No EN rating is provided, and the manufacturer's information sheet states: "cannot protect the diver from head injuries…"
- When using a full-face mask, the time it takes the standby diver to get dressed should not be a concern. NORSOK requires that the standby diver's BA be designed so the diver can don it and enter the water unaided within one minute. Thanks to advances in divers' BA locking mechanisms, a helmet BA can be donned more quickly than a hard-shell full-face mask.
- An FFM/BandMask does not provide the same level of thermal protection as a helmet. Will the standby diver need additional thermal protection for the head and neck in cold water? When a diver's head is exposed to cold water, the following may occur:
    - 'Vertigo' (spinning) is caused by cold water stimulation of the ear.
    - 'Brain freeze' Cold water shock to the head can lead to cognitive effects, including impaired concentration.
- If the standby diver wears a BandMask/FFM, they should not breathe nitrox.
- When rescuing a 'lost diver,' the diver is often disoriented and confused. Confusion, dizziness, anxiety, or panic are common among recovered lost divers. The lost diver might unknowingly harm the standby diver. If the surface standby diver is wearing an FFM/BandMask, the BA may be accidentally removed in a panic or in confusion.
- If the standby diver is deployed wearing an FFM/BandMask, consider the following:
    - Diving in contaminated water.
    - Access to a contaminated seabed.
    - Access to a construction site.
    - Access to an excavation site
    - Access to a high-noise area.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, address the following:

- The surface standby diver should wear a helmet (Photograph 1), not a full-face mask (Photograph 2 & 4):
    - The standby diver should wear the same PPE as the working diver. A Bandmask/FFM does not provide the same level of protection as a helmet.
    - A helmeted standby diver can access cold-water sites and all work sites.
    - The standby diver will be competent in using the helmet, as it is the same BA used daily.
    - A helmeted standby diver can enter a construction site, provided the helmet is impact-tested and certified to EN 397 (Class A).

- The standby diver must wear a neck dam/neck ring assembly that fits and adjusts the helmet neck pad to ensure a proper fit. This should be included as a line item in the standby diver's pre-dive checklist.
- The diving organisation should risk assess the type of material used to form the seal in the neck dam:
  - Latex seals are more prone to damage when an open-ended hose is inserted between the seal and the diver's neck. Neoprene neck seals are more durable and should be used wherever possible.
  - Latex seals have been known to cause rashes on divers' necks. This is caused by an allergy to the natural rubber proteins in latex that some people have. The rashes seem to be exacerbated by shaving.

8.2 The Surface Standby Diver's CCTV and Monitor Access

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practice. These principles apply regardless of the diving technique employed.

Industry recommended practices:

> *"The standby divers' equipment should include a CCTV camera. This is to comply with the IMO Code of Safety for Diving Operations: 'Communications between dive control, the standby diver, and the divers in the water should be recorded (audio and video) and retained for a minimum of 24 hours after the dive is completed.'"*
>
> *ADCI "The topside tenders must be able to hear all communications between the divers and the supervisor and be able to talk directly to the supervisor."*

The following recommendations, based on lessons learned and experience, are considered safe working practices and aim to reduce risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- The surface-supplied standby diver position should have a video feed and monitor the working diver's camera.
  - The standby diver can become familiar with the worksite
  - The standby diver can assess any incident in real time
  - The standby diver will not need a detailed pre-dive briefing, as he will have seen as much as the supervisor.
- The more the standby diver understands the worksite and the events leading up to the rescue, the more effective the response will be.
- As with the working diver, the standby diver's equipment should include a head-mounted camera and a light.
  - The supervisor can assess the situation with a head-mounted CCTV camera.
  - The supervisor can provide quality advice and instruction during a rescue.
  - The light should be powered from the surface.
- The diving organisation must comply with local data protection laws when operating a CCTV system that records images and audio.

8.3 The Standby Divers Communications System

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practice. These requirements may be relevant regardless of the diving technique used.

Industry recommended practices:

"They[The Supervisor] will need to have direct communications with any diver in the water at all times".

The following recommendations, based on lessons learned and experience, are considered safe working practices and aim to minimise risks to ALARP. Diving organisations' procedures should identify the following, where practicable:

- All divers, including the standby diver, should maintain diver-to-diver and diver-to-supervisor communication at all times. This enables the standby diver to hear what is happening subsea and to build a mental picture of any potential situation.
  - The standby diver should monitor the diver's communications.
  - When deployed, the standby diver can communicate directly with any other diver in the water, including the IP, without the supervisor having to relay the message.
    - The more the standby diver knows about the worksite and the events leading up to the rescue, the more effective the response.

Industry recommended practices:

"Two-way voice communications with each diver and the standby diver must be provided".

The following recommendations, based on lessons learned and experience, are considered safe working practices and aim to minimise risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- Pre-dive checks should include confirming audio and verbal communications with the working divers and the supervisor, both in cross-talk and in direct communication.
  - The cross-talk function should not be treated as a 'nice to have' but as safety-critical during a rescue.

Industry recommended practices:

"There needs to be two-way voice communication with the diver at all times".

The following recommendations, based on lessons learned and experience, are considered safe working practices and aim to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- The diving supervisor should not use a 'press to talk' [PTT] within the diver's communication system, as the PTT function prevents the supervisor from hearing the diver.

Industry recommended practices:

"Record all voice communications, starting with the pre-dive checks".

Industry safety code of practice:

"Communications between dive control…. the wet bell, the standby diver and the divers in the water should be recorded (audio and video) and retained for a minimum of 24 hours after the dive is completed".

The following recommendation is based on international best practices for data protection. Diving organisations' procedures should, where practicable, identify the following:

- Any storage of voice and video recordings should comply with local data-protection requirements.

8.4 The Rescue Diver and The Working Diver's Buoyancy

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practice. These requirements apply regardless of the diving technique used, provided the diver(s) are using buoyancy control equipment.

The following safety considerations are worth discussing when preparing diver rescue documentation and apply regardless of the diving technique used. Diving organisations' risk assessments and procedures should identify the following, where practicable:

- If the pneumo supplies gas to a diver's buoyancy system, the rescue procedures should include how to safely disconnect the pneumo end fitting from the buoyancy equipment and insert it under a neck seal without causing damage or injury (Photographs 82 and 18), if relevant to the setup.
- If both the incapacitated diver and the rescue diver are wearing buoyancy compensators, only the incapacitated diver's buoyancy compensator should be inflated.
- How does the incapacitated or rescue diver maintain buoyancy if the incapacitated diver has a pneumo inserted into their BA as an emergency breathing supply?
- A thorough risk assessment must be conducted if the diver is wearing a variable-volume dry suit and a buoyancy compensator.
    - The diver might become over-buoyant, resulting in an uncontrolled ascent.
    - Consideration should be given to any drysuit exhaust valves located beneath the buoyancy compensator.
    - The buoyancy compensator should be able to vent if the diver is inverted. (Photograph 6)
    - The variable-volume drysuit should be able to vent if the diver is inverted.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. The diving organisations' procedures should, where practicable, identify the following where the buoyancy compensator equipment uses the pneumo for inflation:

- All buoyancy compensator equipment must be included in the diving organisation's PMS, including pressure relief and exhaust valves fitted to variable-volume dry suits.
- If divers use variable-volume dry suits for buoyancy, suit inflation should be supplied by the main gas supply or a separate bottle, not from the diver's personal reserve. (Photograph 8)

The following recommendations, based on lessons learned and experience, are regarded as safe working practices and are intended to minimise risks to ALARP. The diving organisations' procedures should specify the following when a variable-volume dry suit is used as a buoyancy compensator: (Photograph 5)

- Exhaust valves on a dry suit should be tested, certified, and included in the PMS.
- Exhaust valves should be installed on the lower leg in the event of a diver inversion. (Photograph 7)
- Suit inflation should be supplied from the main gas supply or a separate bottle, not from the diver's personal gas reserve cylinder. (Photograph 8)
- The use of the side block.
- The LP port is for dry suit inflation; if the fitting fails, it would reduce the gas supply to the diver. The following safety requirements must be observed:
    - An inline flow restrictor must be incorporated.
    - Only good-quality hoses and fittings are to be used.
    - Adapters shall not be used.

8.5 The Standby Diver's In-Water Thermal Balance

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices. These practices may apply regardless of the diving technique employed.

The diving project plan must outline methods for divers to maintain thermal balance. Excessive heat or cold can affect divers' health, safety, and efficiency. The approach to achieving this balance should be formally risk-assessed and documented.

This section focuses on hot water as the heating medium; electric suits are not included.

This section applies to regions where the water temperature at diving depths necessitates the use of active heating by divers.

Industry recommended practices:

> *"Divers must be maintained in thermal balance to avoid excessive heat or cold affecting their health, safety and efficiency"*

The following recommendations, based on lessons learned and experience, are considered safe working practices and aim to minimise risks to ALARP. Diving organisations' procedures should, where practicable, incorporate them:

- If the DPP identifies that the standby diver must be maintained in thermal balance through active heating, the diving organisations' procedures should clearly state:
    - If the standby diver cannot maintain thermal balance, they cannot be safely deployed to effect a rescue, or, if deployed, may succumb to hypothermia during the rescue. The temperature and flow rate of the standby diver's hot water are safety-critical and must be specified in the procedures.
    - While the working divers are deployed, hot water should flow through the standby divers' umbilical. If the water flow or temperature falls outside the specified limits, the dive should be aborted until the standby divers' hot-water supply is restored.
- USN: The effectiveness of the hot-water suit in keeping divers warm depends on maintaining a sufficient flow of water at 11.5 litres per minute (3 gallons per minute) at the correct temperature. This rate should be increased if there is a hot-water supply to the shroud.
    - The standby divers' hot water should be running at the correct rate for at least 15 minutes before diving.
- In the event of a complete loss of active heating, the standby diver should wear a thermal protective undersuit, such as a one-piece wetsuit, under the hot water suit.
    - It is a USN requirement to wear a 'wetsuit liner' for extra protection in the event of an active heating failure and to prevent scalding (Photograph 12).
    - The thermal undersuit should keep the standby diver sufficiently warm to enable him to supply hot water to a hypothermic, incapacitated diver. (Photograph 12)
- The time it takes for them to return to the deployment device might be sufficient for them to develop hypothermia, leaving them unable to respond effectively to the incident or to assist in their own rescue, as no other standby diver is available to rescue them.
    - The loss of active heating would be exacerbated during long excursions, such as when using extended umbilical techniques.
- If there is no independent backup heating arrangement, or if the FMEA identifies a single point of failure in the standby diver's active heating system, the DPP may require the standby diver to maintain thermal balance by passive means, such as a variable-volume dry suit. The diving organisations' risk assessment and procedures should specify the following:
    - The type of undergarments worn to maintain thermal balance (Photographs 9, 10, 11 and 12).
    - How is diver inversion prevented? (Photographs 5, 6 and 7)

Note: A tight-fitting wetsuit or undersuit may reduce bleeding, act like 'compression wear' used by athletes, help prevent swelling, and help maintain blood pressure in the brain.

8.6 The Working Diver and Standby Diver's Umbilical

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices. These may be applicable regardless of the diving technique used.

Industry recommended practices:

> *"The umbilical may be positively, neutrally or negatively buoyant, and any implications of the umbilical buoyancy should be included in the risk assessment."*

The following recommendations, based on lessons learned and experience, are considered safe working practices and aim to minimise risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- The umbilical properties should be suitable for the working site conditions and should not hinder the standby diver. In most cases, the risk assessment may recommend a buoyant or neutrally buoyant umbilical as the safest option.
  - A buoyant umbilical should keep the umbilical clear of debris and prevent fouling during rescue.
  - A buoyant umbilical is lightweight, aiding manoeuvrability in the water.
  - The umbilical properties are suitable for the task (bulk and buoyancy).
  - A long, negatively buoyant umbilical will act to drag a diver down.
- The standby divers' umbilical should not have redundant D-rings or other potential snagging hazards. (Photograph 86)
- The standby diver's umbilical should have a binding with a soft eye about two metres from the D-ring. The standby diver will use this eye to secure the umbilical in the basket during descent and ascent.
- The diver's umbilical should be attached to the rescue harness, not the personal gas reserve harness.
- When the launch positions for standby and working divers differ, the working diver's umbilical may be further restricted to account for the distance between them. However, during a rescue, if practicable, the rescue diver should deploy via the working diver's deployment device. Therefore, the surface standby should be tended from the working diver's deployment area, and the umbilical length calculation should reflect this.

Industry recommended practices:

> *"The umbilical also acts as a lifeline and should be strong enough to lift a fully equipped diver from the water".*

Industry recognises that there may be extreme circumstances in which a diver might need to be recovered or inadvertently suspended by their umbilical. During testing, umbilicals and harnesses must withstand a tensile load of 3500N. The link between the umbilical and the harness comprises the umbilical karabiner, D-ring, and binding.

The following recommendations, based on lessons learned and experience, are considered safe working practices and aim to minimise risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- The umbilical should be attached to the diver's harness using certified and proven lifting accessories, such as a fleeter (Chinese fingers) and a certified karabiner. (Photograph 91)
- If a binding and a D-ring are used, they should meet an auditable standard and be load-tested. (Photograph 92)
- All harness-to-umbilical linking accessories should be in the diving organisation's PMS.

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8.7 The Divers' Rescue Harness

This section ensures that the diving organisation carrying out diving operations has a robust diving safety management system that complies with industry best practices. These may apply regardless of the diving technique used.

Diver harnesses have several names within the diving industry:

> Diver safety harnesses, diving harnesses, lifting harnesses, recovery harnesses, body harnesses, and rescue harnesses are all terms for individual harnesses worn by divers during emergency rescues. A rescue harness should be worn beneath any diver's personal gas reserve to ensure the apparatus remains intact if it is removed. The diver's rescue harness must be the first item donned over the diving suit, with everything else worn on top. This document refers to these harnesses as the diver's *rescue harness*.

Industry recommended practices:

> *"Each diver (including the standby) should have a suitable safety harness. This should be manufactured to an appropriate national or international standard and be fit for the purpose it will be used for".*
>
> *"The diver's end of the umbilical should be fitted with a means which allows it to be securely fastened to the diver's safety harness without putting any strain on the individual whip ends."*
>
> *"The divers' rescue harness should meet the criteria and be tested, at a minimum, according to industry-recommended practices".*

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- If the diver needs to be lifted or suspended, the rescue harness must be used rather than the diver's personal gas-reserve or buoyancy-apparatus harness (even if the harness or jacket is rated for lifting, the diver's rescue harness should be used). The reason is shown in Photographs 26 and 27:
  - It is common for personal gas reserve jackets to either lack crotch straps, have them removed, or be left unbuckled. When crotch straps are provided, they are seldom fastened tightly enough to prevent the jacket from riding up.
    - The personal reserve harness/jacket rides up when lifting an IP, and the weight is distributed to the IP's armpits.
  - When lifted by and supported by the rescue harness, it is easy to remove the IP's personal reserve.
- If the diving organisations allow a diver to be lifted or suspended using the rescue harness's dorsal D-ring, the pre-dive checklist should include a line item to ensure that the dorsal D-ring is visible and easily accessible.
  - The dorsal D-ring often becomes wedged between the suit and the personal reserve jacket.
- If the diving organisations' procedures require a diver to be lifted from the water using the rescue harness thoral (chest) lift points:
  - The two thoral lift points should be easily identifiable.
  - The two thoral lift points should not be used for any other purpose that could hinder the rapid attachment of the rescue lift equipment.

8.8 The Safe Refuge / Place of Safety

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices.

Industry-recommended practices for determining the location of the umbilical datum when calculating surface-supplied diving personal gas reserve endurance conflict with one another, leaving diving organisations to select the calculation that best suits their project.

The more stringent or safer requirement should take precedence when there is a conflict between industry-recommended practices. The safest requirement states:

> *“Duration of the diver’s personal emergency reserve cylinder(s) at the depth. In the event of gas supply loss, the diver must be able to return to the wet bell/diving basket/diving ladder and on deck using his personal emergency reserve, which may dictate the distance he is away from the wetbell/diving basket/diving ladder.”*
>
> *“In the event of loss of gas supply, the diver must be able to return to a place of safety (e.g. a wet bell) or the surface using his bail-out bottle alone, which may dictate the maximum length of his umbilical”.*

The duration of a diver’s personal gas reserve at depth is essential. In the event of losing their gas supply, the diver must be able to return to a place of safety, such as the wetbell or the surface, using their personal gas reserve. This will determine the maximum length of their umbilical (unless diving from a DP vessel or another nearby hazard).

In surface-supplied diving, a personal gas reserve should be calculated to ensure the diver has sufficient gas to reach safety. However, the ‘place of safety’ or ‘safe refuge’ is not always clearly defined.

Industry practices set out different requirements and terms for the ‘place of safety’ and, thus, for calculating the diver’s personal gas reserve endurance.

It is essential to know the endurance of personal gas reserves. When a rescue diver reaches an IP and is breathing from their personal gas reserve, the calculation assumes 1 minute per 10 metres of umbilical deployed. This calculation does not account for the diver not returning immediately to the deployment device or the surface. Therefore, an additional supply must be available.

Industry-recommended practices provide similar yet distinct information on surface-supplied diving datum points for calculations. The only calculation and ‘safe refuge’ that remain consistent across recommended practices pertain to wetbell diving operations. The wetbell is the datum point for umbilical length, personal gas reserve calculations, and safe refuge in these operations. The wetbell serves as a safe refuge, allowing divers to breathe the air within the dome or canopy.

The diving organisations’ diving procedures should:

> *“Identify the divers ‘place of safety’ for each diving technique”.*
>
> *“Identify the diver’s ‘safe-haven’ in each diving technique so it cannot be confused with the ‘place of safety’”*
>
> *“Identify the umbilical datum point for personal gas reserve calculation”.*

Note: Industry Recommended Practices sometimes use the incorrect term. For example, in lifting documents, the diver should be in a ‘place of safety’ or ‘safe refuge’. The same terms are used for a diver returning to a wetbell using their personal gas reserve.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should identify the following, where practicable:

- When divers are deployed from a wetbell:
  - The diver's excursion umbilical datum point should be taken from the centre position of the wetbell.
  - A calculation should show that the capacity of the diver's personal gas reserve cylinder(s) at the planned deepest diving depth will provide breathing gas for 1 minute for every 10 metres of excursion umbilical deployed from the wetbell.
  - This calculation should be carried out using the emergency breathing rates recommended by the breathing apparatus manufacturer or by national legislation, whichever is higher, but not less than 40 litres per minute.
  - The calculation should also consider the available gas pressure in the personal gas reserve cylinder after deductions for depth and the regulator's working pressure.
- When divers are to be recovered by a davit or another emergency recovery method:
  - The diver's excursion distance/umbilical datum point should be taken from the deployment position (such as a ladder)/the length marking in the surface tender's hand.
  - This distance will include the freeboard (or air gap) + length of excursion to the diver (measured to the diver's gas fitting on the breathing apparatus).
  - A calculation should be made to show that the capacity of the diver's personal gas reserve cylinder(s) at the planned deepest diving depth will provide breathing gas for 1 minute for every 10 metres of excursion umbilical deployed from the tender's position on the surface, measured from the davit position, plus the time required to recover the diver to the davit from the surface and remove the breathing apparatus, as demonstrated by a recovery exercise.
- The timing of the recovery drill added to the personal gas reserve calculation is safety-critical. During the davit lift, the IP will not have a secondary supply, such as the standby diver's pneumo. Without gas in his personal gas reserve, he could suffocate.
  - This calculation should be carried out using the emergency breathing rates recommended by the breathing apparatus manufacturer or by national legislation, whichever is higher, but not less than 40 litres per minute.
  - The calculation should also consider the available gas pressure in the personal gas reserve after deductions for depth and the regulator's working pressure.
- When divers are deployed from a basket:
  - The diver's excursion distance/umbilical datum point should be taken from the LARS position/the length marking in the surface tender's hand.
  - This distance will include the freeboard (or air gap), the length to the basket, and the length of excursion to the diver (measured to the diver's gas fitting on the breathing apparatus).
  - A calculation should show that the capacity of the diver's personal gas reserve cylinder(s) at the planned deepest diving depth will provide breathing gas for 1 minute for every 10 metres of excursion umbilical deployed from the tender's position at the LARS.
  - This calculation should be carried out using the emergency breathing rates recommended by the breathing apparatus manufacturer or national legislation, whichever is higher, but not less than 40 litres per minute.
  - The calculation should also consider the available gas pressure in the personal gas reserve cylinder(s) after deductions for depth and the regulator's working pressure.
- Across all diving techniques, the diving organisations' documentation should standardise their terminology. It is suggested that:
  - 'Safe haven' is used by divers in degraded DP status or when the breathing supply is interrupted.
    - Always either the surface or the deployment device
  - 'Place of Safety' is used to describe a subsea area where divers are protected from dropped objects during lifting operations
    - Usually, the deployment device or area is approved by the diving supervisor.

8.9 Ancillary Rescue Equipment

8.9.1 The Diver's Rescue Lanyard

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practice. These requirements apply irrespective of the diving technique used.

Industry recommended practices:

The author found no reference to divers' rescue lanyards in diving industry documentation, even though they are present at every dive site.

A diver's rescue lanyard typically comprises two karabiners attached to a length of rope or climbing tape. There is no standard length or design for a diver's rescue lanyard; it can be a manufactured item or a length of suitable cordage with one or two clips, assembled by the diver. (Photograph 13)

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- The rescue lanyard must be suitable for its intended design length, fit for purpose, and safe to use. Without standards for rescue lanyards, the diving supervisor will be the ultimate authority on the lanyard's suitability.
- The lanyard should be sufficiently long to allow the rescue diver to ascend the umbilical hand-over-hand back to the safe refuge without dislodging the IP's breathing apparatus (Photograph 19). The diving organisation must trial combinations of pneumo and lanyard lengths to ensure that, in an emergency, the pneumo remains inserted into the IP's breathing apparatus throughout all stages of the rescue.
- The length must be assessed for risk. The lanyard should be sufficiently long to allow the rescue diver to ascend the umbilical back to the safe refuge without being hindered by the IP.
- Pre-dive checks must ensure that every diver has an approved rescue lanyard, which ought to be included in the diver's pre-dive checklists.
- During a rescue, the lanyard should always be attached to the diver's rescue harness, not to the diver's personal gas reserve harness or buoyancy compensator jacket.
- The divers' rescue lanyard must have screw-gate karabiners of the same design as those used to attach the diver's umbilical to the harness.
- The rescue lanyard should never be used for lifting or suspending a 'dry' diver.
- There should be a standard for diving organisations on the design and placement of the rescue lanyard.
- The dive site should have a dedicated rescue lanyard for the standby divers' equipment.
    - The standby diver's lanyard should be fitted with an additional 'scaffolders' gated hook. These locking safety hooks have a wider gate opening (usually 65 mm). The wider gate gives the standby diver more options, such as connecting to thicker ropes, the ROV, strops, and metalwork on the deployment device. (Photograph 13.1) The device must be usable with one hand.

8.9.2 The Selection and Use of an Umbilical Cutting Tool

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices. These practices may apply regardless of the diving technique used.

An unavoidable situation can arise if the IP's umbilical becomes fouled or is incorrectly routed. During an emergency, it may not be feasible for the rescue diver to leave an incapacitated diver, for example, when the incapacitated diver is breathing from the rescue diver's pneumo.

Industry recommended practices:

> *"The umbilical shall be attached to the diver so that it cannot be inadvertently released underwater by the diver, fouling, or any other incident. It shall be possible to cut it with hand tools carried by a diver".*

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should identify the following, where practicable:

- The diving organisation should confirm whether the diver's knife can cut a diver's umbilical, including any strength member. If the knife is incapable, the organisation should trial, approve, provide, and risk-assess a suitable cutting tool. (Photographs 87 and 88)
  - If a dive knife is deemed appropriate, the diving organisation should ensure that all dive knives are standardised and issued by the organisation. (Photograph 77.1)
- The diver should be trained to cut an umbilical with the approved cutting tool:
  - Where to make cuts/sever the umbilical.
  - The preferred order in which any individual hose or cable within an umbilical is cut.
- The supervisor should isolate the umbilical's energy supply before cutting.
- Each deployment device should carry a cutting tool, such as a hacksaw or shears, capable of swiftly and cleanly cutting a diver's umbilical.
  - If a hacksaw is used, divers should be familiar with blade changes and the direction of blade attachment.
- At dive sites where the standby diver is deployed via a ladder, the standby diver should carry the diving organisation's approved umbilical-cutting tool.
- The tool should be:
  - Immediately available and ready to use.
  - Resistant to seawater corrosion/regular immersion.
  - Included in the pre-dive checklist.
  - Included in the PMS.

8.9.3 The Recovery 'Chest Spreader' (Spreader Beam) During a Diver Rescue

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices. These may be applicable regardless of the diving technique used.

In all diving techniques, an incapacitated diver may need to be secured in a deployment device or lifted out of the water using their rescue harness. A diver can be secured, suspended or lifted from a single point on their harness.

A single lift, usually via the harness's dorsal D-ring, suspends the incapacitated diver at a forward-leaning angle, making removal of the breathing apparatus difficult. Some diving organisations and divers prefer to be lifted using a 'chest spreader'. This two-point lift provides better access for tenders to remove the IP's breathing apparatus and is more comfortable.

If the diving organisation's rescue risk assessment and advice from their DMP necessitate a lift that angles the IP in a reclined position to provide an open airway, a thoral lift should be employed.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- A thoral lift or suspension should always be performed with a recovery spreader beam to reduce pressure on the incapacitated diver's chest caused by the harness straps being drawn together. When utilising a chest lift without a recovery spreader beam, any chest injuries may be aggravated, and the IP's breathing may become laboured or stop. (Photographs 54, 62, 63 & 64)
- If a recovery spreader beam is used to lift a diver, it should be included in the PMS (Lifting equipment) and comply with the testing requirements for use in a closed-bell diver-rescue recovery system.
- If a recovery spreader beam is used for a thoral lift, it is attached to the front D-rings:
    - This usually puts the diver's head back and may help maintain an open airway.
    - The recovery spreader beam usually provides better access for removing the diver's breathing apparatus.
    - The thoral lift angle of recovery can make casualty handling on the deck easier than a dorsal lift.
    - The two thoral lift points should be easily identifiable.
    - The two thoral lift points shouldn't be used for any other purpose that might hinder the quick attachment of the rescue lift equipment.
- A single-point dorsal lift (Photograph 55):
    - Usually causes the diver to tilt forward, which may impede the IP's airway.
    - This angle of recovery can make casualty handling challenging, as the connection is at the IP's back; the casualty will usually be placed supine. Maintaining the stability of the IP's head and spine during the disconnection of the lifting equipment will be difficult.
    - Removing the diver's breathing apparatus is challenging when the IP is suspended from the dorsal lift point, particularly if the apparatus has a neck dam swing catch.
    - The dorsal D-ring often gets lodged between the suit and the personal reserve jacket. Pre-dive checks should confirm that it is easily accessible.
- If a pulley block-and-tackle arrangement is used to lift or support a diver, it should be included in the PMS (Lifting equipment) and comply with the testing requirements for use in a closed-bell diver-rescue and recovery system.

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8.10 Use of the Pneumo as an Emergency Breathing Supply

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices. These are applicable regardless of the diving technique used.

Using the diver's pneumofathometer as an emergency breathing source has become routine. The pneumo is designed to obtain a pressure reading and is neither audited nor tested as a breathing supply; therefore, it should be regarded only as a 'last resort'. Other gas sources should, where possible, be made available. Industry-recommended practices require that all breathing gas be of the correct composition and have suitable volume, temperature, and flow for all foreseeable situations, including emergencies.

Industry recommended practices:

> *"If the diver can push his pneumo under his neck seal, the diving supervisor may also turn on the gas to the pneumo as a secondary supply."*

The diving organisations' procedures should identify the following

- When an open-ended hose, such as a pneumo, is fed past the neck dam into the BA, the diver transitions from a demand-diving system to a free-flow system. On average, a free-flow system requires at least three times as much air as a demand system.
- The pneumo supply is not considered a breathing supply under industry-recommended practices; therefore, it is not an 'official' breathing source. If the diving organisation designates the pneumo supply as a breathing gas, it should be able to provide a suitable gas at a suitable flow rate and temperature, compatible with the intended diving operation's maximum depth. The flow rate should be specified and tested.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, address the following:

- The diving supervisor should routinely purge the diver's pneumo to remove excess water and mud and to verify its proper operation. The dive should be aborted if the pneumo is designated as an emergency supply and becomes inoperable, particularly if the diver with the blocked pneumo is a potential rescue diver.
    - Once the supervisor purges the pneumo to obtain pressure and depth readings, the hose refills with water. If the end of the pneumo hose is submerged in mud, mud may be drawn up the hose, causing a blockage.
- If the pneumo is operated, it should not compromise a diver by depriving them of breathing gas, including their own. Gas supplies must be arranged so that the operation of a diver's pneumo does not interfere with that diver's gas supply or any other diver's.
- Consideration should be given to the length and end fittings of all divers' pneumo hoses:
    - The pneumo must be of sufficient length so that, when a rescue lanyard connects both divers and the rescue diver climbs an umbilical, the pneumo remains within the IP's BA. (Photographs 17 & 49)
    - The length of the pneumo hose inserted into an IP's BA should be identified. (Photograph 19)
    - Procedures should state how the pneumo is secured in the diver's BA during recovery.
    - Consideration should be given to whether a buoyancy compensator is inflated via the pneumo with a QC fitting. The QC fitting may not permit gas flow when disconnected. (Photograph 18)
    - All QC fittings on site should, where practicable, be standardised. They should not have keyways.

- If the diving organisation states that the pneumo is a breathing supply, the flow rate should be confirmed as adequate using flow meters. The pneumo flow rate should be stated and recorded in the PMS.
  - There should be no end fitting on the pneumo hose (Photographs 18 & 19):
  - - Difficult to insert through the neck seal.
  - - May damage the neck seal.
  - - High risk of injury to the incapacitated diver’s face, eyes, and teeth.
- During a rescue of an unconscious diver, the use of an open-ended pneumo into the IP’s BA might be beneficial in other, less obvious ways:
  - The pneumo will create positive (over) pressure that might help the IP with spontaneous breathing after the airway is opened (and during agonal breathing).
  - The positive pressure will help remove any vomit from inside the BA.
  - The noise of the gas may help the rescue diver assess the level of consciousness by checking whether the diver responds to noise (‘V’ in AVPO means responds to voice, or noise in this case).
- Procedures and risk assessments should specify the breathing medium used by the standby diver. For example, if the working divers are breathing nitrox and the standby diver is breathing natural air or an equivalent artificial mix, the standby diver’s pneumo will most likely match the breathing mix. If the pneumo supply is given to an IP who was breathing nitrox, their decompression profile will change significantly.

8.11 Use of Location Devices During a Diver Rescue

This section ensures that the diving organisation performing diving operations has an effective diving safety management system that complies with industry best practices. The following will not apply to surface swimming and is unlikely to apply to daughter craft or SRP diving techniques.

Acoustic beacons, also known as pingers, are battery-powered devices that emit high-frequency signals when activated. Divers may carry them to track their position, or they may be attached to objects to serve as fixed reference points. Beacon tracking systems can display real-time images showing the positions of vessels, divers, ROVs, and lifted objects relative to subsea assets and surface-breaking offshore structures.

Acoustic positioning beacons are valuable tools for diving operations and have been used during a rescue.

Industry recommended practices:

> *"Where operational depth allows, the deployment device and IWTP can be fitted with a survey beacon(s) to allow its actual location to be plotted and displayed on screen for the dive supervisor and DP operators."*
>
> *"If lifts involve diver or ROV intervention, consideration should be given to … use of subsea load positional beacons."*
>
> *"Acoustic beacon tracking systems do have their limitations.*
>
> *♦ Depending on the type of systems used at manned diving depths, their accuracy can typically be in the order of 0.5 to 1 metre, i.e., 1 to 2 metres between two beacons.*
>
> *♦ Acoustic systems are subject to in-water disturbances – such as air bubbles.*
>
> *♦ The location of the beacons may 'jump' on screen, especially in shallow waters"*

The following safety considerations should be discussed when preparing diver rescue documentation and are relevant regardless of the diving technique used. Diving organisations' risk assessments and procedures should identify the following, where practicable:

- How is an incapacitated diver located if their umbilical has parted (lost diver)?

The following recommendations, based on lessons learned and experience, are considered safe working practices and aim to minimise risks to ALARP. Diving organisations' procedures should specify the following, where feasible:

- Each diver in the water should carry an acoustic positioning beacon (in water depths where the beacon functions accurately) (Photographs 20 and 21):
  - The supervisor can easily direct a second diver in the water to the incapacitated diver without requiring the second diver to trace the incapacitated diver's umbilical from the deployment device, thereby saving time.
  - The supervisor can easily direct a rescue diver or an ROV to a 'lost diver', regardless of visibility or diving conditions in hours of darkness.
  - Knowing the diver's location reassures the supervisor that the diver is out of the line of fire from dropped objects and away from areas of differential pressure, contamination zones, and electrical hazards.
  - Knowing the diver's location reassures the supervisor that the diver is outside the ROV's safe stand-off distance. ROVs and their tethers can pose risks to divers and their umbilicals, potentially causing injury.
  - Following dynamic risk management, the diving supervisor may position a surface lifting device above the incapacitated diver to assist in the rescue.
  - During diving operations on a vessel maintained in position by dynamic positioning, the supervisor, after conducting dynamic risk management, may reposition the vessel and the deployment device closer to the incapacitated diver, thereby reducing distance and rescue time.

- The diving organisation should conduct trials to determine the optimal position for mounting the beacon on the diver. The beacon signal should also operate and be interpreted when the diver is inverted.
- There have been advances in transponders and their batteries over the years; however, the diving organisation should carry out a risk assessment of the beacon's potential for internal pressure build-up within the housing.
- The deployment device should be fitted with a beacon:
    - When deploying loads subsea, at least two independent depth-measuring devices should be used. If there is no line-out meter, a beacon and the diver's pneumo should be available.
    - The beacon will help the supervisor position the deployment device if the vessel needs to move towards an incapacitated diver.
    - The beacon will provide the supervisor with an accurate location of the deployment device's offset, caused by vessel movement or current, relative to subsea assets. If the distance to the nearest recognised hazard has changed, the offset might necessitate shortening the diver's umbilical during the rescue.
    - The beacon will provide the supervisor with an accurate measurement of the depth of the unmanned deployment device relative to subsea assets or an incapacitated diver.
- The IWTP should be fitted with a beacon so the supervisor knows the offset. During a rescue, the supervisor knows the IWTP's position and, if safe to do so, can manoeuvre the vessel to bring the IWTP closer to the IP.

8.12 Use of The Diver’s Hot Water Supply During a Rescue

This section ensures that the diving organisation conducting operations has an effective diving safety management system that complies with industry best practice. The following applies to any diving technique that uses a hot water supply to maintain the diver's thermal balance.

The following recommendations are safe working practices that may benefit an injured diver during a rescue. Diving organisations’ procedures should take the following into account, where practicable:

- If the IP has lost their hot-water supply, it is good practice, under the right circumstances, for the rescue diver to provide the IP with hot water. This will rewarm the IP; however, further consideration should be given to:
    - An individual with severe hypothermia should be re-warmed under medical supervision. Rapid re-warming can cool the blood as it circulates through the cold outer tissues, potentially causing a fatal drop in core temperature when the cooled blood returns to the core. Thus, administering hot water to a hypothermic diver may be harmful.
    - If the IP experiences severe haemorrhage, cold may cause vasoconstriction, which can prevent further blood loss. If the diver’s hot-water supply is removed, the cold water could induce vasoconstriction, thereby reducing blood loss. Therefore, providing hot water to a haemorrhaging IP might be counterproductive.
    - The intense cold may help the rescue diver assess the level of consciousness by checking whether the diver responds to pain (‘P’ in AVPO stands for responds to pain).
- Exiting the water while upright can cause blood to pool in the lower limbs, leading to a drop in heart rate and blood pressure when hydrostatic pressure is released from the legs (circum-rescue collapse). This reduction in blood pressure may affect the brain, possibly leading to loss of consciousness. (An unconscious diver returning to the deck will most likely be diagnosed with an arterial gas embolism.)
    - If the hot water supply is restored while the IP is upright, water within the suit can ‘seal’ at the boots, thereby increasing hydrostatic pressure on the lower limbs.
- If a diver uses hot water to maintain thermal balance and the emergency recovery method is via a rescue davit, the diver’s hot water must be dumped or disconnected before hoisting. Excess water in the suit could increase the risk of suspension trauma and place additional load on the lifting equipment.
    - It has also been found that divers wearing hot-water suits who spend extended periods in hot water may become hyperthermic (body temperature exceeding 39°C). In such cases, the supervisor’s dynamic risk management must account for this risk and instruct the rescue diver to respond appropriately.

8.13 Use of a Diver's Weak-link

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practice. These requirements may apply regardless of the diving technique used.

Industry recommended practices:

> *"In certain circumstances, a diver may secure himself underwater to achieve stability. In such cases, a recommended 'weak link' should be used".*

If following industry-recommended practices, a diver should not secure themselves underwater when a mobile or portable surface-supplied diving system is being used because:

> *"The system should not be used if there is any risk of the diver or his umbilical becoming fouled or where immediate recovery of the diver cannot be achieved".*

The following safety considerations should be discussed when preparing diver-rescue documentation and are applicable regardless of the diving technique used. The diving organisations' risk assessment and procedures should identify the following, where practicable:

- If a working diver is secured underwater with an industry-recommended compliant 'weak link' to maintain stability and becomes incapacitated, the rescue follows the hierarchy of rescue.
  - When a diver is deployed from a basket, can a surface tender overcome the design release load by pulling from the surface? (The umbilical will pass through the umbilical guide)
  - Can the bellman overcome the design release load when a diver is deployed from a wet bell?
  - When a diver is deployed from a basket, can a surface standby diver overcome the design release load by pulling from the basket?
- Does the diving organisation's incapacitated diver rescue drill include the surface tender or standby diver overcoming the release load from the surface or from the deployment device?
- Releasing the weak link remotely during near-surface and mid-water operations could worsen the situation. For example, in dives where the diver is far from the deployment device, releasing the weak link might cause a much deeper excursion than planned. The depth could exceed PPO2 limits or extend beyond the limiting line. In both cases, there may be alternatives to sending the standby diver to such depths.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, address the following:

- The diving organisation should supply all weak links. (Photograph 25)
- The diver should notify the supervisor whenever a weak link is used, and the supervisor should approve the setup.
  - The supervisor should assess the setup for remote release during an incapacitated diver rescue.
- The weak link is a piece of safety-critical equipment; diving organisations should ensure that all weak links are included in the PMS and that they adhere to industry-recommended practices.
- The rescue exercise should include securing the incapacitated diver to a structure.

8.14 Use of an ROV During a Rescue

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system in line with industry best practice. The following does not apply to surface swimming and is unlikely to apply to daughter craft or SRP diving techniques.

Diving organisations often state that an ROV can assist the rescue diver in reaching the incapacitated diver and returning them to the deployment device.

An ROV can help locate an incapacitated diver by giving the supervisor an overview and illuminating the area for the rescue diver.

Industry recommended practices:

> *"It is accepted that in an emergency, assistance to a diver in distress may need to be done without any RAs and TBTs."*
>
> *"An ROV can provide a useful view of the operation [rescue], but it should not be allowed to add to the difficulties by getting too close to the diver …or snagging umbilical."*

Industry-recommended practices outline the key hazards that arise when divers and ROVs are in close proximity. To mitigate these hazards, a minimum safe working distance of four metres is recommended for normal diving operations. Diving organisations' procedures and risk assessments should identify the following:

- Are there any limitations on the ROV's involvement and role in rescuing an incapacitated diver?
- How are the multiple ROV hazards controlled when the ROV is used in a rescue?
- Divers being transported by an ROV need to be practised.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following where an ROV is immediately available:

- There should be no issues using any class of ROV in a passive role during an incapacitated diver rescue, as this should already be risk-assessed and covered in procedures, including tasks such as:
  - Locating the incapacitated diver and illuminating the area.
  - Give the diving supervisor an overview of the situation.
  - Monitoring the umbilical of the incapacitated diver for fouling so the diving supervisor can instruct the tender to take up slack.
  - Monitoring the diver's deployment device and guide weight allows the diving supervisor to lower them deeper, if necessary, to enable quicker egress and access for the diver.
  - Capturing moving images in real time for investigation and lessons learned.
  - Locating a 'lost diver' (a diver whose umbilical has parted).
- If the diving organisation permits the ROV an active role, based on the diving supervisor's dynamic risk management, during an incapacitated diver rescue (Photographs 22 and 23)
  - The diving organisation should specify the minimum ROV class permitted for transporting divers. The Class should ideally include:
    - An extendable tool tray for divers to stand on.
    - Be able to maintain depth and heading automatically.
    - Be fitted with real-time sonar.
    - Be able to monitor the divers at all times while they are on the ROV.
    - Be able to easily isolate any manipulator that could pose a hazard to the diver.
  - The divers' project-specific familiarisation should include the ROV, its hazards, and, if required during a rescue, the safe area to stand or hold.
  - The safe area for a diver to hold on to or stand on should be easily identifiable on the ROV.
  - The ROV must have guards on all moving parts that could injure a diver or damage their umbilical.

  - If the ROV is used to release a fouled or trapped diver's umbilical, the ROV team must recognise it as safety-critical and handle it with care.
  - ROV speed during diver transit: The force exerted on a diver by a current caused by the ROV's movement is proportional to the square of the water velocity. If the current doubles, the force on the diver increases by a factor of 4. In the worst case, the rescue diver might be holding onto the ROV while an incapacitated diver is suspended by the rescue lanyard and subjected to induced drag from two umbilicals. There will be a limit to the rescue divers' grip strength.
  - Minimum depth at which the ROV can transit with divers. If shallow, a diver can sense wave motion to a depth of about half the wavelength. A typical wavelength is 20 msw, with turbulence experienced down to 10 msw. A diver near the surface will be significantly affected by even a moderate swell.
- If the ROV is to be used in a diver rescue, there should be:
  - Procedures and risk assessment.
  - The incapacitated diver recovery drill and exercise matrix should include the use of the ROV.

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8.15 Use of a Deployment Device's Guide Weight During a Rescue

This section ensures that the diving organisation conducting operations has an effective diving safety management system that complies with industry-safe working practices. The following applies to diving techniques using baskets and wetbells.

Diving organisations often state in their rescue procedures that the guide weight can help the rescue diver bring an incapacitated diver to the deployment device. The effectiveness of the guide weight for this purpose depends on the specific circumstances of the diving operation, the diving supervisor's competence, and the diving organisation's dynamic risk management.

The diving organisations' procedures and risk assessment should identify the following and provide general advice or guidance for the diving supervisor to consider:

- When the use of a guide weight as a diver's elevator is a potential, the diving supervisor's dynamic risk management needs to consider personnel and their umbilical being in the 'Line of Fire', such as:
  - Struck by: the guide weight impacting divers or their umbilicals during lowering.
  - Struck by: the guide weight impacting the divers caused by the vessel's heave/roll.
  - Caught in between hazards: the diver or their umbilicals are crushed between the guide weight and the underside of the deployment device.
  - Caught in between hazards: the diver or their umbilical being caught in either a rotating block or a moving wire. (Photograph 24)
- When using a guide weight as an 'elevator', the diving supervisor's dynamic risk management should not consider lowering the guide weight without ROV or diver oversight; it will be a 'blind lift'*. The diving supervisor's dynamic risk management must consider personnel umbilicals and subsea assets, as they are in the 'Line of Fire'.
- It is standard industry practice not to allow a guide weight or the divers' deployment device to contact the seabed or to be positioned below the height of all underwater structures, to prevent fouling in the event of a run-off or black ship event. There will be circumstances, such as when diving from a fixed structure or an anchored vessel, where the diving contractor's risk assessment will allow lowering the guide weight or deployment device to a position near the seabed. The diving supervisor needs to know when they can and cannot lower the guide weight or deployment device below the height of subsea structures or debris.
- Consideration should be given to when and to what depth the standby divers' guideweight is deployed.
  - The guideweight is significantly lighter than the working divers' deployment device; therefore, the water drag coefficients of the guideweight and the deployment device will differ, causing a deviation from the vertical.
  - How is the guideweight prevented from fouling the deployment devices' wires or umbilicals (wet bell and divers) during deployment or recovery in currents and vessel movements?

*Note: Subsea lifts are blind lifts. The deployment and recovery of a manned, industry-compliant deployment device are considered routine operations

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should identify the following, where practicable:

- If the deployment device guide weight is stated in the rescue procedure:
    - The maximum vessel heave and roll parameters should be stated.
        - The diver may struggle to grip the guide weight if vertical movement is excessive.
        - Vertical movement may cause a diver to be struck by the guide weight.
        - The deployment device should have a beacon to let the supervisor know the guide weights' relative position to the divers (with beacons) and subsea assets (displayed on the navigation screen).
- A guideweight should never be lowered as a 'blind lift' while the vessel moves location.
- The guide weight usually contains moving or rotating parts.
    - Each guideweight should be risk-assessed for hazards, including line-of-fire risks.
    - Not all guide weights are the same. Some are well-designed, with all moving parts enclosed within the weight and guards at the point where the wire enters the block, preventing the hands and umbilical from being drawn in. Others lack guards and rely on being 'safe by position'; when the guide weight is near the bottom of the deployment device, the umbilical can't be drawn in, and divers have no reason, during normal operations, to approach the guide weight.
- The incapacitated diver recovery drill and exercise matrix should include the use of the guideweight, if it is included in the diving organisation's procedure.
- Consideration should be given to when and to what depth the standby divers' guideweight is deployed. The guideweight is significantly lighter than the working divers' deployment device; therefore, the water drag coefficients of the guideweight and deployment devices will differ, causing a deviation from the vertical.
    - Each guideweight should be assessed for the potential to foul the working divers' deployment device, such as:
        - The proximity of the standby and working deployment devices.
        - Current strength and direction – A current meter should be deployed at the same depth as the planned guideweight storage depth.
        - Weight and surface volume of the guideweight affect the amount of deviation.
        - The depth at which the working deployment device is deployed. Currents are usually near the surface.
        - Shelter from the hull - Depending on the current direction, the hull might either provide lee or increase current flow.
        - Speed of deployment. The guideweight usually deploys at half the deployment device's speed.
        - Further consideration should be given to any items protruding from the hull, such as a bilge keel. The bilge keel can cause fretting on the guidewires if in contact or foul the guideweight on recovery.

8.16 Use of a Crane During a Diver Rescue

This section ensures that the diving organisation has an effective diving safety management system that adheres to safe working practices.

Note: ‘crane’ is used as a generic term. This section applies to any approved lifting appliance.

Diving organisations frequently state that a crane (or another appropriate lifting appliance) can assist with rescues in multiple ways. Typically, details are omitted, depending on the diving supervisor’s dynamic risk management.

The following safety considerations should be addressed when preparing diver rescue documentation and apply regardless of the diving technique used. The diving organisations’ risk assessment and procedures should identify the following, where practicable:

- When a surface-lifting device in a passive role can be used during a rescue, such as:
  - Positioning a crane over an incapacitated diver to assist a rescue diver in locating the IP in challenging seabed conditions.
- When a surface lifting device in an active role can be used during a rescue, such as:
  - When working ‘midwater’, a lifting device could assist significantly by:
    - Transporting the rescue diver to the incapacitated diver.
    - Transporting both divers back to the deployment device (or surface).
  - When working on the seabed, a lifting device can assist in returning both divers to the deployment device.
  - Lifting debris from a fouled umbilical or a trapped diver.
  - Recovering a ‘lost’ diver on the surface.
  - Recovering an incapacitated diver on an extended umbilical directly to the deployment device.
- Does the vessel crane comply with any ASOG requirement during a rescue? Typically, a vessel crane should not be located within 10m of a surface structure.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to reduce risks to ALARP. Diving organisations’ procedures should, where practicable, identify the following:

- The vessel/crane heave limits should be stated. If movement at the block is excessive:
  - The diver(s) risk injury from the block/hook (Line of Fire).
  - Divers might find it challenging to maintain their grip on the lifting device if vertical movement is excessive (heave).
    - Can the lifting device be put in active heave?
  - A beacon should always be installed on the lifting device and the diver.
- The rescue diver should not attach himself or the IP to the lifting equipment unless the intention is to recover the IP to the surface.
  - If the contingency plan involves retrieving the IP directly to the surface, the lifting device's connection to the IP’s harness must be considered. Typically, lifting rigging is too large to fit on a harness D-ring.
  - The diver’s rescue lanyard should not be used to attach the IP to the lifting equipment.
  - Under no circumstances should the lifting device be attached through or directly to the harness straps.
    - The harness straps will be brought together, resulting in crushing or restricting the IP’s breathing.
- The incapacitated diver recovery drill should include the use of a crane (or site lifting device).

8.17 Use of a Diver Swim Line during a Rescue

This section ensures that the diving organisation has an effective diving safety management system that adheres to safe working practices, regardless of the diving technique used.

During surface-supplied diving, diving during 'windows' of slack tidal currents is standard practice. The dive is planned to start when the current decreases to approximately 0.8 knots and to recover the diver when it reaches approximately 0.7 knots. A current meter should be on site, and tidal and current trends should be monitored over days to build a picture of local water movements.

Although certain types of normal diving operations can continue at currents up to 1 knot, drag forces on a diver increase. The force exerted on a diver by a current is proportional to the square of the water velocity; if the current doubles, the force acting against the diver increases fourfold.

When diving in areas with strong currents, there is a risk of an unplanned event that may require a rescue and extend the dive beyond the planned dive window. This may result in a rescue taking place, partially or wholly, in a current stronger than the diving organisation's allowable diving parameter.

An IP attached to a rescue diver in a current will experience considerable drag. The rescue diver must overcome drag on himself, the IP, and potentially on both umbilicals.

Ascending an umbilical or swim line is not the same as climbing a rope at the surface; the diver can use only their arms and upper-body strength. Ascending an umbilical or swim line in a current is physically exhausting.

When a diver uses only an umbilical to ascend to the deployment device (or the surface) in a current, he will be swept by it. Due to the current's drag, the diver is often at right angles to the deployment device. If the rescue diver uses a swim line from the deployment device, he and the IP should gain direct access, regardless of the current strength.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, address the following:

- If the diver rescue is 'mid-water', the rescue diver and IP may descend to the length of the deployed umbilical, which may involve a long horizontal excursion. This may compromise the planned decompression schedule and possibly exceed the limit line or the maximum allowable PPO_2 of a nitrox bottom mix.
- A diver with a parted umbilical (lost diver) can safely self-rescue ascending a swim line.
- The swim line should be of a circumference that allows easy grip
- The swim-line diameter should be compatible with the karabiners on the diver's rescue lanyard.
- The rescue diver should use a rescue lanyard to secure themselves to the swim line, thereby conserving their strength during the ascent while being assisted.
- The rescue diver should use a rescue lanyard to secure themselves to the swim line. The rescue lanyard and swim line will reduce the effects of drag on the rescue divers' arms during an unassisted ascent. The rescue diver will only need to traverse to the deployment device.
- The rescue diver should use a rescue lanyard to secure himself to the swim line. The rescue lanyard and swim line will prevent a 'blow-up' when wearing a buoyancy compensator or a variable-volume dry suit. The swim line will stop ascent at the deployment device.
- The release/breakout of any weak link used to secure the swim line at the work site needs to be assessed. The required force should exceed that of two divers ascending the swim line in the maximum predicted current.

8.17.1 SRP Standby Divers Swim-Line

During SRP diving operations, a downline or swim line should be set up from the surface to the worksite.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- During SRP diving, the swim line descending from the surface allows deployment of a lazy shot for in-water decompression. The diver/rescue diver needs a rope to secure themselves during any unplanned decompression stops.
- The rescue diver secures their rescue lanyard to the swim line, using it as a running jackstay. This allows safe deployment and recovery in currents and leaves the rescue diver with a free hand, as they do not need to hold the swim line.
- During SRP diving, a swim-line prevents the diver or the rescue diver from descending to the full extent of the deployed umbilical during a horizontal deployment.
- During a rescue, the standby diver traverses the swim line while the surface tender attempts to bring both divers to the surface or to the wet stop depth.
- The swim line allows a diver to maintain their depth:
    - When clearing their ears during descent.
    - If the diver loses a fin/both fins
    - If the current is running.
    - If the diver gets a cramp

8.17.2 Standby's Deployment Device to Working Deployment Device Swim-Line

It must be recognised that when two deployment devices are deployed in proximity, there is a potential for the divers' deployment device to be offset from its calculated position due to currents or tides. When working in such conditions, due consideration must be given to the equipment specifications, deployment geometries, and current flows, both present and predicted. For example, a heavy wetbell will have much lower displacement from currents than a lightweight standby diver basket deployed to the same depth.

The standby divers' basket and the working deployment device (basket or wetbell) should be positioned as close together as practicable. This enables the standby diver to deploy from the same deck area as the working divers, thereby reducing the distance they must travel to the deployment devices.

The following recommendations, based on lessons learned and experience, constitute safe working practices intended to reduce risks to ALARP levels. The diving organisations' procedures should identify the following, where practicable:

- A suitable rope should be fitted with spliced soft eyes and shackles on each eye. The rope must be sufficiently thick to provide the diver with a secure grip and to allow a karabiner to be attached. The running shackles should be fixed to the inner guide wire of each deployment device. This rope serves multiple purposes and is crucial for safety during a surface-standby rescue (Photograph 46).
    - The standby diver can locate the working deployment device in poor visibility and at night.
    - In strong currents and wave motion, the standby diver can pull himself to the working deployment device and vice versa. (Generally, a diver can sense wave motion to a depth of about half the wavelength. A typical wavelength is 20 msw, with turbulence experienced down to 10 msw. A diver near the surface will be significantly affected by even moderate swell.)
    - The standby diver can secure himself and/or his umbilical when leaving the standby basket and moving to the working deployment device to perform the rescue.
- The risk assessment and procedures should make it clear that the deployment device-to-deployment device swim line will only prevent the two deployment devices from moving apart. No mechanical device prevents them from moving closer together, potentially resulting in contact or entanglement. Two deployment devices placed close together pose a significant line-of-fire hazard to divers, their umbilicals, and the deployment devices.
    - A current meter should be installed on site to monitor current strength and direction. Where feasible, the diving supervisor should position the vessel so that deployment devices and their guideweight do not come into contact with divers or their umbilicals, or pose a line-of-fire hazard to divers.

8.17.3 Deployment Device to Worksite Swim-Line

A swim line should exist between the working deployment device and the work site. During a diver rescue, the swim line will be a safety-critical element.

The method of attaching the swim lines may vary by vessel, but they are typically connected to the work site at the deployment device's guide weight.

When a dive platform is maintained on station using dynamic positioning, the swim line should be managed from the surface and connected to a weak link at the work site via a shackle, either on the deployment device or on the guide weight. Both methods allow recovery of the deployment device without retrieving the swim lines after each dive.

The surface tender can assist with an IP recovery during a diving operation using a basket. The extent of assistance the tender can provide is unknown, as it must overcome drag and friction on the umbilical both as it passes through the basket and while in the water.

If divers are deployed from a wetbell, there is no surface tender to assist. During operations where a bellman has exited the wetbell to conduct the rescue, there may be a delay while waiting for the surface standby diver to deploy and assume the bellman's role at the wetbell. Therefore, the bellman conducting the rescue will benefit from using a swim line between the work site and the wetbell.

Industry recommended practices:

> *"Swim lines <u>should be installed</u> between the deployment device and the work site".*
>
> *"An expendable breaker or weak link should be used to attach to the worksite".*

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. The diving organisations' procedures should identify the following, where practicable:

- The method for attaching a swim-line to the deployment device should be standardised and risk-assessed.
- When a dive platform is maintained on station using dynamic positioning, the swim line should be managed from the surface and connected to a weak link at the work site via a shackle, either on the deployment device or on the guide weight. Both methods allow recovery of the deployment device without retrieving the swim lines after each dive.
- Swim lines should be installed between the deployment device (or the surface when utilising SRP) and the work site during all diving operations.
    - During a rescue in a current, without a tender recovering the umbilical, it is easier for the rescue diver to ascend a rope directly to the deployment device than to climb the umbilical and most likely end up 'in the breeze'. The drag caused by the current will leave the rescue diver exhausted.
- During a rescue, the standby diver climbs the swim line while the surface tender attempts to pull both divers towards the deployment device.
- Consideration needs to be given to where the swim line is attached subsea; it is commonly secured between the guide weight and the structure/worksite.
    - When attached to the guideweight, there is a difficult transition between the guideweight and the deployment device, especially with current and vessel heave.
    - Where practicable, consider attaching the swim line to a high point on the deployment device. This will allow the rescue diver and the IP to enter the deployment device directly.

8.18 All Stop on Subsea and Vessel Moves during a Rescue

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that adheres to industry best practices. These may be applicable irrespective of the diving technique used.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, address the following:

- If the diving supervisor loses communication with the diver or the diver loses gas, the supervisor should call an 'All Stop' on any ongoing vessel move that could affect the diver, their umbilical, or the deployment device. It should be reasonably apparent within a short time whether the move can or cannot continue.
- The supervisor should call an 'All Stop' on any ongoing operations, such as lifting appliances and ROV movements. It should be reasonably apparent within a short time whether the move can continue.

8.19 All Stop on Subsea Tooling during a Rescue

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices. These may apply irrespective of the diving technique used.

Industry recommended practices: (below refers to an HPWJ HPU)

> *"The diving supervisor should be able to initiate the pump unit shutdown in an emergency. This will require either direct, immediate contact with the person responsible for operating the pump during jetting operations, or an emergency cut-off switch close at hand".*

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, address the following:

- In all rescue situations, the supervisor must call a complete stop to the diver's tooling. All tooling should be isolated and de-energised at the surface.
    - As a matter of best practice, the diving supervisor should have direct and immediate control of all subsea tooling energised from the surface. The tooling energy source, whether an HPU, compressor or electrical supply, should have an emergency stop button in the dive control, which should be tested and readily available.

8.20 Moving the DSV Towards an IP during a Rescue

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices. These requirements apply when diving from a vessel and maintaining position by dynamic positioning.

If the diving supervisor's dynamic risk management indicates it is safe to move the vessel towards the incapacitated diver, consider that the vessel may move faster than a rescue diver deployed from the deployment device in many circumstances. It may be safer and more effective for the rescue diver to remain in the deployment device during the move. Under certain conditions, waiting for the vessel to move the deployment device to the incapacitated diver could be advantageous. Sometimes, what initially seems slower may actually be the faster and better option.

Moving the vessel, and therefore the deployment device, towards the incapacitated diver(s) offers benefits, such as:

The move should bring the standby diver nearer to the IP; this decreases.

1. The distance the standby might have to swim (The first option will be to pull the IP back to the basket)
2. The IP's angle to the deployment device enables the standby diver in the basket to recover the IP more effectively with a vertical pull.
3. The likelihood of the standby diver's umbilical becoming fouled if he exits the deployment device.
4. The fatigue on the standby diver

The following safety considerations are worth discussing when preparing diver rescue documentation and apply regardless of the diving technique used. Diving organisations' risk assessments and procedures should identify the following, where practical:

- If moving the vessel towards the incapacitated diver is acceptable, some operational areas might not meet the ASOG requirements. In most situations, the vessel master may override this and take action in the event of a life-threatening situation. This should be clarified at the project kick-off meeting.

The following recommendations, based on lessons learned and experience, are considered safe working practices and aim to reduce risks to ALARP. Diving organisations' procedures should specify the following where practicable:

- Before any vessel moves towards the incapacitated diver, the supervisor must assess the effects of any 'All Stop' (required at the start of the incident), as there may be loads attached to cranes or suspended in mid-water. Consideration should also be given to DP references, particularly any deployed taut wires and their weights.
- If the supervisor wishes to move the vessel towards the incapacitated diver before the surface standby reaches depth, the IP's umbilical route and whether it is fouled must be considered.
- If the vessel moves towards the IP, consideration must be given to any loads and equipment that may still be in 'All Stop'.

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8.21 Diver's Compromised Gas Supply

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that adheres to safe working practices, applicable regardless of the diving technique used.

The terms "compromised gas" or "contaminated gas" refer to the gas used as a breathing medium for divers that has been adversely affected by pollution, poisoning, or poor management.

Three succinct criteria can adversely affect a diver's breathing gas and supply, and therefore the diver:

1. Gas containing contaminants such as CO_2, CO, hydrocarbons, etc.
2. Gas with incorrect composition (oxygen, nitrogen, helium and trace chemicals);
3. Gas supplied with incorrect flow rate and pressure, volume or temperature (including no gas supplied)

Contamination occurs when a diver's breathing gas is contaminated by another gas, such as CO_2, CO, H_2S, VOCs, compressor oil, impurities in the pipework, pipe-cleaning fluid, or electrical arcing. A compressor can generate CO during pyrolysis, the chemical breakdown of lubricating oil caused by heating. Pyrolysis occurs when the system is warm but not overheating, and the resulting short-term elevated CO levels may not be detected during periodic sampling.

Contaminated gas can also be an inappropriate breathing mix, such as incorrect oxygen content when using nitrox.

The diving environment poses unique risks when using a compressed-air breathing apparatus. The increased pressure at depth causes a proportional rise in the partial pressure of inhaled gaseous contaminants at any given level of contamination. Consequently, air considered acceptable at the surface in terms of contaminant tolerance may become toxic as the diver descends and pressure increases.

When a diver becomes incapacitated without an obvious external cause, gas contamination in the breathing mixture is likely the cause. Usually, the diver will report a taste or odour in their breathing air to the supervisor, or complain of headache, light-headedness, vertigo, or nausea.

If only one diver is in the water and no response is received, a contaminated breathing supply should be suspected, and a shift to an alternative may be necessary.

Industry-recommended practices:

> *"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."*
>
> *"Two divers working in the water simultaneously require three sources: a separate primary source for each diver, with a common secondary, or a common primary source feeding both divers, with independent secondary sources."*
>
> *Surface Standby Diver Main Source: There must be a primary air source to the standby sufficient to enable him to rescue an injured diver, arranged to be separate from the primary and secondary sources for the working diver(s).*
>
> *"Surface Standby Diver Secondary Source: There must be a secondary source for the standby diver, but this may be common with the working diver(s) secondary source, provided it is protected from malfunctions."*

Note: Industry has reported contaminated gas supplies caused by:

- *overheating or burning of electrical insulation or other materials*
- *contaminants associated with the diving operation*
- *improper location of compressor air intakes*
- *degassing of paints or resins*
- *impurities in pipework*
- *cleaning fluid in pipes*
- *electrical arcing*

The following recommendations, based on lessons learned and experience, are considered safe working practices and aim to reduce risks to ALARP. Diving organisations' procedures should specify the following, where practical:

- The diver's immediate action should be to vent their BA to remove any accumulated CO_2 .
- Actions taken by the supervisor to ensure that all divers in the water can be supplied immediately with a known, uncontaminated gas:
  - Shifting to an alternative supply, such as a pneumo or diver's personal gas reserve, filled using the same HP compressor, may contaminate these air supplies.
  - Ensure that every pre-filled air or nitrox quad cylinder is checked for oxygen content and contamination upon arrival at the work site and before it is put online to a diver. Do not rely on manufacturers' certificates.
- If there is a second diver in the water sharing a common primary supply with the incapacitated diver, that diver should be instructed to flush their umbilical after the supervisor opens the secondary supply.
- When working near the surface or in mid-water while breathing air or nitrox, the partial pressure of O_2 in the mixture must be considered if the diver becomes incapacitated at the maximum depth of umbilical deployment (for example, while working beneath a large flat-bottom vessel or during a horizontal excursion to a platform), i.e., 'hanging' from the deployment device.
- How communications are maintained when a diver flushes their BA using the bypass valve or when a pneumo is inserted into the BA.
- It is standard industry practice for two divers to share a common primary source. However, to minimise the risk of both divers receiving contaminated gas simultaneously, they should ideally have separate, mutually independent primary and secondary supplies.
  - If the diver's gas is contaminated, any alternative supply provided to the diver should be independent of it. 'Independent' includes any HP storage charged by different HP compressors, thereby preventing the risk of internal contamination from pyrosis, unless a CO analyser is installed.
  - The LP supply does not include shared items and has adequately separated air intakes in a pollution-free area, eliminating an external contamination source. However, when using an LP compressor, the air supply cannot be guaranteed to be EN12021- or equivalent-compliant before it is connected online.
- Any CO analyser should be equipped with visual and audio alarms. The alarms should activate if CO is detected outside the pre-set limits, as stated in the diving organisation's diving procedures.
  - The alarms should alert the supervisor to shift supplies <u>before contaminated gas leaves the panel</u> and reaches the diver.
  - The CO analyser and alarm should be calibrated and tested with an appropriate calibration gas.
- Additional monitoring for H_2S and VOCs is required to achieve an ALARP risk mitigation.

The diving industry's fundamental principle for the provision of breathing gas to divers is that any diver should have ready access to two sources of breathing gas: primary and secondary. At least one of these should be supplied solely for the individual's use to provide an independent supply of breathing gas. (The diver's personal gas reserve is neither the primary nor the secondary supply.)

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, address the following:

  - Each diver should have independent primary and secondary supplies from <u>entirely separate</u> sources.

9 SUSPENSION TRAUMA DURING A DIVER RESCUE

This section outlines suggested rescue actions and their rationale. It offers good practices that the diving organisation may find helpful when choosing safe diving equipment and when developing diver rescue drills, exercises, procedures and their accompanying risk assessments.

This section also ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices. These are applicable regardless of the diving technique used.

9.1 Overview of Suspension Trauma

During surface-supplied diving, one or more divers may be suspended as part of a diver rescue, for example, in a basket or wet bell, or when SRP diving using a davit or similar device to recover an incapacitated diver.

If procedures are followed and equipment functions as intended, surface-supplied divers should be suspended briefly. However, if things do not go according to plan, suspension trauma can occur and has led to fatalities. Diver rescue drills are often halted before the diver is hoisted or suspended, as even momentary pain and discomfort can be unbearable.

European law, especially the Working at Height Regulations, acknowledges the dangers of a casualty remaining suspended for more than a few minutes.

9.1.1 Mechanics of Suspension Trauma

Guidance and codes of practice state that you must never intentionally suspend someone in a harness for more than a few minutes unless they are suspended in a safe knee-up / sitting position. Intentionally suspending a diver should be formally risk-assessed, and the potential risks of suspension trauma must be recognised.

Anyone suspended in a safety harness is at risk of shock and unconsciousness due to inadequate blood flow. Unconsciousness can become life-threatening within a few minutes. Shock, caused by reduced blood flow, occurs when blood pools in the lower limbs because the leg muscles relax and the so-called ‘muscle pump’ stops functioning.

Venous pooling occurs when blood accumulates in the veins due to gravity. Some venous pooling occurs when a person stands, which is a normal physiological response. Muscular action in the limbs, together with one-way valves in the veins, usually helps blood return to the heart. If the legs do not function properly, excess blood builds up in the veins. The veins in the lower limbs can expand significantly, thereby holding a large volume of blood. (Photographs 26 & 27)

Blood pooling in the venous system reduces the blood volume available for circulation. In response to this reduction, the body increases the heart rate to maintain adequate blood flow to the brain. However, this response may become ineffective if the blood supply is significantly diminished. The body may then abruptly lower the heart rate, leading to a drop in arterial blood pressure. Consequently, the circulatory system becomes compromised. During excessive venous pooling, cardiac output and arterial pressure decline, which can severely impair the quality and quantity of oxygenated blood reaching the brain, potentially leading to fainting.

Although ascent through the air gap should be brief, harness suspension reviews used volunteers weighing less than 100kg. A dressed-in diver’s weight is calculated as 150kg. Due to gravity and harness suspension, blood pools in the IP's lower limbs and does not return because the weight rests on the upper thigh. Testing would not have considered the additional weight, dehydration, fatigue, blood loss, hypothermia, pain, decompression sickness, or other causes of incapacitation (hypoxia, anoxia, hyperoxia). Tests with a 100 kg torso found that unconsciousness can occur in only 5 minutes. Adding the weight of the diver's equipment to the weight pressing on the thighs would mean unconsciousness in a suspended diver could occur sooner than 5 minutes.

9.1.2 Symptoms of Suspension Trauma

Warning signs preceding fainting, such as palpitations, nausea, dizziness, sweating, and confusion, are collectively referred to as presyncope. When upright, for instance, suspended by a harness, blood must be forced against gravity to reach the head, necessitating precise regulation of blood pressure. The body does not respond well to disruptions of its circulatory system, such as venous pooling. It triggers compensatory reactions at the first signs of imbalance, which manifest as presyncope symptoms. The body enters a state of orthostatic shock. Loss of consciousness (if not suspended, the individual would collapse onto the floor) restores blood flow to the brain. However, in a suspended person, remaining stationary further increases venous pooling and diminishes circulating blood volume.

9.1.3 Treatment of Suspension Trauma

The heart is a positive-displacement pump. It can push blood out into the arteries but cannot suck it back up through the veins, hence the need for significant positive blood pressure. To maintain this function, the suspended diver must keep his legs moving. By doing this, blood circulation is achieved, and the accumulation of blood in the legs is prevented. If a diver is conscious but incapacitated, he may quickly lose consciousness if suspended.

Injury, pain, shock, and potentially stress resulting from an accident can exacerbate suspension trauma.

The most crucial step in treatment is to evaluate the risk of suspension trauma. Despite low blood pressure, typical shock conditions can cause acute right ventricular failure. There have been cases where victims die within minutes of rescue. Although not entirely accurate, the term ‘rescue death’ has gained acceptance. Venous pooling and syncope can both lead to death, as they deprive the brain and kidneys of essential oxygen. Moving the patient to a horizontal position—an instinctive response—can cause a substantial return of deoxygenated (and potentially toxic) blood to the heart, which might not handle the load, resulting in cardiac arrest. Therefore, elevating the upper body and carefully increasing blood volume is advised.

The diving industry may have unintentionally caused fatalities or inflicted life-changing injuries on divers due to suspension trauma.

9.1.4 Management of Suspension Trauma

- Suspension trauma during surface-supplied diving is a low-probability, high-consequence event. It must be taken seriously and thoroughly risk-assessed.

The following recommendations, based on lessons learned and experience, are considered industry-accepted practices and are expected to mitigate risks. Diving organisations’ procedures should identify the following, where practicable:

- Work systems and rescue procedures should be established to prevent suspension trauma.
  - Consider alternative methods to suspension, such as placing the IP in a sitting position within the deployment device. (Photograph 57)
  - Consider a cradle recovery stretcher, which recovers an IP horizontally. (Photographs 29,68 69 & 75)
- If suspended, the diver should be suspended in an appropriate harness.
  - The diver should wear a rescue harness that complies with EN15333. This type of harness does not guarantee that a person suspended motionless in it will be free from suspension trauma, but it should at least delay its onset. (Photographs 15 & 16)
- DMTs and diver 1st aiders should be trained to recognise and treat suspension trauma and toxic shock.
  - A misdiagnosis can prove fatal.
    - The IP might be treated for an AGE or DCS if not diagnosed with suspension trauma.
- Advice from the diving organisation’s appointed DMP should be sought regarding any adverse effects that suspension (restricted blood flow) may have on an incapacitated diver’s decompression schedule or treatment. When communicating with the onshore doctor, include a note in the diving organisation’s DMAC 001 (or similar) form stating that the diver was in suspension, regardless of whether trauma was present.
- Suspension trauma relief straps should be readily available whenever a conscious but incapacitated diver needs to be hoisted and suspended in a harness. These straps allow the diver to offload some of their weight through their feet during the rescue, thereby reducing the risk of suspension trauma. Suspension trauma relief straps must always be within easy reach during any recovery of an incapacitated diver and should be used during drills when suspending a diver. (Photograph 28)
- The length of the diver suspension system within the deployment device should be calculated to ensure that no team member remains fully suspended. The length should enable a conscious diver to stand if necessary, while remaining secure if they become incapacitated during ascent.

The diving contractor should prepare a well-documented plan to provide initial first aid to an injured diver and to contact specialist medical personnel for advice. This plan is intended to stabilise an IP until a decision is made on whether further treatment is needed.

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10 CIRCUM-RESCUE COLLAPSE

This section sets out suggested rescue actions and the rationale behind them. It offers good practices that the diving organisation may find helpful when choosing safe diving equipment and when developing diver rescue drills, exercises, procedures and their accompanying risk assessments.

This section also ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices. These are applicable regardless of the diving technique used.

Industry-recommended practices based on findings from a Safety Flash. Although these findings are from a bell dive, the drop in hydrostatic pressure is the same whether a closed-bell diver re-enters the bell or a surface-supplied diver is recovered from the water in the deployment device:

> *"It is essential that a diver is monitored, ….., when entering and exiting a bell [or transiting the water-air interface] during the hydrostatic change, which occurs during this period."*

10.1 Overview of Circum-Rescue Collapse

Circum-rescue collapse is a life-threatening condition that happens during or after rescue from cold water, causing sudden illness, unconsciousness, or death due to a sharp drop in blood pressure when the water pressure supporting the body is lost. This collapse can be a complex reaction to the body's prolonged exposure to cold, which impairs organ function and can lead to cardiac arrest.

What happens during a circum-rescue collapse?

- When a person is lifted from cold water, the external water pressure supporting their body is suddenly removed.
  - This loss of pressure can lead to an abrupt drop in blood pressure, a phenomenon known as hypotension.
  - The resulting hypotension can cause the heart to fail, leading to unconsciousness or sudden death from cardiac arrest.
  - This collapse can occur in an IP already suffering from hypothermia and other effects of cold water immersion.
- The symptoms can range from a mild decline to a dramatic and fatal cardiac event:
  - Fainting,
  - Unconsciousness,
  - Cardiac arrest, and
  - Dramatic worsening of the patient's condition.
- While challenging to prevent, awareness of the dangers is key. Efforts should be made to support the person's body when removing them from cold water to maintain pressure.

10.2 Recommended Actions to Mitigate Circum-Rescue Collapse Potential

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. The diving organisations' procedures should identify the following, where practicable:

- A cold diver may collapse upon leaving the water due to the dilation of surface blood vessels and the removal of hydrostatic pressure; blood pressure in the brain will drop as blood flow through the legs increases. Consequently, the policy of the diving organisation should be:
  - All divers who have lost thermal balance should be secured in the deployment device for the ascent.
  - Any diver who has been rescued, regardless of circumstances, should be secured in the deployment device for the ascent.
- A tight-fitting wetsuit or undersuit can function like 'compression wear' used by athletes and help maintain blood pressure when the diver loses 'hydraulic squeeze' upon exiting the water.
- When carrying out SRP diving or surface swimmer operations, and there is a risk of hypothermia or loss of the diver/swimmers' thermal balance, consideration should be given to recovering the IP in a horizontal position where practicable (Photographs 29, 68, 69, & 75)
- When recovering divers in a deployment device, consider securing the IP in the heart attack or 'W' position.
  - This position helps reduce pressure on the heart by opening the thoracic cavity. It can be easily achieved in a corner of the basket (Photograph 57). The rescue diver should stand facing the incapacitated diver, with knees on either side of the IP's breathing apparatus, supporting the IP's head and neck.
  - The 'W' sitting position eliminates the risk of blood pooling in the extremities, which can cause unconsciousness when the hydrostatic pressure on the legs is removed.
- Dive teams should be aware of circum-rescue collapse; prevention, symptoms and treatment.

11 DIVER RESCUE: DRILLS, EXERCISES, COMPETENCY, & PROCEDURES

This section sets out suggested rescue actions and the rationale behind them. It offers good practices that the diving organisation may find helpful when choosing safe diving equipment and when developing diver rescue drills, exercises, procedures and their accompanying risk assessments.

This section also ensures that the diving organisation conducting operations possesses an effective diving safety management system that adheres to industry-safe working practices. The following applies to all diving techniques.

Industry recommended practices:

> ".. include plans to deal with foreseeable emergencies
>
> "… plans and procedures to deal with all reasonably foreseeable emergencies".

The system FMEA should:

> *"..be a resource for crew familiarisation and training, including identification of emergency response training and drills to enhance awareness and preparedness."*

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. The diving organisations should identify the following, where practicable:

- The incapacitated diver drills, exercise scenarios and rescue procedures must have accompanying risk assessments for all stages.
- The drills, exercise scenarios, and rescue procedures should be documented in the Diving Safety Management System with traceability.
  - Name and position of the person who developed and approved the document
  - Document number
  - Revision number
- Each project should have a Drill and Exercise Matrix that states:
  - Frequency of specific drills and exercises -Yearly, quarterly, bi-monthly, weekly, daily, etc.
  - Drill type--practical or theoretical
- Feedback from rescue drills and exercises must be used to develop and improve diver rescue risk assessments, equipment and procedures.
- The diving organisation should maintain a document that accompanies the Drill and Exercise Matrix and outlines the required learning outcomes. These outcomes should be included in the divers' familiarisation form. Once an outcome is satisfactorily achieved, the supervisor can sign it off. The completed form should be filed for audit and incident investigation.

11.1 Difference between Rescue Drills, Exercises, and the Rescue Procedure

The diving industry uses the terms 'drill' and 'exercise' as if they are interchangeable. However, in practice, they are not.

- A drill is a repetitive, structured training and practice designed to perfect a specific skill or action.
- An exercise is a scenario or series of interconnected scenarios designed to test one or more skills in a foreseeable event or events.
- The rescue procedure typically consists of a list of approved actions that all on-site stakeholders need to follow. These actions are usually accompanied by a straightforward flowchart outlining options and actions.

11.2 Incapacitated Diver Rescue: Drill Procedures

This section confirms that the diving organisation undertaking diving operations has an effective diving safety management system that complies with industry best practices.

Industry recommended practices:

> *“Emergency drills should be carried out regularly. These include diver recovery drills, basket or wet bell recovery drills and chamber emergency drills.”*
>
> *“Drills should be documented and analysed to identify areas for possible improvement. Drills should include any remote telemedicine systems with the onshore medical support organisation”.*
>
> *“Any lessons learnt during the drills should be discussed. Additional training should be provided as required, and where applicable, emergency procedures should be modified”.*

A drill is a repetitive, structured practice designed to perfect a specific skill or action. It is an effective training method for acquiring or reinforcing knowledge, skills, or attitudes through instruction, practice, or feedback. Then repeat a specific skill or task until it becomes automatic, fluent, or effortless.

- Drills are highly specific, structured, and prescriptive, focusing on a single skill or a series of related skills.
- Drills are training for specific scenarios or responses.

The diving organisation’s drill procedure, matrix, and risk assessment should cover all equipment, personnel, and potential rescue methods for an incapacitated diver, as outlined in the rescue procedure, including but not limited to the following:

- Recovering an IP to the deployment device (Using hierarchy of rescue).
- Activation of personal gas reserve.
- Function of a basket-carried reserve gas supply (QC fittings or open-ended hose into BA).
- Function of O_2 administration equipment.
- Exposing the diver’s chest and using the AED.
- Placement of a neck brace and airway management.
- Transporting an IP on a stretcher from the LARS into the DDC or medical facility.
- Use of the umbilical cutting tools.
- Carrying out a neurological assessment.
- Contacting the DMP and transmitting the neurological exam results (DMAC001 or equivalent)
- Use of a remote medical device in the DDC (HRF), transmitting live data to the DMP.
- Use of the guideweight to bring the divers to the deployment device.
- The rescue divers’ immediate-action drill upon reaching an IP.
- Immediate medical action taken upon arrival at the deployment area.
- Omitted decompression for the maximum number of divers deployed
- Placing the IP(s) on a stretcher into the DDC (and closing the ML door).
- Putting the maximum number of IPs into the DDC with a tender.
- Treatment table, extended bottom time, or deeper depth table selection.
- During extended umbilical operations, drill bypassing the IWTP and return directly to the deployment device.
- Use of an ROV during a rescue.
- Failure of lifting plant or machinery and recovery from the depth of the divers

There should be a sign-off and attendance sheet as part of the drill procedure. The diving organisation should appoint persons deemed competent to provide training and instruction for each drill.

11.3 Incapacitated Diver Rescue: Exercise Procedure

This section confirms that the diving organisation undertaking diving operations has an effective diving safety management system that complies with industry best practices.

Exercise can be defined as a task designed to practise or test one or more skills. It can vary and does not require strict repetition of a single movement; instead, exercises are broader, more adaptable activities aimed at improving overall system performance.

Industry recommended practices:

> *"An emergency recovery exercise is to be carried out before the start of operational diving."*
>
> *"Diver recovery exercises should be undertaken where one diver recovers the other from the full extent of their umbilical back to the basket or bell."*

The diving organisation should have a documented exercise procedure and a corresponding risk assessment. The exercise procedure should cover all equipment, personnel, and potential rescue methods for an incapacitated diver, as set out in the rescue procedure.

The Incapacitated Diver Recovery Exercise Procedure should:

- Outline a scenario or a series of scenarios that test the individual's and team's responses in real time and adequacy of procedure, interfaces, communication and equipment.
- Be the same or similar to one of the actual foreseeable incapacitated diver recovery procedures.
- The exercise should only be completed when the IP has completed the correct 'treatment', i.e., either in a DDC, sickbay, hospital or HRF. The exercise does not end once the IP reaches the deployment area.

The main difference between the exercise procedure and the rescue procedure is that the exercise procedure will include all potential equipment scenarios and all previously conducted drills, combining them into a realistic chain of events that could occur at the current worksite. The exercise should:

- Test the effectiveness of the previous drill/continuation training and lessons learned from the drills.
- Evaluate the abilities, techniques, tools, and resources of the rescue procedure.
- Evaluate and condition the participants' responses.

The incapacitated diver rescue exercise procedure should be followed. Any deviation from the written procedure should be recorded in the diving operations logbook. Any exercise non-compliance or improvement finding, usually documented in a Drill Analyses Form, should be formally discussed, and equipment, training, or procedures should be amended accordingly, in line with the diving organisation's document control process.

Lessons learned and actions for improvement should be completed before operational diving commences. Operational diving should commence once <u>all diving supervisors agree</u> that diver-rescue procedures, equipment, and competencies are satisfactory.

It is standard industry practice to leave the question of whether the exercise is scheduled (pre-planned) or unscheduled (occurring without prior notification) to the diving organisation's senior representative on site. The first on-site practical rescue exercise should always be scheduled.

Before any scheduled practical incapacitated diver rescue exercise begins, the following should be in place:

- A comprehensive pre-exercise meeting with all stakeholders. The pre-exercise meeting to include:
  - An exercise risk assessment and JSA.
  - Exercise 'safeguard rules'; something has gone wrong, and it's no longer a drill, it's a genuine emergency.
- Explaining the mechanics of an incapacitated diver and the drill.
- A walkthrough of the topside support equipment.
- The list of emergency phone numbers, usually found within the ERP, is called and verified to be correct.

- All members of the dive team have defined roles and responsibilities during normal operations. Each position at the dive site should have assigned responsibilities during an emergency. Some positions are often overlooked. During the TBT, the supervisor should assign emergency roles and responsibilities, such as the team member responsible for:
  - Ensuring the O_2 administration equipment is delivered to the IP's location.
  - Ensuring the defibrillator, tuff-cut scissors, and a towel are delivered to the IP's location.
  - Ensuring that the appropriate stretcher is brought to the IP's location. (The stretcher for the DDC might be different to the one used to take the IP to the sick bay or for transportation ashore)
  - Ensuring that the first aid kit, including a neck brace, is brought to the IP's location.
  - Recording the time of events or videoing the rescue as evidence for any potential investigation and for learning.

11.4 Diver Rescue Competency

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system compliant with industry best practice. These requirements should apply regardless of the diving technique used.

Industry-recommended minimum competency*:

Diving Superintendents and Supervisors		
Knowledge	Ability	Demonstration
Project emergency and contingency plans	*Participate in all diving emergency drills and in- house familiarisation* *Deliver dive system emergency familiarisation training* *Oversee the implementation of project emergency and contingency plans*	*Assessment by approved company assessor*
Divers		
Knowledge	Ability	Demonstration
Relevant emergency procedures	*Follow project emergency and contingency plans.* *Participate in all diving emergency drills and in-house familiarisation.* *Respond appropriately to a diving emergency .*	*Satisfactory completion of drills in accordance with company requirements* *Assessment by approved company assessor*
Others such as dive techs, DPOs and tenders (who might not be qualified divers), may be involved in the rescue. They to will require documented competency. *The table above is an overview and not exhaustive.		

The following competency recommendations, based on lessons learned and experience, are considered best working practices. The diving organisations should identify the following, where practicable:

- The diving organisation should appoint a suitably qualified and experienced person to serve as the company assessor to assess the superintendent (or the senior diving organisation representative on the project) prior to mobilisation.
    - The assessor needs to have in-depth knowledge of the industry and of the diving organisations' incapacitated-diver recovery methods, equipment, and medical treatments.
    - The assessor should be assessed against a documented company standard to ensure consistency across the diving organisation's work sites.
    - The assessor's knowledge and competence to conduct rescue assessments should be auditable.
- The diving organisation's operations manual should include a section detailing the actions expected of each member of the diving team and of personnel involved in the diving project in the event of a foreseeable emergency during operations.
    - The assessor should be the owner of the diver rescue section within the operations manual and responsible for revising and updating it, including medical advice from the DMP.

- The diving organisation’s competency scheme should clearly document the competency expectations and minimum requirements for participating in a diver rescue, such as:
    - The person's job role during the rescue requires different actions for each position on the worksite.
    - The minimum number of exercises.
- *Participation* in all emergency diving drills does not test a diver’s ability to perform a diver rescue. Likewise, *satisfactory completion of drills* is neither a standard nor auditable.
- It is common practice for the diving organisation to allow the diving supervisor to train and ensure that ‘his team’ are competent in all aspects of the incapacitated diver rescue.
    - If the diving supervisor is authorised to approve each team member's competency, this should be formally documented in either the contract of services or the Letter of Appointment.
    - The diving supervisor should have at least the same level of competency as the company assessor who assessed the superintendent (or senior diving organisation representative on the project).

Diving supervisors should be aware that, in the event of a serious incident that may result in a fatality, the inquiry or investigation may find that the emergency response, including the diver's rescue, was inadequate and that personnel lacked the necessary competence. The supervisor may face charges of corporate homicide.

The supervisor is the ultimate authority on whether the team and equipment are competent to commence operational diving.

11.5 Incapacitated Diver Rescue: Rescue Procedure

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system compliant with industry best practice.

Industry recommended practices:

> *"Site-specific contingency plans supported by risk assessments must be in place for all foreseeable emergencies to provide reference to personnel who have responsibility or involvement in a diving project in the event of an emergency".*
>
> *"Recovery of an injured/unconscious diver from working depth to a safe place for treatment, and any consequential decompression treatment "*
>
> *"Suitable procedures should be in place, based on the particular circumstances of the diving operation, to permit recovery of a diver in an emergency."*
>
> *"The diving supervisor must be fully aware of all the company's documented contingency plans and emergency procedures, both generic and those referring specifically to the diving operation and worksite. The diving supervisor must ensure that all members of the dive team are also aware of the procedure"*

The following competency recommendations, based on lessons learned and experience, are considered best working practices and should mitigate risks to ALARP and are applicable regardless of the diving technique employed. Diving organisations should identify the following, where practicable:

- Every foreseeable emergency requires specific procedures tailored to the unique risks and appropriate responses. Therefore, there should be a documented rescue procedure for each foreseeable potential incapacitation event.
- It is recommended that written procedures be presented as a list with additional rationale, and as a flowchart as an easy-to-follow aid-memoire. The procedures should consider the hierarchy of rescue and capture:
  - Top-side and subsea indications
  - In-water actions
  - Top-side actions at the dive site
- Top-side actions by key personnel not directly involved in the diving operation, such as DPO, Medic, Crane Operator, and Deck Foreman.
- When diving (and surface swimming) from a vessel maintained in position by dynamic positioning, or when an identified hazard requires umbilical restrictions, such as differential pressure, approved umbilical excursion drawings must be available to support the surface standby.
- In all diver-rescue (and surface-swimmer) cases where an identified hazard exists, such as thrusters or differential pressure, and a diver is recovered using a different deployment device or from a different location, there must be verified and approved umbilical-length calculations and diagrams to support the rescue.

The supervisor should be aware of events occurring subsea. If a rescue is initiated and steps go beyond the organisation's documented risk assessment and procedures, the supervisor should continue to manage risks using dynamic risk management techniques. When dealing with rapidly changing circumstances during an operational incident, the supervisor should implement control measures to ensure an acceptable level of safety and, above all, to preserve life. This is a continuous process of monitoring, reviewing, identifying hazards, and assessing risk throughout the diving operation.

During an emergency, the diving organisation has delegated responsibility for responding to dynamic conditions to the diving supervisor, whom it deems competent. The organisation should consider documenting this in the diving supervisor's roles and responsibilities.

The situation may become dynamic, but the risks should remain predictable. Risk is an evaluation of hazard and likelihood; the only difference is whether the supervisor has evaluated it beforehand or during the rescue. The supervisor should no longer be concerned with in-water time. The focus of dynamic risk management should be on the divers involved in the incident, rather than being overly concerned with project risk assessment criteria and policies, such as equipment costs, vessel scheduling, environmental concerns, or company reputation. Preventing further injury and preserving life should be the supervisor’s primary focus.

The diving supervisor is deemed competent and authorised by their employing diving organisation, as set out in their Letter of Appointment, to ‘manage predictable risk in a dynamic situation’. The supervisor may also issue direct health and safety instructions to any person involved in or influencing the diving operation. These instructions take precedence over any company hierarchy.

12 THE DIVER RESCUE

This section sets out suggested rescue actions and the rationale behind them. It offers good practices that the diving organisation may find helpful when selecting safe diving equipment and when developing diver rescue drills, exercises, procedures and their accompanying risk assessments.

This section also ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practice. These requirements should apply regardless of the diving technique employed.

12.1 Briefing the Rescue Diver

The supervisor should brief the rescue diver on what has happened and what to expect upon reaching the IP. The rescue diver needs to prepare mentally. The standby diver should monitor the working divers' camera/monitor and communications, and be fully conversant with the dive site.

12.2 Multiple IPs

If there are multiple IPs, the supervisor should conduct a dynamic assessment of the circumstances, perform 'triage', and direct the rescue to the diver most likely to survive.

12.3 The Rescue Divers' Immediate In-Water Actions and Assessment of an IP

As with all first-aid: ABC (D)

1. Airway. Ensure, as far as reasonably practicable, that the IP has an airway;

- BA is not flooded
  - Clear any water.
  - Use the IP's bypass/demister if the IP has an uncontaminated surface-supplied gas.
  - Use pneumo if immediately available to preserve the IP's emergency reserve.
- BA has no vomit inside
  - Clear any vomit.
  - Use the IP's bypass/demister if the IP has an uncontaminated surface-supplied gas.
  - Use pneumo if immediately available to preserve the IP's emergency reserve.
- IP should be in a chin-up position to maximise the chance of spontaneous breathing.
  - Clear all water and vomit from the BA before opening the IP's airway.

2. Breathing. Ensure the IP has an uncontaminated, free-flowing air supply and is breathing.

3. Circulation. Any major haemorrhage is stabilised.

- Improvise a tourniquet from shock cord (bungee cord) or rope.

4. Decompression. The supervisor's dynamic risk management should include the decompression obligation. If the IP must be surfaced without decompression, the injury from DCS may be as severe or more severe than the original injury.

The rescue diver's immediate in-water assessment of the incapacitated diver may determine how the rescue is conducted and managed; the rescue diver's actions should always be consistent. The diving organisation's procedures should specify the following:

- During the rescue, the rescue diver should, as reasonably practicable, keep the diving supervisor informed of their position and progress, report any changes in depth, and describe what they can see, feel, and hear. Upon reaching the operating depth, the diver must orientate themselves to their surroundings, verify the site, and assess underwater conditions. In particular, the rescue diver should report potential hazards, such as noise from differential pressure. The rescue diver should also report any concerns to the supervisor.
- Action: The rescue diver should follow and pull in the incapacitated diver's umbilical, where practicable. This action quickly brings both divers together and enables the surface tender (or wetbell bellman) to retrieve the incapacitated diver's umbilical, ensuring the IP's umbilical is not fouled or trapped.
- Action: Upon reaching the incapacitated diver, immediately report to verify that the diver has a breathable gas supply on their BA. The rescue diver should report the incapacitated diver's status:
  - The integrity of the incapacitated divers' breathing apparatus.
    - Is the incapacitated diver's BA flooded or dry?

  - Is the incapacitated diver's BA damaged?
- Is the incapacitated diver breathing?
  - Is there any vomit inside the incapacitated diver's BA?
- What gas supply is open to the incapacitated divers' BA?
  - Is the incapacitated diver's BA free-flowing?
  - Is the incapacitated diver on the umbilical supply or on the diver's personal gas reserve?
- Verify the status of the incapacitated divers' personal gas reserve.
  - Is the incapacitated diver's personal gas reserve open?
  - What pressure does the incapacitated diver's personal gas reserve gauge indicate?
- What is the level of consciousness of the incapacitated diver?
  - Motionless, moving, fully alert?
  - Reposition the IP's head to clear the airway. If the IP regains consciousness (spontaneous breathing) after this manoeuvre, allow a short stabilisation period before continuing the rescue.

- Action: If the incapacitated diver has been breathing from their personal gas reserve, provide the IP with another primary supply, such as the rescue diver's pneumo, and secure the personal gas reserve. The rationale is that the diver's personal gas reserve duration is calculated at one minute per ten metres of umbilical deployed. This calculation doesn't account for a diver who doesn't immediately return to the safe refuge.
- Action: If the diver has no gas supply, close the BA bypass and the IP's personal gas reserve. Maintain positive pressure in the IP diver's BA using an external gas supply.
- Action: If the incapacitated diver's gas is supplied from the secondary panel and the diver's personal gas reserve is closed, open the BA bypass and flush the gas (vomit, water, etc.) from the umbilical and BA. This should flush any potentially contaminated gas remaining in the umbilical and clear any build-up of CO_2 from any 'dead space' within the BA. The secondary benefit of this action is that the noise of flushing the BA may help establish the IP's level of consciousness.
- Report: if the incapacitated diver has any apparent injury, including catastrophic bleeding. Catastrophic or profuse bleeding is defined in this case as a strong possibility that the blood lost during the return to the deployment device and the surface may be substantial, creating severe shock and affecting survivability. The haemorrhages should be addressed by applying a temporary improvised extremity-constricting device, such as a bungee cord or rope (and a spanner or ruler to tighten), as a tourniquet above the wound.
- Action: Check the status of IP's hot water. (if applicable)*
- Action: Attach a diver rescue lanyard to the incapacitated diver's rescue harness
- Action: Jettison the IP's weights, along with any tools or task-specific equipment. (Release from the weak link)

*Note 1. Cold constricts the blood vessels, preventing further blood loss. This applies to a diver with a significant haemorrhage. If the diver's hot water supply is shut off, the diver's vascular system will constrict due to the cold, thereby reducing blood loss.

12.4 Actions when the Incapacitated Diver Arrives at the Deployment Area

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices. These may apply regardless of the diving technique employed.

Once the rescue diver and IP arrive at the deployment area:

- Action: The rescue diver will no longer be involved. Keep out of the way and let the topside team attend to casualty assessment, treatment, and handling.
- Action: One team member should be assigned to support the IP's neck and spine to keep it aligned and maintain the IP's airway.
    - Avoid moving the head/neck.
    - Fit a cervical collar as soon as possible.
        - Some cervical collars still allow enough head movement to cause further injury.
        - Continue to stabilise the casualty's head even after a collar is fitted. This can be achieved by placing a hand on either side of the head and gripping the IP's collar. (Try to keep the ears clear so the IP can hear.)
        - This action also prevents the IP from automatically answering questions by nodding or shaking their head.
    - Supervise the O_2 administration and, if required, fit the appropriate airway device.
- Action: One team member should be responsible for filming or documenting the actions, including the timeline.
- Report: The topside team will need to remove the IP's equipment. The team member performing this task should announce what they are doing and the condition in which it is found, such as
    - "BA secured with locking devices."
    - "Bailout open, gauge pressure XX bar," etc.
- Report: If the personal reserve cylinder or the breathing apparatus's emergency gas supply reserve valve is to be closed, the following must again be declared, ideally recorded audio, and, in all cases, logged with the time:
    - "bailout cylinder valve closed X turns"
    - "BA bailout side block valve closed X turns."
- Action: All gas cylinders and volume tanks should be closed and secured, and their contents should be retained for analysis.
- Action: The personal emergency reserve jacket, diver's rescue harness, neck dam, and suit should be removed to minimise the IP's movement. To prevent movement, equipment should be cut off using Tuff-Cut scissors.
    - If the IP has decompression obligations, they should remove their suit and possibly their underclothes before entering the DDC. The supervisor must check for secondary injuries, and the neurological examination requires access to all body parts.
        - A tight-fitting wetsuit or undersuit may reduce bleeding, act like compression garments worn by athletes, help prevent swelling, and maintain cerebral blood pressure. In some cases, the supervisor should consider keeping the underclothing on until the individual reaches the DDC or is transferred to the vessel's sick bay, as removing the suit could cause a significant drop in blood pressure.

The diving organisation should prepare a well-documented plan to provide initial first aid to an injured diver and to contact specialist medical personnel for advice. This plan is intended to stabilise an IP until a decision is made on whether further treatment is needed.

12.5 IP Care and Triage

- If there is more than one IP, the supervisor might need to set priorities to maximise the number of survivors.
- If there is severe bleeding, this needs to be addressed before recompressing immediately.
- If CPR is required, this will take priority over the need to recompress.
- CPR may be necessary during transport to the chamber and during pressurisation.
- CPR should not be commenced on a severely hypothermic diver unless it is confirmed that the heart has stopped or is in ventricular fibrillation.
- Unless the AED is approved for use in a DDC, it should not be used under pressure. Instead, it should be used before the IP is pressurised in the DDC.
  - Avoid recompressing a pulseless diver who has failed to regain vital signs after using an AED.

12.5.1 Cutting Tool For Removing an IP's Diving Equipment/Suit

This section ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practices. These practices may apply regardless of the diving technique employed.

When an incapacitated diver returns to the deployment area, there are several reasons to remove the diving suit and undersuit. The on-site medical responsible person, typically a DMT, and the supervisor will need to expose the chest to attach AED pads and to check for haemorrhage sites and broken bones. If the IP requires treatment in a chamber, the body must be exposed to conduct a neurological examination.

In most cases, it is preferable to remove the suit and clothing before entering the DDC, as there are more people to assist, more room, and better access to both sides of the IP. If the IP requires defibrillation, the upper body must be exposed quickly. If the IP cannot remove the items, they should be cut off.

Industry-recommended medical practices specify scissors in various kits; however, only one pair of Tuff-Cut* scissors is designated.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, address the following:

- If an IP arrives on deck and requires immediate defibrillation, their upper torso must be exposed. Tools should be immediately available to remove the personal gas reserve jacket, rescue harness, suit, and undergarments with minimal disturbance to the IP's neck and spine.
  - One pair of Tuff Cut scissors is inadequate. (Industry documentation does state that this is the minimum requirement.) These scissors are a single point of failure within on-site medical kits.
  - At least 4 pairs of Tuff-Cut scissors should be available at the deployment site.
    - Four pairs of Tuff-Cut scissors enable rapid removal of equipment from both sides, allow simultaneous cutting of suit legs and arms, and provide redundancy.
    - The scissors should be stored alongside the defibrillator (AED), and a dedicated towel should be used to dry the IP's upper torso before attaching the electrode pads.
    - The pre-dive checklist should confirm that four pairs of scissors (or an approved cutting device) and a towel are available at the worksite.

*Note: Tuff Cut is a brand name. The requirement is to have proven tools on site that can cut effectively and safely, and remove any items worn by a diver, including zips, harnesses, and hot water tubing.

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DIVER RESCUE: Deployed by BASKET (Recovered by Basket)

13 DIVER RESCUE: DEPLOYED FROM A BASKET & RECOVERED IN A BASKET

This section sets out suggested rescue actions and the rationale behind them. It offers good practices that the diving organisation may find helpful when choosing safe diving equipment and when developing diver rescue drills, exercises, procedures and their accompanying risk assessments.

This section also ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practice. These requirements should apply regardless of the diving technique employed.

13.1 Rescue Equipment When Deployed by Basket

13.1.1 Launch And Recovery System

The launch and recovery system deploys and recovers the baskets. The type of system used may affect the methodology and the feasibility of a diver rescue. Industry-recommended practices enable the use of various types of LARS and other energy sources.

Industry recommended practices:

> *"Where the working divers and standby divers' LARS are combined, then the failure of a single component should not compromise the ability of the standby system to perform an emergency recovery."*

The diving organisation's operations document for diving, together with its accompanying risk assessment, should address the following points:

- When diving operations are near a surface asset, the standby divers' LARS A-frame should be luffed in so that, if the asset is impacted during a DP event, the standby diver's LARS will remain undamaged. The working diver can then be safely recovered via the standby diver's basket.
- When planning the dive system layout, no part of the LARS should extend beyond the vessel's sides. If the DP system is compromised and either drifts onto or drives into a structure, the LARS and any surface baskets will likely be damaged and may be the first to make contact. There will be no means to recover divers or deploy the standby diver. (Photographs 35 & 36)
- The competency of the LARS/winch operator and the 'lead diver' should be verified. The winch operator is a 'powered lifting equipment operator' for man-riding equipment, and the lead diver is a banksman.
- During routine operations and emergencies, diver tenders face the risk of falls from height, which could result in suspension trauma or drowning. A robust gate should be integral to the LARS design to prevent falls from height once the basket is deployed. Although the opening to the sea/fall is 'temporary' and used only during the dive, it remains a designed and recognised entry point to the sea with fall and MOB consequences. A rope or chain barrier is not ALARP, nor is wearing a PFD and fall-arrest equipment; both serve as mitigation or recovery measures in the event of a fall or MOB. ALARP will only be achieved when a rigid barrier is installed, providing equally adequate protection. (Photographs 38)

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, address the following:

- Using two baskets with a shared A-frame for the LARS is not recommended where there is a risk of a deployment device or a guideweight fouling a subsea asset or impacting a surface asset during a degraded DP system event, such as a drive-on or drift-on to a surface asset, subsea asset, or anchor mooring, which could damage the single A-frame. (Photograph 30) If the A-frame becomes inoperable or damaged, it may not be possible to deploy or recover the standby basket.
- Both LARS should be mutually independent, with any energy cross-connects identified in the risk assessment and the FMEA (Photographs 31, 32 and 33).

- Diving systems should be designed to minimise the likelihood and impact of human error as far as reasonably practicable.
  - The LARS A-frame should have a limit switch (chandeliers) and/or an overload alarm to prevent damage when approaching the basket and luffing in on the A-frame. Other non-diving lifting devices offshore are equipped with such safety devices. (Photograph 34) DNV and NORSOK require limit switches.
  - A line-out meter should be installed to indicate the amount of wire spooled out. This meter should be reset to verify the basket's depth; it could measure either the basket's depth or the guide weight depth.
  - Industry best practice requires at least two independent depth references when deploying loads subsea. If there is no line-out meter, the only reference available is the diver's pneumo. If the diver has a beacon or one is installed in the basket, this may eliminate the need for a line-out meter. However, beacons are less effective at shallow depths.
  - A robust gate should be integral to the LARS design to prevent falls from height when the basket is deployed.
  - The diving industry's recommended practice requires formal qualifications for personnel operating 'powered lifting equipment'. The wetbell and standby basket winch operator should either be formally qualified to the appropriate standard or be approved in writing by the relevant approved competent person.

13.1.2 The Dive Basket

Using a diving basket is the most common method for deploying divers during a surface-supplied diving operation from a dynamic positioning vessel, a moored vessel, an offshore structure, or a vessel-maintaining station.

Diving Basket: A diver-deployment device generally designed with an open cage, as defined in Section 5 of IMCA D023.

Industry recommended practices:

> *"Where the freeboard is more than two metres, two baskets will be on site: one to deploy the working diver and another to deploy the surface standby diver."*
>
> *"The working divers' basket should be able to carry two divers comfortably/in an uncramped position".*
>
> *"A basket … surface-supplied diving…should be designed to prevent the diver from falling out."*
>
> *"The structure should prevent divers from falling out during operations, enabling the recovery of a helpless diver while maintaining the safety of the rescue diver."*
>
> *NORSOK's requirements are realistic…" Diving baskets shall be of adequate size, be equipped for the number of divers intended to man them, and be suitable for handling unconscious and/or injured divers."*

The diving organisation's operations document for diving, together with its accompanying risk assessment, should address the following points when two divers are deployed from a two-man working basket:

- If a worst-case failure occurs, how will three divers be accommodated in a two-man DDC?
- How can two incapacitated divers safely ascend without the standby diver being in the same basket?
  - How is an unconscious diver's neck supported in a neutral position during ascent?
  - A diver with an unsupported neck who wears a BA might sustain a neck injury due to the BA's weight and motion at the air-water interface.
- How the standby diver secures both divers in the basket to prevent injury and to support recovery.
- Team size. An additional winch operator will need to be on-site at all times.
- Winch speed and capability. Do both baskets travel at the same speed?
- The working diver's basket and the standby diver's basket should be as close as practicable.
- Is the standby diver expected to monitor the incapacitated divers from the standby basket during the ascent?
  - If so, are both baskets close enough to be seen?
  - Will visibility always be sufficient to monitor the incapacitated divers and their umbilicals?
  - If the pneumo is inserted into an incapacitated diver's BA, the supervisor will have no means of communication with that diver. The supervisor may need to switch off the IP communication, as the noise will disrupt contact with the rescue diver.
- How does a basket with open sides protect the diver, and how is a single chain an adequate barrier to prevent a diver from falling out of or being washed out of the basket?
- Some basket manufacturers place seating at the back of the basket, which also serves as a toolbox.
  - The seat usually occupies a significant amount of floor space, reducing the standing room in the basket.
  - How the standby diver's umbilical is moved from the standby basket to the working basket, or the incapacitated diver's umbilical is transferred from the working basket to the standby basket, while keeping the umbilical within the maximum safe length specified in the dive plan.
  - If there is a seat/toolbox, either one or two 'J' emergency reserve cylinders carried in the basket are positioned at the front, obstructing easy egress and access to the LARS.
- How is the standby diver's guide weight prevented from fouling the working diver's basket wires or umbilicals during ascent?

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, address the following:

- There should be a swim line between the two deployment devices.

- If the diving organisation's risk assessment or procedures require all divers to ascend together in the same basket, either the working or the standby basket, the divers will need to relocate to that basket. All diver umbilicals must remain within the maximum safe umbilical length specified in the dive plan.
- When planning for emergencies, such as recovering two incapacitated working divers, the worst-case scenario should be considered. The safest recovery would involve the standby diver ascending in the same basket as the incapacitated divers. The standby diver must ensure both divers receive breathable gas, monitor their umbilicals, remain secure within the basket, provide head support, and maintain an airway during ascent. Consequently, ALARP will be achieved only if a dive basket is designed and approved for three divers. The minimum payload rating for the basket should be 590 kg (DnV 740 kg).
- The basket must have a designated secure attachment point for each diver's umbilical. The diver will secure their umbilical for ascent and, if it becomes fouled, will not be pulled out of the basket. The surface standby diver will secure their umbilical on both descent and ascent to prevent being pulled out of the basket by a fouled umbilical or by strong surface currents.
- The water drag coefficient of each basket.
    - A lighter one-man standby basket might deflect more from the vertical under environmental conditions than a heavier two- or three-man working basket. This could result in fouled baskets during deployment.
        - Current speed and direction should be known.
        - The amount of deflection should be known.
- The water drag coefficient of the standby divers' guideweight.
    - When deployed, it will exhibit greater deflection from the vertical under environmental conditions than the working divers' basket. This could result in the guideweight fouling the working basket wires or divers' umbilicals.
        - Current speed and direction should be known.
        - The amount of deflection should be known.

The working diver's basket and the standby diver's basket should be designed to ensure the maximum safety of the occupants. The equipment risk assessment should take into account the following:

- Divers work at height in a basket during launch and recovery. When working at height on a suspended platform at an onshore construction site, national regulations require significantly more safety measures and risk mitigation than in dive baskets, including guardrails, toeboards, full-body harnesses, and fall arrest equipment. Industry-recommended practices state that '*the structure should prevent the divers from falling out'*; however, the structure, e.g., the chain, does not prevent a diver from falling out.
    - A diver's harness, rescue lanyard and umbilical are not fall-prevention or arrest equipment.
    - Just as construction workers on a suspended working platform or MEWP are secured, divers must be secured within the basket using approved equipment attached to recognised strong points.
- Consider installing two gates on the basket. This will provide maximum access and egress for routine diving and in emergencies. (Photographs 37 and 39)
- Each basket should have suitable, proven, strong points for each diver to secure their umbilical. This will prevent them from being pulled out of the basket if their umbilical becomes fouled. Additionally, there should be another proven strong point to connect the diver to the basket.
- The basket should include integral umbilical guides and a gate. The uppermost part should be a roller to minimise friction when assisting an incapacitated diver from the surface.
- The working diver's basket and the standby diver's basket should be fitted with additional equipment to support emergency response. The equipment risk assessment should consider the following:
    - Each basket should contain a ready-to-use pair of fins. These should be the correct size for the standby diver and compatible with their lower-leg protection (Photograph 81).
    - Diving baskets should not have a toolbox/seat if it impedes divers.
    - Each basket should carry a tool proven capable of cutting a diver's umbilical. (Photographs 87 and 88)
- The diving organisation's risk assessment should take the basket's design into account.

13.1.3 Basket Carried Reserve Gas Supply

When surface-supplied divers use a diving basket, emergency breathing gas cylinders must be provided within the basket in case of primary gas failure or contamination. Divers must be able to access the cylinders rapidly in an emergency.

Industry-recommended practices stipulate that each dive basket must contain sufficient reserve gas for divers to ascend to the surface without missing decompression stops in the event of a primary gas failure. This practice also treats such a scenario as a ‘place of safety’. It is improbable that a diving supervisor would proceed with the dive while the diver relies on the basket’s emergency reserve air.

For the diver to use the basket emergency reserve, a catastrophic event would likely have occurred, resulting in the loss of both primary and secondary surface breathing supplies. Most likely, there would be no voice communication (if there were, the diver and supervisor wouldn’t be able to communicate effectively because gas would be introduced into the breathing apparatus, or because the diver would be breathing from the emergency demand valve).

Following industry-recommended practices:

> *“The cylinder requirement is usually met with baskets carrying a ‘J’ bottle (floodable volume of 44.4 litres) reserve <u>for each working diver</u> charged to a minimum of 150 bar”.*
>
> *“The emergency breathing gas cylinders must be supplied in a standard, agreed layout within the basket. This enables divers to access the cylinders rapidly in an emergency.”*
>
> *“Each cylinder should be fitted with a first-stage regulator. There should then be a double connection:”*
>
> *“One side should be equipped with an accessible valve and hose that is rigid enough to be pushed up inside the seal of the diver’s breathing apparatus.”*
>
> *“The other side should go to a suitable means of allowing a diver to breathe if he needs to remove his breathing apparatus. This could be a normal second-stage regulator and demand valve with a mouthpiece and mask or a full-face mask”.*

The diving organisation’s operations document for diving, together with its accompanying risk assessment, should address the following points:

- It is unclear what reasoning and circumstances led industry leaders to recommend supplying a second-stage regulator and demand valve with a mouthpiece and mask, or a full-face mask, on one side of the first-stage regulator on the basket-carried reserve cylinder. Most likely, this was introduced during an era when working divers commonly wore BandMasks/FFM and before ‘keepers’ were introduced (Photograph 89).
- It is unlikely that a diver could quickly remove a diving helmet on their own while trying to breathe in a heaving basket. The following are the manufacturer’s instructions for removing a popular model of diving helmet:
    1. Start by pulling out each sealed pull pin and turning so each remains open.
    2. Tilt your head and helmet forward, then swing the locking collar assembly behind your shoulders.
    3. Tilt your head upright again, push the swinging tongue catch forward with one hand, and hold it in this position.
    4. Grasp the pull strap and pull it down towards your shoulders. This will break the seal between the neck dam and the neck ring on the base of the helmet. Once the seal is broken, the neck ring assembly will come loose from the helmet.
    5. Pull the nose block device knob away from your face and lift the helmet off your head.
    6. (The diver will also need to remove the secondary securing device, usually a chin strap.)
- Divers do not drill the removal of their helmet, breathing from a mouthpiece, or donning an FFM:
    - The mouthpiece will likely be flooded and will need to be purged or a forceful exhale before breathing.
- When an open-ended hose extends beyond the neck dam, the diver switches from a demand-diving system to a free-flow-diving system.
    - A free-flow system typically requires at least three times the air volume of a demand system.
- How pneumo’s or basket-carried reserve gas is supplied and maintained for the incapacitated diver’s BA when no standby diver is present.
- Instead of removing the diver’s helmet as a “last resort” or inserting an open-ended hose beyond the neck dam, consider coupling the supply directly to the helmet.
    - This would create a more secure connection and eliminate the need to remove the helmet in extreme conditions.

    - An interoperable supply connection would allow any diver to access spare gas from the basket via a coupling that delivers it directly to the helmet.
    - This can be easily achieved using a readily available quick-disconnect coupling. These couplings could be integrated into a helmet's side block or linked to a first-stage regulator's low-pressure fitting (Photographs 47, 50 and 52).
- If the diving organisation uses only one cylinder in the basket but has two working divers, its risk assessment should take into account the following:
    - How the first-stage regulator is designed to support two incapacitated divers.
    - Does the manufacturer of the first-stage regulator allow two divers to breathe simultaneously and ensure adequate pressure and flow rates at the maximum intended depth?
- If the diving organisation installs two cylinders in the basket, their position in the basket must be considered:
    - If placed at the 'back' of the basket, the two cylinders reduce the egress or access aperture that divers must use to reach the worksite. This makes it challenging to bring an incapacitated diver into the basket during a rescue.
    - If placed at the 'back' of the basket, the two cylinders shift the centre of gravity. The basket then hangs at an angle, causing issues with both deployment and recovery.
    - Consider placing the cylinders diagonally opposite each other; this balances the basket at the correct centre of gravity and increases the access and egress aperture at the back of the basket.
- Helmets are impact-tested and certified to international standards. If an impact damages a helmet to the point of requiring removal, the wearer will likely be in critical condition. The wearer will probably be unable to remove the helmet to insert a mouthpiece or don an FFM.
- Removing a helmet quickly can be challenging for the wearer, who may need assistance from another diver.
- Removing the helmet in cold water (if it is not already flooded) can cause cold-water shock and brain freeze, potentially leading to cognitive decline. This triggers an involuntary gasping reflex, which can result in drowning as water is drawn into the airway.
- The practice of providing a mouthpiece has long been in place.
    - This requirement is often seen as a remnant of the era when working divers used FFM/Band Masks before 'keepers' were introduced. There have been cases in which the mask frame has become detached from the hood and the face seal (Photograph 89).
    - If divers wear helmets, a risk assessment might indicate that a mouthpiece or a full-face mask (FFM) is unnecessary. It is important to recognise that, within the industry-recommended diving equipment systems, the inspection guidance classifies the need for these items as category B.

      Industry-recommended practices (Category B):

        - B) This indicates a requirement that is considered necessary, but there may be other ways of meeting it than the method identified in the 'Requirement' column. It is left to the discretion of the person completing this document *[The audit document - The 'auditor'*] to determine whether the requirement is being suitably met.
    - Therefore, the auditor/Dive System Assessor is the authority for the diving organisation regarding the suitability of the basket carried reserve gas supply.
- It is common for the demand valve to free-flow under external pressure once the basket has left the surface. The cylinder is therefore closed. Once closed, the emergency equipment is no longer available for 'rapid access in an emergency'. (If the first-stage regulator is not pressurised during descent, seawater may leak through the hose assemblies and the first-stage circuit, causing the first-stage regulator to fail.)

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- Industry-recommended practices provide unclear guidance on the number of basket-carried reserve cylinders. One cylinder per working diver mitigates risk to ALARP. Each cylinder should:
    - Position the cylinders in the basket so that it is balanced and provides easy egress and access. (Consider carrying cylinder(s) externally on the basket to maximise internal space for divers and rescue, or placing smaller cylinders under the basket floor as part of the basket's integral design.)

- Installing the two reserve cylinders diagonally opposite each other ensures they remain accessible when the event fouls at the front of the basket (Photographs 37, 45, 46 and 47).
- Use a first-stage regulator rated by the manufacturer to 50 msw and operating at the expected ambient seawater temperature.
- The first stage should be fitted with an overpressure relief valve. The valve vents excess pressure if the first-stage regulator leaks or creeps.
  - Without a pressure-relief valve, the full pressure of the emergency cylinder could be applied to the low-pressure hoses. This could cause the hoses to burst, damage any inline ¼-turn valve, or prevent a quick-connect fitting from mating.

- One side of the first-stage regulator should be fitted with an open-ended hose. The hose should:
  - Be long enough to reach all areas of the basket, including a diver seated in a corner, and allow free head movement.
  - Be flexible, non-kinking, and long enough to fit under the neck seal.
  - Be fitted with an inline ¼-turn valve.
  - Use a karabiner or another method to ensure the hose remains within an IP's BA during ascent.
  - Be marked to indicate the maximum length that should be inserted under the neck seal into a BA.
- The other side of the first-stage regulator should be fitted with a quick-connect fitting that mates with a quick-connect on the diver's low-pressure personal gas reserve hose (Photograph 52).
  - The LP hose should be fitted with an inline ¼-turn valve.
  - All QC fittings within the divers' breathing stream should, where practicable, be standardised.
    - The QC fittings should not have keyways.
- In all cases, there should be an option for an open-ended hose with an inline 1/4-turn valve.
  - The open-ended hose will create positive (over) pressure that might help the IP with spontaneous breathing after the airway is opened (and with agonal breathing).
  - The positive pressure will help remove any vomit from inside the BA.
- The cylinder valve stems and the octopus assembly should be protected from accidental damage by divers and their umbilicals.
- The pre-dive checklist should include confirming that the emergency cylinder valve is open, the hoses are pressurised, and the inline ¼-turn valve is closed (to trap LP gas between the QC fitting and the ¼-turn valve)
    - This action ensures that the QC fitting can always mate easily with the LP supply, even if there is pressure creep in the first stage.

13.1.4 Securing an Incapacitated Diver in a Basket

Once an incapacitated diver is brought to the dive basket, the rescue diver must secure them for the ascent.

Following industry-recommended practices:

> *"A means should be fitted so each working diver can be secured in the diving basket if unconscious."*

It has become standard practice to secure the incapacitated diver when diving from a basket by attaching a short rope to the basket's roof and clipping a karabiner to the diver's rescue harness. (Photograph 53)

The diving organisation's operations document for diving, together with its accompanying risk assessment, should address the following points when an incapacitated diver is brought into the basket for ascent and secured to the rope and karabiner:

- Which harness is the rope and karabiner attached to: the rescue harness or the buoyancy control apparatus/personal gas reserve harness?
- If the rescue diver ascends in the same basket, where is he positioned?
- Does a suspended diver suit all types of foreseeable injuries?
- How the incapacitated diver's neck is supported during ascent, particularly when transiting close to and through the air-water interface.

- If the diving organisation's risk assessment, DMP, and procedures require suspending an incapacitated diver, the anchor point and suspension device (usually a rope and karabiner) must be included in a PMS (Photograph 53).
- If the diving organisation's risk assessment, DMP's advice, and procedures require suspending an incapacitated diver, the karabiner must always be attached to the diver's rescue harness rather than to the diver's personal gas-reserve or buoyancy-control harness.
    - If the diver's personal reserve harness suspends the incapacitated diver, the harness can constrict the thoracic region, restricting full lung inflation.
- Exiting the water in a vertically suspended position may cause blood to pool in the extremities, resulting in a drop in heart rate and blood pressure when the hydrostatic pressure on the legs is removed. The blood pressure in the brain drops, causing unconsciousness. (An unconscious diver returning to the deck will most likely be treated for an arterial gas embolism.) This is a circum-rescue collapse.
- The risk assessment and procedures should state whether the thoral or dorsal D-rings suspend the incapacitated diver. (Photographs 54 & 55)

Industry-recommended practices:

"The standby diver must remove his helmet and the diver's helmet, check for breathing, and start resuscitation once the diver's head is clear of the water".

- Removing the incapacitated divers' BA during ascent in a basket is poor practice and should not be performed under any circumstances.
    - The rescue diver cannot deliver effective resuscitation in a basket.
    - The time spent in the air gap during a normal ascent is short.
    - Once the diver removes their BA, communication with the supervisor is lost.
    - When suspended from the dorsal lift point, removing a helmet with a hinged locking collar is challenging.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- If one incapacitated diver and one rescue diver are in the basket during ascent, the IP should be secured in the heart attack or 'W' position. This position helps reduce pressure on the heart by opening the thoracic cavity. It can be easily achieved in a corner of the basket (Photograph 57). The rescue diver should stand facing the incapacitated diver, with knees on either side of the IP's breathing apparatus, and support the IP's head and neck. It must be recognised that an incapacitated diver is particularly vulnerable when in the basket and within the surface water influence area.
    - The 'W' sitting position allows the rescue diver to support the IP's head and neck.
    - The 'W' sitting position allows the rescue diver to lift the IP's chin to maintain an airway.
    - The 'W' position is recommended for an IP with a heart disorder.
    - The 'W' sitting position is better for the control of severe bleeding.
    - The 'W' sitting position removes the risk of suspension trauma.
    - The 'W' sitting position eliminates the risk of blood pooling in the extremities, which can cause unconsciousness when hydrostatic pressure on the legs is removed, leading to a drop in heart rate and blood pressure.
    - The 'W' sitting position is better for the rescue diver to control and protect the IP. As with all patients, rough handling should be avoided, including ascending through the splash zone, which can aggravate existing conditions. Casualty handling is a crucial aspect of first aid. The casualty should be handled gently, with the head and spine kept stable and any broken limbs monitored.
- A cold diver may collapse upon leaving the water due to the dilation of surface blood vessels and the loss of hydrostatic squeeze; blood pressure in the brain will drop as blood flow through the legs increases. Consequently, the policy of the diving organisation should be:
    - All divers who have lost thermal balance should be secured in the basket during the ascent.
    - Any diver who has been rescued, regardless of the circumstances, should be secured in the basket for the ascent.

  - A tight-fitting wetsuit or undersuit may act like ‘compression wear’ used by athletes, helping to maintain blood pressure when the diver loses ‘hydraulic squeeze’ upon exiting the water.

- When two incapacitated divers and the standby diver are in the same basket during ascent, the standby diver should secure one IP in the sitting ‘W’ position in the corner of the basket and, although sub-optimal, secure the other IP using the rope and karabiner. The standby diver should face the incapacitated diver, with his knees on either side of the IP’s helmet, supporting the sitting IP’s head to keep the neck neutral and maintain the airway. He should also attempt to support the suspended diver’s head with his hands and keep the chin elevated to maintain the airway.
- If there is a rope and a securing device in the basket for suspending or securing an incapacitated diver.
  - There must be a stainless-steel screw-lock karabiner or a similar locking device.
  - The suspension device, karabiner, and anchor point should be within a PMS. The anchor point should be identified, and the SWL should be stated in accordance with industry best practices for a diving bellman lift.
  - The length of the rope should be sufficient for an incapacitated diver to stand. This will help mitigate suspension trauma and prevent unnecessary pain and suffering during ascent through the air gap.
  - If pulley blocks and tackle are used, they shall meet the mechanical advantage (6:1) and the testing requirements for a closed-bell diver rescue recovery system.
- Even though the rescue diver’s and the incapacitated diver's ascents may be emergencies, the rescue diver should still carry out ‘leaving bottom checks’. These checks must include securing each diver’s umbilical to a strong point in the basket.

Note: The author has found that the dive system inspector is often regarded as ‘the approver’ of the diver’s securing system. This security system appears as a line item in the dive system’s audit.

13.2 Diving System Set-Up: Diving From a Basket to Achieve ALARP Risk Mitigation

It is assumed that the diving organisation complies with industry-recommended practices. During the project planning stage, follow the hierarchy of manned intervention.

First: Eliminate the need for diving operations

Second: Use Remotely Operated Vehicles or Remote Intervention Techniques

Third: Use a manned diving technique.

If the diving risk assessment determines that the safest and most suitable technique for manned diving is surface-supplied diving with a basket deployment system, the following equipment and methodology at the worksite may be considered ALARP.

Rescue Exercise

1. Diver rescue exercise before operational diving commences. All supervisors agree on the team's acceptable competency and that the equipment is fit for purpose. Supervisors should confirm in writing in the operations logbook.

Basket

1. Two three-man baskets.
2. Both baskets carry two emergency reserve cylinders.
3. Both cylinders are fitted with a 1st-stage regulator rated for the maximum intended depth and temperature, one open-ended hose with an in-line ¼-turn, and another with a quick-connect/disconnect that can be coupled to the diver's medium-pressure emergency reserve hose.
4. Both cylinder valve stems and octopus assemblies are to be protected from accidental damage.
5. Both baskets have a swim line attached to the inner guidewires
6. Both baskets are to be fitted with an acoustic beacon.
7. The working divers' basket should be equipped with umbilical guides for each working diver.
8. Both baskets to have mesh gates at both egress and access points.
9. Both baskets should, as far as reasonably practicable, be enclosed with mesh.
10. Both baskets are to carry saws or shears capable of cutting divers' umbilicals.
11. Both baskets must contain a pair of correctly sized fins for the standby diver.

Launch And Recovery System

1. Two mutually independent and 'identical' launch and recovery systems
2. Both LARS are to be rated with an SWL for three divers: 150 kg each (DnV 200 kg)
3. Both LARS are to be rated to carry two emergency 'J'-bottle cylinders: approximately 70 kg each
4. Both LARS are to have a line-out meter.
5. Both LARS to have chandeliers/limit switches
6. Both LARS have gates to prevent falls from height when the basket is deployed.
7. The standby LARS should be luffed inboard when diving alongside an asset.
8. Both LARS areas are to be of an adequate size for two IPs in stretchers and 1st aid teams to work.
9. Consideration to be given to the potential of standby LARS guideweight fouling the working basket

The Working Diver

1. Diver to wear a helmet
2. Diver to carry an acoustic beacon
3. Diver to wear a buoyancy compensator
4. The diver is to wear a rescue harness under the personal gas reserve buoyancy compensator harness
5. Diver to carry a rescue lanyard
6. Diver's personal gas reserve to have a quick connect/disconnect on the low-pressure hose
7. Air supplied by two independent sources, including the charging of any HP cylinders
8. Diver to have open, diver-to-diver and diver-to-supervisor communication.

The Standby Diver

1. Standby diver to watch a monitor and listen to diver-supervisor communications when 'on standby.'
2. Standby diver to be free of medical issues.
3. Standby diver to be clear of decompression penalties.
4. Standby diver to wear a variable-volume drysuit.
5. Standby diver to wear a helmet c/w light and camera. (Light to be energised from the surface)
6. Standby diver to carry an acoustic beacon.
7. The standby diver is to wear a rescue harness beneath the personal gas reserve harness.
8. Standby diver to carry a rescue lanyard.
9. Standby diver to carry a tool capable of cutting an umbilical: saw or shears.
10. Standby divers' personal gas reserve to allow quick connect/disconnect on the low-pressure hose.
11. Air supplied by two independent sources, including the charging of any HP cylinders.
12. Standby diver to have diver-to-diver and diver-to-supervisor communication.

13.3 Basket Rescue Procedure

Suitable procedures should be in place, based on the particular circumstances of the diving operation, to permit the rescue of a diver in an emergency: one-diver deployment, two-diver deployment, and rescue of the standby diver.

13.3.1 Hierarchy of Rescue

The diving organisation's procedures should establish a 'hierarchy of rescue' when diving from a basket. Nearly all diving organisations limit procedures to a surface standby diver deploying and conducting the rescue, which is the least desirable option because it risks exposing another diver to harm.

The hierarchy shouldn't override the supervisor's aworst-cas wassumption It is always better to send in a standby diver unnecessarily than to fail to send him in when needed.

The hierarchy of rescue when a diver or divers are deployed from a basket should be as follows:

First: Rescue by another diver already in the water.

Second: Rescue by assisting an incapacitated (not unconscious) diver by the surface tender hauling on the IP's umbilical until the IP is in the basket.

Third: Deployment of the surface standby.

Rescue from the working basket by hauling the IP into the basket

Fourth: Rescue by the standby diver, exiting the basket and retrieving the IP.

The diving supervisors' dynamic risk management assessment should include:

- Type of thermal protection worn. If the diver is using a variable-volume dry suit, there is a risk of inversion and an uncontrolled (rapid) ascent to the surface (or descent to the length of the umbilical deployed from the basket) (Photographs 9, 10, 11 and 12).
- If the diver is wearing buoyancy compensator equipment, there is a risk of an uncontrolled ascent (or to the length of the umbilical deployed from the basket) and potential for dysbaric injury.
- If the diver is working mid-water, there is a risk of descending to the length of the umbilical deployed from the basket, thereby compromising the planned decompression schedule and possibly exceeding the limit line or the maximum allowable PPO_2 for a nitrox bottom mix.
- Bottom mix. If the incapacitated diver is breathing nitrox, the diver should remain at depth until rescued by the standby diver.

13.3.2 Rescue Procedure with Rationale

This section suggests rescue actions, explains why they are taken, and provides considerations that the diving organisation may find useful when developing its diver-rescue procedures and risk assessments for rescue drills.

The primary aim of the following generic rescue guidance is to provide consistency and a systematic approach for rescuing an incapacitated diver during a basket-diving operation. However, the applicability of the recommendations to any particular case can vary with circumstances, vessel, worksite, and LARS. Therefore, each diving organisation should assess how the recommendations apply to the specific circumstances of each diving system and implement measures accordingly to meet those requirements.

Diving organisations should formulate rescue procedures for each foreseeable scenario within the rescue hierarchy; many actions should remain consistent regardless of who performs the rescue. The procedures should include the following general guidance, suitably amplified or amended by individual organisations to account for their particular circumstances, including team size, available equipment, and the worksite.

Diver rescue procedures should guide dive teams and, where applicable, the ship's crew on the actions to take. The Lessons Learned report states that during an actual rescue, the entire vessel's crew's ability to work together and recognise the importance of acting swiftly and professionally will ultimately influence the outcome.

There should be site-specific procedures for a diver rescue in which all divers are deployed and recovered using a basket. Procedures should be in place at the work site for the applicable recovery methods, such as:

- Where the standby diver is deployed from the standby diver basket and recovered in the working basket with the IP(s) present.
- Where a second diver affects the rescue and is recovered in A) the working basket, B) the standby basket.

- Where the standby diver is deployed and recovered using the standby diver basket with the IP(s).

If the standby diver's basket SWL is insufficient or the basket isn't large enough to accommodate the number of divers to be recovered, the procedures should specify how and in what order IPs are recovered.

Suitable procedures should be in place, based on the specific circumstances of the diving operation, to enable the diver's recovery in an emergency.

If a rescue is initiated:

1. Supervisor Immediate Actions:

Although this section seems timely, the supervisor's actions will only take a few seconds to discharge.

1.1 Call an ALL-STOP on:

- Assets such as ROVs, vessels, cranes, downlines, and other equipment that could affect subsea conditions should be stopped immediately. The diving supervisor will declare an 'All Clear' for each piece of equipment once it is confirmed that its movement has neither caused nor contributed to the incident.
- All divers' and subsea tool energy sources from the surface should be isolated.

1.2 Change the supply gas to the secondary panel gas source for all divers in the water.

- Not all incidents will be caused by contaminated gas. However, switching to the secondary source will be a positive step with no downside.
- If a second diver in the water shares the same primary gas source as the incapacitated diver, the supervisor should switch the second diver's gas supply to an alternative (secondary) source.
- Once on the secondary supply, the second diver should be instructed to flush their umbilical. This will remove any potential contamination in the umbilical from the previous, possibly contaminated primary source.

1.3 Instruct the second diver (now the rescue diver) to proceed to the incapacitated diver. If there is no secondary diver in the water, instruct the surface standby to don their gear and prepare to deploy.

- Give the rescue diver a briefing. If the surface standby is deployed, conduct the usual pre-dive check. This can be done during deployment.
- The supervisor should instruct the ROV pilot to investigate and, if available, to provide an overview.
- The supervisor should delegate the task of informing the superintendent, the control room, the bridge DMTs, and the medic, if they still need to be informed of the situation.
- With an ROV on the scene, the supervisor can obtain an overview (if visibility is suitable) and identify potential causes. The ROV will aid the rescue diver by illuminating the scene. The supervisor can advise the rescue diver and dynamically assess any risk to them.

1.4 Depending on the IP's level of consciousness, communication, and potential injury, instruct the surface tender to assist the IP in returning to the basket by hauling on the IP's umbilical.

2. Rescue Divers In-Water Actions

This section assumes the incapacitated diver cannot return to the basket. Once the standby diver is out of the basket, the surface standby and the second diver perform the same actions.

2.1 Deploy the surface standby.

- The standby diver must be physically escorted to the basket to ensure that no slips, trips, or falls could jeopardise the rescue operation.
- The surface standby to don fins (if required) while descending in the basket.
- When at depth, secure the karabiner to the soft line between the two baskets, release the umbilical, and then secure the karabiner. Then relocate the karabiner to the working basket, secure the umbilical with a karabiner, and release the karabiner from the soft line.
- Haul up on the incapacitated diver's umbilical. When it is tight, give line-pull signals. If there is no response, try to pull the incapacitated diver to the basket—have the surface tender come up on the incapacitated diver's umbilical.
- If the incapacitated diver cannot be hauled into the basket, the surface tender should keep the IP's umbilical taut so the standby diver can use it as a swim line to reach the IP.
- Unclip and exit the back of the basket, following the incapacitated diver's umbilical.
- Dynamic risk assessment: If the IP is secured to the work site with a weak link, and that link breaks, will the IP descend to an unacceptable depth, resulting in an unplanned decompression penalty or an unacceptable PPO_2?
- Whilst the standby diver is in the working basket, the diving supervisor should conduct a dynamic risk assessment.
  - Moving the vessel towards the incapacitated diver reduces the distance and the deployed umbilical length.
  - Lowering either the guide weight or the guide weight and the basket to assist the rescue diver.
  - Positioning a crane block near the site, especially when the divers are mid-water, will keep it 'on standby' in case the standby diver requires it during the rescue.
  - Consideration must be given to any downline and to any swim line attached to the basket.
  - Consider whether the crane is attached to an anchor point. This may need to be released.
- Follow the (now taut) umbilical of the incapacitated diver to the casualty. If the umbilical has parted (lost diver), the diving supervisor needs to dynamically assess and manage available assets to locate the lost diver and deploy the standby diver to them. This may include using diver beacons and the ROV. If the incapacitated diver has gas, a gas stream should be visible.

2.2 Rescue Divers' Immediate Actions on Reaching the IP

The rescue divers' immediate actions upon reaching an incapacitated diver are detailed elsewhere in this review. These actions should remain consistent, regardless of the deployment method.

3. Recovery of the Incapacitated Diver to the Basket

This section assumes the worst-case scenario in which the IP cannot assist in their own rescue.

3.1 Recovering the IP to the Basket.

- With the incapacitated diver secured to the rescue diver via a rescue lanyard and the IP supplied with gas, the rescue diver should return to the basket. This can be achieved using one or more of the following methods:
  - Walking to the basket (Basket lowered to the seabed)
  - Walking to the guide weight (which has been lowered to the seabed) and then riding it near the basket.
  - The rescue diver ascends the swim line hand over hand. If the current is running or there is a risk that divers could over-inflate their buoyancy, attach a rescue lanyard to the swim line.
  - The rescue diver ascends <u>his umbilical</u> hand over hand. If the rescue diver encounters difficulty swimming or climbing with the affected diver, the rescuer should slowly inflate <u>the affected diver's</u> buoyancy compensator.
  - The surface tender hauling up on the <u>rescue diver's umbilical</u>. (In the worst-case failure, the IP's umbilical might be severed.)
  - Choke a rescue lanyard to the IP's umbilical and secure it to the IP's personal reserve dorsal D-ring. This will keep the IP upright. (Photograph 14)
  - The rescue diver 'riding' the crane to the basket.
  - Use of ROV

3.2 Securing the Incapacitated Diver in the Basket

- The rescue diver needs to secure the incapacitated diver in the basket. The rescue diver should pass the incapacitated diver through the back of the basket; this is much easier if the basket has a gate.
- Once the incapacitated diver is in the basket, the rescue diver should unclip the lanyard from himself and secure it to a strong point in the basket to temporarily secure the diver.
- Swap the pneumo supply (if used) from the open hose end to the basket-carried reserve gas supply or the QC fitting.
- The rescue diver should enter the basket from the rear, secure the incapacitated diver, and conduct a further assessment to confirm the gas supply.
- Secure both umbilicals to the D-ring and prepare to leave bottom.

4. Recovering the Incapacitated Diver from Depth to the Deployment Area

4.1 The incapacitated diver must be secured within the basket; the rescue diver must:

- Maintain the gas supply to the IP.
- Maintain the IP's airway.
- Stabilise the IP's head and spine (if possible)
- Maintain positive physical control of the IP when near and at the surface, and prevent his arms and legs from flailing and causing further injury.

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DIVER RESCUE: Deployed by LADDER (Recovered By Davit)

14 DIVER RESCUE: DEPLOYED FROM A LADDER & RECOVERED BY A DAVIT

This section sets out suggested rescue actions and the rationale behind them. It offers good practices that the diving organisation may find helpful when choosing safe diving equipment and when developing diver rescue drills, exercises, procedures and their accompanying risk assessments.

This section also ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practice. These requirements should apply regardless of the diving technique employed.

14.1 Rescue Equipment When Deployed By Ladder

14.1.1 Ladder Deployment and Emergency Recovery Methods

When diving from an anchored vessel or floating structure with no hull obstructions near the diving site and with freeboard less than 2 metres, it is permissible to deploy the diver via a ladder. If a ladder is used, a dedicated recovery arrangement must be in place to bring an incapacitated diver back to the deck.

Industry practices:

> *"The ladder should have sufficient holds under and above water and on deck level to allow the diver to step easily onto the deck. In addition, a dedicated arrangement—e.g., a crane, A-frame, or davit certified for man-riding, with sufficient reach—should be present to recover an incapacitated diver from the water by, for example, transferring them by their safety harness onto the deck".*
>
> *"Arrangements must be made to recover an injured or unconscious diver to the deck. In most cases, this would not be practicable with only a ladder".*
>
> *"Arrangements should also be made to transport an injured or unconscious diver from the water to the deck of the small vessel".*
>
> *"The method used should be tested, proven safe, and fit to recover the diver onto the deck without further pain or harm".*

14.1.2 Overview of SRP/Daughter Craft Diving System

Under certain conditions, a mobile, portable, or daughter craft surface-supplied system can replace a complete traditional surface-supplied diving system when access to a full system is restricted or unavailable.

When using this system, divers are deployed and recovered via a ladder. During the recovery of an incapacitated diver, a davit or other lifting system is typically used. Emergency recovery via a ladder is unacceptable.

Mobile, portable, and daughtercraft systems vary considerably in their capabilities.

At its simplest, an SRP comprises three cylinders of breathing air mounted in a frame, with a small control panel and an umbilical for each diver. It can be placed in an inflatable boat, typically for a single diver, or used on a large barge or platform to enable diving from a remote location relative to the main diving area. This type of system is readily portable, offering greater flexibility during diving operations; however, it is limited by the availability of breathing air.

At the other end of the spectrum, they can be quite large, custom-built daughter vessels that carry two divers working simultaneously underwater. They can undertake several dives before returning to a mother vessel for replenishment.

SRP systems are also used during underwater ship husbandry and dockside operations, with divers deployed from moored vessels or quaysides. The diver deployment and recovery methods remain unchanged.

14.1.3 Limitations of SRP Diving

Industry-recommended practices:

> *"The technique is suitable for using compressed air or nitrox to a maximum depth of 50msw; however, it is usually limited to less than 30msw".*
>
> *"A mobile/portable surface-supplied system should not be used where there is a reasonable possibility of the diver or his umbilical becoming fouled or where immediate recovery of the diver cannot be achieved".*

The amount of gas available for SRP diving operations varies, which in turn affects the depth and scope of the work that can be accomplished. In its simplest form, in accordance with industry-recommended practices, the SRP system will consist of three cylinders, each with a minimum floodable volume of 46 litres and a working pressure of at least 150 bar. The cylinders will be manifolded through a diving control panel that provides the diver and the standby with their dedicated primary air supply. The third cylinder will supply either or both divers with their secondary air supply.

The setup described above is used as the benchmark for this review, as it represents the worst-case scenario.

The diving organisation's operations document and its accompanying risk assessment should cover the following points:

- Some diving organisations use a Jason's cradle (or a similar device) as an emergency recovery device for an incapacitated diver. When utilising a cradle or similar device: (Photographs 68 & 75)
  - How is a non-responsive, unconscious diver placed horizontally in the water so they can be captured by the device? The cradle is designed to lift an MOB in the horizontal position. A lifejacket helps achieve this position.
  - How is an IP stabilised to prevent further injury when using this device? An IP is rolled within the device as it is brought on board. A 150kg diver wearing a helmet and carrying a personal gas reserve doesn't roll. The rolling action can harm the IP and could cause further pain or injury.
  - A Jason's cradle has a 2:1 mechanical advantage. Even so, getting a fully dressed IP inboard requires at least two crew members (Photographs 68 and 75).
  - Has the small craft been stability-assessed for use with this device? When lifting an IP, the personnel bringing the IP inboard will need to be on the same side of the small craft.
  - Does the Manning Level Risk Assessment allow for personnel to be lifted onboard?
  - Such devices depend on specific environmental conditions for safe operation. Do diving activities stop when these limits are reached?
  - The type of personal gas reserve worn by the IP can affect the IP's airway when the IP is on a stretcher or in a cradle. The compatibility of the rescue device and the personal gas reserve should be assessed for risk.
- When using a davit to recover an incapacitated diver:
  - Industry-recommended practices provide general guidance on testing criteria. Which document does the diving organisation use to verify that all components are fit for purpose?
  - How does the diving organisation manage suspension trauma?
  - There should be an approved (by the DMP) attachment point for the recovery device:
    - Thoral lift with a spreader (this leans the diver back and helps keep the airway open)
    - Dorsal lift (this causes the diver to tilt forward and may impede the airway)
- How does the diving organisation mitigate the use of a pneumo as an emergency breathing supply with a limited supply?
- During SRP diving, one of the safety requirements is that the diver must be immediately recoverable. How does the diving organisation ensure that an incapacitated diver, secured with a weak link, can be recovered immediately?
- How is a lost diver found? (Lost diver is a diver with a fully severed umbilical)
- The use of nitrox as the breathing medium during SRP should be avoided.
  - Both the diver and the standby diver would be breathing nitrox as a bottom mix.
    - If a diver experiences oxygen toxicity ('O_2 hit'), the standby diver breathing the same mixture could also be affected, as nitrox is usually decanted from the same source.

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- If a cradle that requires the IP to be 'rolled', a risk assessment must identify how: (Photographs 68 & 75)
  - The IP's neck is stabilised
  - How the diver's personal gas reserve and other personal items are prevented from fouling the cradle during the process of rolling.
- If a rescue cradle or stretcher is used, it must be rated to lift a fully kitted diver (150 kg)
  - If a basket-type stretcher is used, an enhanced inspection regime should be implemented due to saltwater immersion. The basket and straps should be in the PMS.
  - If a cradle is used, an enhanced inspection regime should be implemented due to saltwater immersion. The cradle, straps, and any securing devices should be in the PMS.
- When using a davit (harness, or stretcher) to recover an incapacitated diver:
  - The davit should be rated for man-riding and tested in accordance with the requirements for lifting appliances and equipment used for man-riding, with a minimum SWL of 150 kg.
  - If the davit is powered, there should be a contingency for manual slewing.
  - If the winch is powered, there should be a contingency for manual winching in the event of a power failure.
  - If the winch is powered, a safety device should prevent the incapacitated diver from being drawn into the top sheave.
  - Moving parts of the winch should be guarded.
  - The wire rope and end termination should be tested to the same standard as a LARS wire rope.
    - Regular exposure to salt water and passing over sheaves can cause wear and deterioration of the lift wire.
  - The end termination should not have a protective plastic coating.
    - The protective coating (heat shrink) can potentially cause a corrosion cell and prevent a thorough pre-use visual inspection (Photograph 85).
  - In all cases where a diver needs to be secured, an approved dual-acting locking connector (Photograph 70) should be used.
  - Before operational diving, a recovery exercise should be conducted. The davit must be left in the position directly below where the tender was supporting the IP via their umbilical.
- Consider alternative methods rather than lifting the incapacitated diver by their harness. Casualty management is a crucial part of first aid. The casualty should be handled gently, with the head and spine kept stable and any broken limbs monitored.
- If a spinal injury is suspected, efforts should be made to stabilise the diver's head as he is brought to the surface. The weight of the head and helmet may cause it to swing sharply.

- The type of personal gas reserve worn can affect the diver's airway during the recovery from the water to the deck.
    - When recovered in a rescue stretcher with a single-cylinder personal gas reserve, the IP will be on the left or right side (Lateral recumbent). There is no guarantee that while the IP is wearing a BA, their airway is open.
    - When recovered in a rescue stretcher with a twin-cylinder personal gas reserve, the IP will be on their back. The head usually tilts back to open the airway.
    - In all cases, the personal gas reserve should not be worn high on the back, where it could impede the IP's head from moving back and opening the airway.
- An approved lift plan is required if the diver is to be lifted by a davit or a cradle. All man-riding lifts require both a lift plan and a risk assessment.
- If pulley blocks and tackle are used, they must meet the mechanical advantage requirement (6:1) and the testing requirements for a closed-bell diver rescue recovery system.
- If a 'chest spreader' is used to lift a diver, it should be included in the PMS (Lifting equipment) and meet the testing requirements for use in a closed-bell diver rescue and recovery system.
- The minimum safe SRP setup requires four 'J' bottles at a minimum pressure of 150 bar.
    - A four-cylinder system provides both divers with independent primary and secondary breathing gas supplies.
    - A four-cylinder system allows a standby diver and the standby's pneumo to supply an IP.
    - Nitrox should not be used with the 3-cylinder SRP system because the standby diver will also be breathing nitrox.
        - If the working diver 'falls' to a depth exceeding the allowable PPO2 because of the length of the deployed umbilical, he could get an 'O_2 hit'. If the standby diver is on the same mix, he cannot reach the same depth to assist with the rescue.
    - All divers should carry personal gas reserves with QCs on the LP hose (Photograph 52). This enables the rescue diver to supply gas to the incapacitated diver in extreme circumstances.

14.2 Diving System Set-Up: Diving Using SRP to Achieve ALARP Risk Mitigation

It is assumed that the diving organisation complies with industry-recommended practices.

During project planning, follow the hierarchy for manned intervention diving.

First: Eliminate the need for diving operations

Second: Use Remotely Operated Vehicles or Remote Intervention Techniques

Third: Use a manned diving technique
(where practicable another diving method should be used other than SRP)*

*It should be noted that SRP diving has fewer safety features than other diving techniques, including:

- The diving technique usually does not:
  - Permit the use of beacons on divers, cranes, or deployed loads.
  - Allow the use of a survey system or screen.
  - Allow for ROV support.
- There is no deployment device; therefore,
  - No other emergency gas reserve is available, such as a basket carried reserve gas supply.
  - There is no safe refuge, such as a wetbell dome
  - The surface does not control the rate of ascent.
  - There is no ‘place of safety’ for unplanned decompression stops or tidal streams.
  - A diver rescue is more physically demanding.
- There is a limited gas supply to all divers.
  - This could affect the rescue if both divers are breathing off the same supply, i.e., standby diver on demand and IP on the standby divers’ pneumo on free flow.

Location of the DDC

Industry-recommended practices for other surface-supplied diving methods impose stricter requirements on the DDC's location. When the SRP system is utilised, recommended diving practices permit the mothership to be 15 minutes away; however, getting an IP in the DDC takes longer. Surface-supplied diving using alternative deployment methods requires the DDC to be immediately available on-site. Consequently, SRP diving offers fewer safety features than other diving techniques and provides inferior mitigation and recovery practices. For example:

- Inshore diving and ship husbandry are limited to 10msw unless a DDC is on site. However, an SRP dive is permitted at any depth down to 50msw with a DDC at least 15 minutes away.

Although the hierarchy of manned diving can be applied, the SRP diving technique is not considered ALARP under certain conditions, as outlined above. Other techniques offer greater inherent safety and recovery measures.

The following recommendation, based on the above ‘reduced safety features of SRP techniques’, should be discussed at a high level and formally recorded:

- The project risk assessment must identify that the decision to use SRP is not based on financials but is considered most suitable due to the access criteria at the work site.

If the diving risk assessment determines that the most suitable method of manned diving is surface-supplied diving using the SRP system, the following equipment and methodology at the worksite may be considered ALARP.

Rescue Exercise

1. The diver recovery exercise should be performed before operational diving commences. In the worst-case scenario, the IP will be brought from the work location to the mothership and then to the DDC.
2. The exercise should account for an incapacitated diver and a rescue diver performing decompression stops.
3. . Supervisors should confirm in writing in the operations logbook.

Small Craft Used for Diving Operations

1. Boat to have saws or shears capable of cutting a diver's umbilical.
2. Shot line with a lazy shot (in case decompression stops are needed, and there is no communication).

Recovery System

1. Rescue davit to be manually operated; slew and winch.
2. The entire recovery system was tested in accordance with industry-recommended practices and rated for man-riding.

The Divers Air Supply System

1. Each diver must have an independent primary and secondary supply, with the secondary equipped with a cross-over.
2. Cylinders are charged using different HP compressors; no diver should have a primary supply from the same compressor. (Therefore, the minimum SRP setup comprises four 'J' bottles (46 litres) at a minimum of 150 bar.)

The Working Diver

1. Diver to wear a helmet
2. The diver must wear a buoyancy compensator (if not wearing a variable volume dry suit).
3. The diver is to wear a rescue harness under the personal gas reserve buoyancy compensator harness.
4. Diver to carry a rescue lanyard.
5. Air supplied by two independent sources, including the charging of any HP cylinders.
6. Personal gas reserve calculations include the time required to recover to the deck by the davit.
7. Diver to have diver-to-diver and diver-to-supervisor communication.

The Standby Diver

1. Standby diver to watch a monitor and listen to diver-supervisor communications when 'on standby.'
2. Ensure the standby diver is clear of any medical issues.
3. Standby diver to be clear of decompression penalties.
4. The standby diver must wear a variable volume drysuit.
5. Standby diver to wear a helmet c/w light and camera. (Light to be energised from the surface)
6. Standby diver to carry a strobe light.
7. The standby diver must wear a rescue harness under the personal gas reserve harness.
8. Standby diver to carry a rescue lanyard.
9. Standby diver to have a device proven to cut an umbilical.
10. Air supplied by two independent sources, including the charging of any HP cylinders.
11. Standby diver to have diver-to-diver and diver-to-supervisor communication.

SRP Rescue Procedure

Approved procedures should be established, based on the specific circumstances of the diving operation, to allow for the rescue of a diver in an emergency: one-diver deployment, two-diver deployment, and rescue of the standby diver.

14.3.1 Hierarchy of Rescue

The diving organisation's procedures should establish a 'hierarchy of rescue' when diving using the SRP technique and deploying by ladder. However, the hierarchy should not override the supervisor's worst-case assumption. It is always better to send a standby diver unnecessarily than to fail to do so when needed.

The hierarchy of rescue when a diver or divers are deployed by ladder should be as follows:

First: Rescue by another diver already in the water.

Second: Rescue by assisting an incapacitated (not unconscious or when utilising nitrox) diver by the surface tender, hauling on the IP's umbilical until the IP is on the surface.*

Note: The standby diver will have to be deployed to secure the IP to the recovery device

Third: Deployment of the surface standby to depth.

* The diving supervisors' dynamic risk management assessment should include:

- Type of thermal protection worn. If the diver is wearing a variable-volume drysuit, there is a risk of inversion and uncontrolled ascent.
- If the diver is wearing buoyancy compensator equipment, there is a risk of an uncontrolled ascent.
- If the diver is working mid-water, there is a risk of descending to the full depth of the deployed umbilical, particularly during a long horizontal excursion, which can compromise the planned decompression schedule and possibly exceed the limit line or the maximum allowable PPO_2 of a nitrox bottom mix.

14.3.2 Rescue Procedure with Rationale

This section outlines rescue actions, explains their purpose, and offers considerations that the diving organisation may find helpful when developing its diver-rescue procedures and rescue/drill risk assessments.

The primary purpose of this generic rescue guidance is to ensure consistency and a systematic approach to rescuing an incapacitated diver during an SRP diving operation. However, the application of these recommendations may vary depending on the circumstances, boat, and worksite. Therefore, each diving organisation should assess how these recommendations align with the specific conditions of its diving system and implement measures accordingly.

Diving organisations should develop rescue procedures for each foreseeable scenario within the rescue hierarchy; many actions should remain consistent regardless of who carries out the rescue. The procedures should incorporate the following general guidance, suitably expanded or modified by individual organisations to reflect their specific circumstances, including team size, available equipment, and the worksite.

Diver rescue procedures should guide dive teams and, where appropriate, the boat's crew on the necessary actions. Lessons-learned reports show that during a real rescue, the team's ability to work together and recognise the importance of acting quickly and professionally ultimately determines the outcome.

There should be site-specific procedures for diver rescue, in which working divers are deployed by a ladder and recovered by a cradle alongside the vessel or by a davit. Procedures should be in place at the work site for the relevant recovery methods, such as:

1. Deployed by ladder: IP recovered by the diver's harness on a lifting device (Photographs 27.62 to 67)
2. Deployed by ladder: IP recovered using Jason's cradle or a similar device (Photographs 68 & 75)
3. Deployed by ladder: IP recovered using a rescue stretcher on a lifting device (Photographs 29 & 69)

Suitable procedures should be developed in line with the specific circumstances of the diving operation to facilitate the recovery of a diver in an emergency.

The example below illustrates a typical SRP rescue. It assumes that no ROVs or location devices are available.
If a rescue is initiated:

1. Supervisor Immediate Actions:

Although this section seems timely, the supervisor's actions will only take a few seconds to discharge.

1.1 Call an ALL-STOP on subsea moves.

- Assets such as cranes, downlines, and other equipment that could affect subsea conditions should be halted if their movement could cause an incident, such as fouling divers' umbilicals.
- All energy sources for divers and subsea tools should be isolated from the surface.

1.2 Change the supply gas to the secondary cylinder for all divers in the water.

- Not all incidents will be caused by contaminated gas. However, switching to the secondary supply will be a positive step with no drawbacks. (The primary supply will remain available.)
- If a second diver in the water shares a common primary supply with the incapacitated diver, the supervisor should switch to the secondary supply unless the HP supplies were independently charged with different compressors. Once on the secondary supply, the second diver should be instructed to flush their umbilical. This will remove any potential contamination in the umbilical caused by the possibly contaminated primary supply.

1.3 Conduct a dynamic risk assessment of the situation and follow the hierarchy of rescue:

- Instruct the second diver (now the rescue diver) to reach the incapacitated diver.
- If no secondary diver is in the water, instruct the surface standby to don their gear and prepare to deploy.
- Depending on the IP's level of consciousness, communication ability, and potential injuries, instruct the surface tender to assist the IP to the surface by hauling on his umbilical.
    - Dynamic risk assessment: If the IP is secured to the work site with a weak link and that link fails, will the IP descend to an unacceptable depth, resulting in an unplanned decompression penalty or an unacceptable PPO_2?
    - Dynamic risk assessment: if the IP wears a variable-volume dry suit or buoyancy compensator, consideration must be given to how quickly the surface tender can recover the IP via the umbilical. The recovery rate should match the suit or buoyancy compensator's relief valves. If recovery is too rapid, the IP could experience an uncontrolled ascent.

- The supervisor should delegate the task of informing the mothership. If available, the second craft (FRC) should proceed to the dive boat and stand off until called alongside.

2. Rescue Divers In-Water Actions

This section assumes that the incapacitated diver cannot be assisted back to the surface. Once the standby diver has left the surface, the standby diver and the second diver in the water perform the same actions as the rescue diver.

2.1 Deploy the surface standby.

- The standby diver must be physically escorted to the ladder. This ensures that no slip, trip, or fall could jeopardise the rescue.
    - The standby must be deployed by a ladder (or other controlled method) and must not be tempted to jump.
        - Jumping into the water is dangerous and can cause injury (industry-recommended practices and diving BA manufacturers disapprove of divers doing so).
        - Jumping into the water could invert the helmet's exhaust valve, allowing water to enter the helmet. The standby diver would then need to be recovered, delaying the rescue.
- The diver's tender should keep the incapacitated diver's umbilical taut, providing the standby diver with a 'swim-line' to the IP.
- Standby diver to descend the (now taut) incapacitated divers' umbilical to the IP. (If the IP's umbilical is severed, the rescue diver should look for the IP's exhaled gas stream and follow it down.)

2.2 Rescue Divers' Immediate Actions on Reaching the IP

- The rescue divers' immediate action response to an incapacitated diver is detailed elsewhere in this review. Their actions remain consistent, regardless of the deployment method.

3. Recovery of the Incapacitated Diver to the Surface from Subsea

3.1 With the incapacitated diver securely attached to the rescue diver via a rescue lanyard and the IP having a gas supply, the rescue diver must return to the surface (or to an in-water stop). This can be achieved by one or more of the following methods.

- Ascending a downline, a swim-line, or a shot rope.
- Being hauled up by the rescue divers' umbilical.
- Walking along the seabed until reaching the area beneath the small craft, then climbing or being hauled up via the rescue divers' umbilical.
    - In the worst case, the supervisor's dynamic risk management, the IP might have a severed umbilical.
    - If the rescue diver has difficulty swimming or climbing with the IP, they should jettison any weights or tools and, if necessary, slowly inflate the IP's buoyancy compensator or variable-volume drysuit. However, the rescue diver must monitor the IP's buoyancy and be prepared to manually exhaust or dump air from the buoyancy compensator or variable-volume drysuit.
    - The rescue diver should choke a rescue lanyard to the IP's umbilical and connect it to the dorsal lift point on the IP's personal gas reserve jacket. This will make controlling the IP easier during ascent and on the surface, as it provides vertical lift rather than pulling from the waist D-ring (Photograph 14).
- The supervisor's dynamic risk management should include any decompression obligation. If the IP needs to surface without decompression, the injury from DCS could be as serious as, or even more serious than, the initial injury due to the delay in reaching the DDC.

4. Recovering the Incapacitated Diver from the Surface to the Deployment Area

- Once on the surface, the rescue diver should check the IP's breathing status and ensure there is no vomit in the BA.
- The surface crew should have arranged the lifting setup before diving operations began.

The following options are common methods of recovery.

4.1 Recovered by **Diver's Harness** (Photographs 27 &.62 to 67)

- As part of the pre-dive checks, the davit arm should be slewed out and the wire or rope deployed, ready for immediate use. The davit safety hook should be positioned so that the surface tender supports the IP by their umbilical.
- Choke a rescue lanyard to the IP's umbilical and secure it to the IP's personal reserve dorsal D-ring. This will keep the IP upright. (Photograph 14) If this is not done, the IP will be supported at the waist and will be on their side during the rescue.
- The surface crew should support the IP while on the surface.
- The standby diver attaches the recovery system's locking snap hook or screw-gate karabiner to the IP's dorsal D-ring on the IP's rescue harness.
  - The supervisor's dynamic risk management should include consideration of the IP's breathing supply.
    - If the IP is breathing from the rescue divers' personal reserve (via a QC) or from the rescue divers' pneumo supply, the IP will not have a breathing supply during the lift from the water to the deck.

4.2 Recovered by **Rescue Cradle** or Similar Device (Photographs 68 & 75)

- The rescue cradle should be secured in the same position as identified during the pre-dive recovery exercise.
- The surface crew will have already deployed the cradle.
- The standby diver will guide the IP into the cradle position, and the surface crew will then come up to capture the IP.
  - The supervisor's dynamic risk management should include consideration of the IP's breathing supply.
    - If the IP is breathing from the rescue divers' personal reserve (via a QC) or from the rescue divers' pneumo supply, the IP will not have a breathing supply during the lift from the water to the deck.

4.3 Recovered by **Rescue Stretcher** (Photographs 29 & 69)

- As part of the pre-dive checks, the davit arm* should be slewed out. The rescue stretcher should have two taglines attached and ready for immediate use. The davit should be positioned at the location identified during the predive recovery exercise.
- The surface crew will position and orientate the rescue stretcher at the optimal location identified during the pre-dive recovery drill.
- The standby diver should attach a rescue lanyard to the IP's umbilical and secure it to the IP's personal reserve dorsal D-ring. This will keep the IP upright (Photograph 14). The surface crew should support and guide the IP into the rescue stretcher.
- Depending on the type of rescue stretcher, the standby diver might have to push the stretcher under the IP, secure the IP within the stretcher, and secure the strops on one side. This will have been practised in drills and the rescue exercise.
- The standby diver will need to guide the IP into the stretcher.
  - The supervisor's dynamic risk management should include consideration of the IP's breathing supply.
    - If the IP is breathing from the rescue divers' personal reserve (via a QC) or from the rescue divers' pneumo supply, the IP will not have a breathing supply during the lift from the water to the deck.

*The rescue stretcher can be attached to any suitable, certified man-riding lifting equipment, such as a vessel or a mobile crane.

DIVER RESCUE: Deployed by WETBELL (Recovered by Basket)

15 DIVER RESCUE: DEPLOYED FROM A WETBELL & RECOVERED IN A BASKET

This section sets out suggested rescue actions and the rationale behind them. It offers good practices that the diving organisation may find helpful when selecting safe diving equipment and when developing diver rescue drills, exercises, procedures and their accompanying risk assessments.

This section also ensures that the diving organisation conducting diving operations has an effective diving safety management system that complies with industry best practice. These requirements should apply regardless of the diving technique employed.

15.1 Rescue Equipment when Deployed by a Wetbell

The Wetbell and Standby Diver's Basket Launch And Recovery Systems (LARS)

The launch and recovery system deploys and recovers the wetbells and the basket. The type of system used may influence the methodology and the feasibility of a diver rescue. Industry-recommended practices permit various types of LARS and other energy supplies.

The diving organisation's risk assessment should consider the following:

- When diving operations are near a surface asset, the standby divers' LARS A-frame should be luffed in so that, if the asset is impacted during a DP event, the standby diver's LARS remains undamaged. The working divers can then be safely recovered using the standby diver basket.
- When planning the dive system layout, no part of the LARS should extend beyond the vessel's side. If the DP system is compromised and drifts into or collides with a structure, the LARS and the standby basket on the surface will likely be damaged, and they may be the first items to make contact. There will be no way to retrieve any divers or deploy the standby diver.
- The competencies of the LARS/winch operator and the 'lead diver' must be defined. The winch operator is a 'powered lifting equipment operator' for man-riding equipment, while the lead diver acts as a banksman.
- During emergencies, the standby divers' tender is at risk of falling from height, potentially resulting in suspension trauma or drowning, as the temporary barrier is usually inadequate. (Photographs. 37 and 38.)

Based on lessons learned and experience, the following recommendations are considered safe working practices and should reduce risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- Both LARS should be mutually independent, with any energy cross-connects identified in the risk assessment and the FMEA (Photographs 31, 32 and 33).
- Diving systems should be designed to minimise human error as far as reasonably practicable.
    - Both LARS A-frames should be equipped with a limit switch (chandeliers) and/or an overload alarm to prevent damage when approaching the basket/wetbell and when luffing-in on the A-frame. Other non-diving lifting devices offshore are similarly equipped. (Photograph 34)
- A line-out meter should be installed to indicate the amount of wire spooled out. This meter must be reset regularly to monitor the deployment device's depth; it can measure either the deployment device's depth or the guide weight. Industry-approved practices require at least two independent depth references when deploying loads subsea. Without a line-out meter, the diver's pneumo is the sole reference. If the diver carries a beacon, or one is installed in the wet bell and standby basket, this may remove the need for a line-out meter. However, beacons are less effective at shallow depths.
- A robust gate should be an essential part of the LARS design to prevent falls from height once the wetbell has deployed. It should also be an integral component of a reliable fall prevention system when the wetbell and basket are in use. Although the sea opening is 'temporary'—open during the dive—it is a planned and known opening to the sea that poses fall and man-overboard risks. A rope or chain barrier is not as low as reasonably practicable (ALARP), nor is wearing a personal flotation device (PFD) and fall arrest equipment; both are mitigations or recovery measures in the event of a fall or man-overboard incident (Photographs 32 & 38). ALARP will be achieved once a properly constructed, dependable barrier (that complies with national/flag state regulations) is installed, providing effective protection.
- The diving industry's recommended practice requires that personnel operating 'powered lifting equipment' hold formal qualifications. The wet bell and standby basket winch operator should either be formally qualified in accordance with the relevant standard or have written approval from the designated competent person.

The Wetbell

A wetbell requires a dome and a main supply umbilical from the surface, which provides (at a minimum) breathing gas to a manifold inside the wetbell and diver excursion umbilicals terminated at the wetbell. A diving basket fitted with a dome is not a wetbell.

NORSOK (best definition)Wetbell: "an open unit with an upper section containing a pocket of breathable gas used to lower and recover divers to and from worksites subsea. The unit is equipped with onboard contingency breathing gas and a diver's panel for the diver's umbilical."

Industry recommended practices:

"When diving from a DP vessel or an anchored vessel or floating structure, where there are obstructions at the diving site and/or a freeboard of more than 2 metres, one of the following options should be fitted: a wet bell and equipment for deploying a surface standby diver, or…

"The wetbell should be able to carry at least two divers without cramping."

" … must have chains or a gate at the entry point to prevent the divers from falling out."

Wetbells: The structure should prevent divers from falling out during operations and enable the recovery of a helpless diver while maintaining the safety of the rescue diver.

"Consideration should be given to the size and layout of the wetbell, particularly with regard to the umbilical stowage space (if relevant), as well as the space required for an unconscious diver plus the standby diver in the event of the standby diver having to rescue the working diver."

A diver's rescue from a wetbell differs from that from a basket. The diver's umbilicals terminate at the wetbell; therefore, no assistance is available from a surface tender.

Note: Industry-recommended practices for wetbell diving operations can be ambiguous in some respects, as wetbells may be used for air diving to 50msw and for surface mixed-gas diving to 75msw (where permitted by national regulations). Both diving techniques are similar but not identical.

The diving organisation's operations document for diving, together with its accompanying risk assessment, should address the following points:

- How does a wetbell with open sides protect the diver, and how does a single chain function as an effective barrier to prevent a diver from falling out or being washed out of a wetbell? The requirement is that the structure or design should prevent divers from falling, not a lanyard or similar device; safe by design.

The wetbell diving systems should be designed to minimise the likelihood and impact of human error as far as is reasonably practicable. The equipment risk assessment should consider the following:

- Divers work at heights during launch and recovery in a wetbell. When working at heights on suspended platforms at onshore and offshore construction sites, personnel and equipment must comply with national regulations that require significantly enhanced safety measures and risk mitigation compared with those in a wetbell. These measures include guardrails, inward-opening gates, safety catches, toeboards, full-body harnesses or restraint belts, and fall arrest equipment.
    - National Regulations do not provide an exemption for divers working at height.
    - A diver's harness, rescue lanyard, and umbilical are not fall-prevention or fall-arrest equipment.
    - The divers' D-ring and binding are neither load-tested nor certified for fall protection. As with construction workers on a suspended working platform or MEWP, divers should be secured within the wetbell using approved equipment attached to designated strongpoints.

The Wetbell Dome/Canopy 'Safe Refuge'

A wetbell has a 'dome' that can be filled with air. In an emergency, divers could remove their breathing apparatus and breathe the air within the dome.

The air-filled dome is designated a 'safe refuge'; industry-recommended practices and diving organisations' procedures permit suspending an incapacitated diver, removing their breathing apparatus, and administering resuscitation within the dome.

Industry-recommended practices address emergency scenarios for a wetbell used in air diving operations to 50 msw, in the same way as for a wetbell employed for surface mixed gas to 75 msw. It is unlikely that during an air dive the rescue diver and IP would have the opportunity to remove their breathing apparatus and initiate resuscitation before the wetbell arrives at the surface or deployment area.

Industry-recommended practices:

> *"The wetbell should remain negatively buoyant when the dome is filled with air."*
>
> *"The wet bell should have a securing mechanism for attaching to the diver's harness. This will ensure that the head of an unconscious or injured diver can be kept in the gas bubble of the wetbell dome."*
>
> *"Requires an appropriate method for assisting the working diver (or both, if two are involved) with their heads above water in the event of unconsciousness."*
>
> *"Needs a suitable means for supporting the working diver (or each of them if there are two) with their heads in the air space if unconscious."*
>
> *"The procedures are similar to surface-supplied diving, but the bellman recovers the diver to the bell. He should be able to perform resuscitation inside the bell's canopy."*
>
> *"The wetbell should be able to carry at least two divers without cramping."*

If the diving organisation's appointed DMPs' advice, documentation, and accompanying risk assessment recommend suspending an incapacitated diver in the wetbell during ascent, the following points should be addressed.

- How is the incapacitated diver's neck supported and spinal movement minimised during ascent, particularly when passing near and through the air-water interface?
- Is suspending a diver appropriate for managing all foreseeable types of injury?
  - How does the diving organisation manage suspension trauma?
- What are the testing criteria for equipment that suspends or supports an incapacitated diver?
  - Industry-recommended practices relate to testing criteria. Which document does the diving organisation use to verify that all components are fit for purpose?
- How does the standby diver secure two divers in the wetbell to prevent injury and support recovery?
  - Are there two anchor points sufficiently far apart to secure both divers?
  - Is the dome or canopy large enough for three divers to stand?
- How is any CO_2 accumulation managed within the dome during CPR?

Industry recommended practices:

> *"The procedures are similar to surface-supplied diving, but the bellman recovers the diver to the bell. He should be able to perform resuscitation inside the bell's canopy [dome]."*

If the diving organisation's DMPs' advice, documentation, and accompanying risk assessment permit the removal of the incapacitated and rescue divers' breathing apparatus at depth for resuscitation within the air-filled dome, the following points should be considered:

- What is the diving organisation's stance on where the suspension device should be attached to the incapacitated diver?
  - Thoral or dorsal lift/suspension?
- Which harness is the lifting/suspending device attached to?
  - The diver's rescue harness or buoyancy control apparatus/bailout harness?
  - With or without a chest spreader?
- How does the rescue diver perform resuscitation on a suspended diver within a wetbell dome or canopy?
  - What is the advice from the diving organisations appointed DMP?
  - Does the dome exude water to a safe level that allows the IP's and rescue divers' breathing apparatus to be removed?
  - Can the IP be suspended at a level where a rescue diver can give EAR?
  - Following closed-bell best practices, chest compressions are not recommended for a suspended diver unless the water level is safe. What is the advice of the diving organisation's appointed DMPs?
  - What method of chest compressions is to be used? What is the advice of the diving organisations appointed DMPs?
- If a worst-case failure occurs, how will three divers be managed in a two-man DDC? (Possibly four, if a surface standby is at depth or a tender/DMT is required in the chamber.)
- Procedures should specify that if, during a dive, the dome cannot be de-watered or cannot maintain its status as a safe refuge, the dive should be aborted.
- When the breathing apparatus is removed inside the dome, the dome should maintain a steady airflow from a known, uncontaminated source to prevent CO_2 build-up.

If the diving organisations' DMP advises that suspending an incapacitated diver in the wet bell and performing resuscitation are permissible, and the rescue documentation and accompanying risk assessment specify this, the following recommendations are considered safe working practices and should help reduce risks to ALARP.

- Before removing the IP's breathing apparatus, the rescue diver must determine whether the IP is breathing. Unless the nature of the incident makes it evident, it is unlikely that a rescue diver can accurately assess breathing.
  - Consider leaving the IP's breathing apparatus in place. Ensure the IP's airway is open and provide a free-flow air supply to the apparatus (defogger, pneumo, or an open-ended hose from the onboard emergency cylinder). The pressure in the breathing apparatus should be slightly higher than ambient. Open the IP's airway and observe for spontaneous breathing. This action may serve as a substitute for 'rescue breaths' without further exposing the IP to the risk of inhaling water.
- If the IP and a rescue diver have removed their breathing apparatus, audio and visual communication will be impaired. Industry-recommended practice requires the supervisor to maintain direct communication with any diver in the water at all times.
  - The safe refuge should be equipped with communication equipment, such as a bullhorn. (If divers remove their helmets, the supervisor cannot effectively communicate or manage the emergency.) Any installed bullhorn should have sufficient volume to be heard over the noise of the dome being flushed.
  - The safe refuge should have a camera installed. (If divers remove their helmets, the supervisor cannot monitor or manage the emergency.)
- Industry-recommended practices specify the term '*Resuscitation*' within the dome. This may refer to expired-air resuscitation (EAR), mouth-to-mouth resuscitation, or cardiopulmonary resuscitation (CPR). EAR is a component of CPR. If EAR or CPR is to be practised in the dome, the following considerations should be taken into account:

- As in closed-bell diving, where the flood-up is essential for safety, the amount of water expelled from an open wetbell is equally vital.
  - If the water level in the dome is too high, there is a risk of drowning or of inhaling water.
  - If the dome's water level is high and a rescue diver exits the dome, the water level will rise due to the diver's displaced air, potentially drowning the IP.
- The diving organisation must specify how CPR is administered in a wet bell.
  - CPR is not advisable when a diver is suspended.
  - The recommended industry practices for delivering CPR in a closed bell, assuming the knee-to-chest position, will most likely not be feasible in a wetbell, as the IP will be so low that the IP will be submerged outside the dome bubble.
- If the water level is low, the IP will be suspended. If the diver requires chest compressions while upright, the wetbell must remain flooded to apply hydrostatic pressure to his lower body. When CPR is performed on a fully suspended diver, blood is pushed from his upper body to his legs, where it pools and fails to return to the vital organs because it must overcome the weight of the diver in the harness, the personal gas reserve, and gravity. All this weight is supported by the harness on the IP's thighs (femoral arteries and veins).
- There is no 'open/wetbell first aid kit'. If CPR/EAR is considered an option within the diving organisation, some basic airway-management medical devices should be available in the dome and ready for use.

- If an IP is to be suspended within the wetbell, consideration must be given to how the IP is attached to the lift system.
  - A thoral lift with a chest spreader tilts the diver backwards, making it easier to access the breathing apparatus for removal. This method is preferable to a dorsal lift, which can obstruct the removal of the breathing apparatus when a hinged locking collar is positioned behind the diver's shoulders.
  - A thoral lift with a chest spreader angles the diver backwards and helps keep the airway open. This is preferable for EAR and CPR. A dorsal lift causes the diver to tilt forward, obstructing the airway.
  - If the thoral lift is used, it must be accompanied by a chest spreader. Using two strops directly on the harness will pull the diver's thoracic area together, constricting it and limiting full lung expansion.
  - The lift rigging should be attached to the diver's rescue harness, not to the diver's personal reserve harness or buoyancy control harness.

- If the diving organisation permits suspending an incapacitated diver in the wetbell during ascent:
  - If a spinal injury is suspected, efforts should be made to stabilise the diver's head and minimise spinal movement as he is brought to the surface. The weight of the head and breathing apparatus may cause the head and breathing apparatus to swing abruptly.
    - When recovering the wetbell with an incapacitated diver, significant wave effects may be experienced near the surface. A fully alert diver can struggle to hold on as they transition from weightlessness to full body weight (plus equipment). An incapacitated diver, especially an unconscious one, will thrash around, with a high likelihood of breaking limbs.
    - Generally, a diver can detect wave motion to a depth of about half the wavelength. A typical wavelength of 20 metres can produce turbulence felt down to 10msw. A diver near the surface will be noticeably affected by even moderate swell. Divers must be securely contained within the wetbell, and barriers such as enclosed gates should be in place to prevent limbs from protruding from the wetbell.
    - Exiting the water while in a vertically suspended position can cause blood to pool in the extremities, leading to a drop in heart rate and blood pressure as the hydrostatic pressure on the legs is released. This results in a fall in blood pressure in the brain, which can cause unconsciousness. (An unconscious diver returning to the deck will most likely be treated for an arterial gas embolism.)
    - Explore alternative methods rather than suspending an incapacitated diver by their harness. Casualty management is a vital part of first aid. Handle the casualty gently, keeping the head and spine stable and attending to any fractured limbs. Consider positioning the IP in the heart attack or 'W' position. This is explained in the Dive Basket section of this review.

- If pulley block and tackle are used within the wetbell:
  - When the diver is in the water, the IP may be suspended; however, upon reaching the surface, he may be regarded as 'lifted', especially if a pulley block-and-tackle suspends him. The block-and-tackle system must be lowered to confirm that the IP should be treated as suspended.
  - An approved lift plan is required to lift the diver.

  - The pulley block-and-tackle arrangement should be documented in the PMS and meet the mechanical advantage (6:1) and the testing requirements for a closed-bell diver rescue recovery system.
  - The suspension strongpoint within the dome to which the IP is attached should be included in the PMS (lifting equipment) and meet the testing requirements for use in a closed-bell diver-rescue and recovery system.
  - Any karabiner used should be made of stainless steel and be locking. It should also be identified and listed in the PMS (or batch-tested and identifiable).
  - Equipment should be capable of lifting or suspending at least two incapacitated divers.
- If a ‘chest spreader’ is used to lift a diver, it should be included in the PMS (lifting equipment) and comply with the testing requirements for use in a closed-bell diver rescue and recovery system.
- A cold diver may suffer from circum-rescue collapse after leaving the water due to the dilation of surface blood vessels and the loss of hydrostatic squeeze; blood pressure in the brain will decrease as blood flow through the legs increases. Consequently, the policy of the diving organisation should be:
  - All divers who have lost their thermal balance should be secured in the basket during the ascent.
  - Any diver who has been rescued, regardless of the circumstances, should remain secured in the basket throughout the ascent.
  - A snug wetsuit or undersuit can serve as ‘compression wear’ for athletes, helping to maintain blood pressure when the diver loses ‘hydraulic squeeze’ upon leaving the water.

Surface Standby Diver's Basket

The design of the surface standby divers' baskets, the emergency gas setup, the diver recovery procedures, and the equipment should comply with industry standards and address the comments considered in this review.

The diving organisation's risk assessment should consider the following:

- If the worst-case failure occurs and the wetbell cannot be recovered, how will incapacitated and non-incapacitated divers be brought to the surface?
  - Can the surface standby divers' basket support the number of divers being recovered?
  - Are there enough reserve gas supply cylinders carried in the basket?
  - Are there sufficient diver-securing points and equipment?
  - Is the basket big enough, and does it have an SWL that supports the maximum number of divers required to be recovered in a single ascent?
    - The diving organisations' emergency procedures should state how divers are recovered and, therefore, the basket requirements.
  - Are the umbilicals on the wetbell of sufficient length to allow divers to reach the LARS deployment area?
  - Does the diving organisation have emergency procedures for this scenario?

There are two scenarios for the surface standby diver, depending on the number of working divers and whether a bellman is present. In both cases, the surface standby must leave the basket and relocate to the wetbell.

When a wetbell is deployed, the surface standby diver will be lowered in a basket* from an independent LARS.

Based on lessons learned and experience, the following recommendations are considered safe working practices and should mitigate risks to ALARP. The diving organisations' procedures should, where practicable, identify the following:

- The wetbell and the standby diver basket should be positioned as close to each other as reasonably practicable. A suitably sized rope with spliced soft eyes and shackles must be used at each end. The rope must be thick enough to ensure the diver has a secure grip. The shackles should be attached to the inner guide wire of the standby basket and the wet bell. This rope serves multiple purposes and is vital for safety during a rescue involving the surface standby diver.
  - The standby diver can secure himself and/or his umbilical when leaving the standby basket and moving to the wetbell to carry out the rescue or to act as a bellman.
  - The surface standby diver can locate the wetbell in poor visibility and during a night dive.
  - The surface standby diver can pull himself towards the wetbell in strong currents and wave motion. (Generally, a diver can sense wave motion to a depth of approximately half the wavelength. A typical wavelength is 20 msw, with turbulence experienced down to 10 msw. Even a moderate swell will significantly affect a diver near the surface.)
- The standby diver's basket is much lighter than the wet bell; therefore, the water drag coefficients of the basket and wetbell will differ, leading to a deviation. How is the basket prevented from fouling the wetbell's wires or umbilical during deployment or recovery in currents and vessel movements? (The basket-to-wetbell swimline only prevents the basket from moving away from the wetbell; there is no mechanical device preventing the two deployment devices from getting closer.)
- Consideration should be given to when and to what depth the standby divers' guideweight is deployed.
  - The guideweight is significantly lighter than the wetbell; therefore, the water drag coefficients of the guideweight and the wetbell will differ, causing a deviation from the vertical.
  - How is the guideweight prevented from fouling the wetbell wires or umbilicals (wet bell and divers) during deployment or recovery in currents and vessel movements?

- When planning diving operations in the presence of a current, the chosen diving method must be considered. A diver operating from a wetbell is better equipped to handle currents than a surface-oriented diver, as their umbilical is shorter and deployed horizontally, and therefore experiences significantly less resistance to water movement. Consequently, the surface standby's umbilical may be subject to a stronger (surface) current than the divers deployed from the wetbell at depth.
- When planning, the worst-case scenario should be considered, such as recovering two or three incapacitated divers in a basket following a wetbell LARS failure. The safest recovery is for the standby diver to ascend in the basket with the incapacitated divers. The standby diver must ensure the incapacitated divers receive breathable gas, monitor their umbilicals, keep them secure within the basket, provide head support, and maintain their airways during ascent. Therefore, ALARP is only achievable if a dive basket is designed and approved for three divers. The basket's minimum payload rating should be 590 kg (DnV 740 kg). Recovering two incapacitated divers, or two incapacitated divers and the bellman, in the surface standby diver's basket is a logistical challenge. The diving organisation's rescue procedures and risk assessments should cover all potential scenarios.
- There should be enough emergency cylinders and open-ended hoses in the standby divers' basket for each diver to have access to. In the worst case, the bellman and two working divers may need an emergency supply.
- The basket must have a designated secure attachment point for each diver's umbilical. The diver will secure their umbilical for ascent, and if it becomes fouled on the wetbell, they will not be pulled out of the basket. The surface standby diver will secure their umbilical on both descent and ascent to prevent being pulled out of the basket due to a fouled umbilical or strong surface currents.

*Other options are available, such as a ladder or another wetbell. However, a basket is the most common means of deploying a surface standby diver when diving to 50 msw.

15.2 The Wetbell: Umbilical Properties for Rescue Purposes

Working Divers' Umbilical Length

Industry recommended practices:

> *"All divers operating under normal working conditions, leaving their deployment device, are classified as working divers, and working diver umbilical restrictions apply to their maximum umbilical lengths. Only divers deployed in rescue situations are permitted additional umbilical reach to carry out diver rescues. The length of the working umbilical allowed must be physically restricted to ensure the diver cannot reach within 5m of a hazard. The length of the standby/tender umbilical allowed must be physically restricted to ensure the diver cannot reach within 3m of a hazard, but the diver can reach beyond the working diver by 2m."*

The diving organisation's risk assessment should consider the following:

- If a worst-case failure occurs, such as the inability to recover the wetbell (whether the divers are incapacitated or fully conscious), how will the wetbell divers be brought back to the surface?

Based on lessons learned and experience, the following recommendations are safe working practices and should reduce risks to ALARP levels. Diving organisations' procedures should identify the following, where practicable:

- All umbilicals within the wetbell should be long enough to reach the standby diver's tender at the LARS from the wetbell's deepest point (Depth + freeboard). This ensures divers can be recovered from the standby diver's basket without cutting their umbilicals or removing their BAs when surfacing, should the wetbell be unrecoverable.
- If the length of the umbilical required to reach the standby diver tending point places the diver within 5 metres of an identified hazard, umbilical management procedures should be in place.
- In the vessel-specific umbilical excursion length drawings (for the wetbell), there should be a column stating the umbilical length required to recover divers from the standby divers' basket to the vessel deck. This should be: Distance from the wetbell to the basket + Depth + Freeboard + Distance the wetbell is luffed out + Allowance to disembark from the basket to the tending position. Note: the wetbell depth could be the same as the guideweight's depth.
- There should be a precise procedure detailing how the divers are moved from the wetbell to the standby basket for recovery:
  - How is the safe umbilical length maintained for each diver?
    - The working divers' umbilicals will most likely be restricted in length for the operational dive. The restraints on the umbilicals will have to be removed to allow them to reach their maximum length to the standby divers' deployment area during ascent in the standby divers' basket.
    - The umbilical may be buoyant or negatively buoyant. Both properties should be risk-assessed for fouling or entanglement of either the deployment devices or the seabed assets.

The Bellman's Umbilical Length, Storage and Release

Industry recommended practices:

> *When using a wet bell, the bellman is the standby diver and will stay inside the bell unless he needs to leave the wetbell in an emergency.*

The bellman's umbilical is usually stored outside the wetbell. Careful planning and calculation are required to maintain the safe excursion length.

The diving organisation's risk assessment should consider the following:

- If a worst-case failure occurs, such as the inability to recover the wetbell (whether the divers are incapacitated or fully conscious), how will the divers in the wetbell be brought back to the surface?

Based on lessons learned and experience, the following recommendations are considered safe working practices and should minimise risks to ALARP. Diving organisations' procedures should identify the following, where practical:

- All wetbell excursion umbilicals should be long enough to reach the standby diver's tender at the LARS (Depth + freeboard) from the deepest point the wetbell reaches. This ensures that divers can be recovered from the standby diver's basket without cutting their umbilicals or removing their BAs if the wetbell cannot be recovered and the divers reach the surface.
- If the length of the umbilical required to reach the standby diver tending point brings the bellman within 3 metres of an identified hazard, umbilical management procedures should be in place.
- There should be a precise procedure detailing how the wetbell bellman is moved from the wetbell to the standby basket for recovery detailing :
    - How is the safe umbilical length maintained?
        - The bellman's umbilical should be on a quick-release umbilical rack. The umbilical restraints will likely involve tying up coils to limit length. If the bellman is recovered in the surface standbys' basket, the umbilical restraints and any restrained coils must be released (usually by cutting) before the quick-release mechanism is activated.
        - If rope restraints need cutting, there should be a designated knife for that purpose, secured close by. The diver should not use their diving knife with an open blade in case the umbilical is damaged. (Photograph 77.2)
        - The umbilical might be buoyant or negatively buoyant. Both properties should be risk-assessed for fouling or entanglement of either the deployment devices or the seabed assets upon release, not only for rescue but also for bellman recovery in the standby divers' basket.
- Within the vessel-specific umbilical excursion length drawings (for the wetbell and standby basket), there should be a column indicating the umbilical length requirements when a bellman and a contingency surface standby diver are present. Procedures must explicitly specify how to manage the additional 2m of the bellman's umbilical.
    - The bellman should have the industry-standard additional 2m of umbilical length. The contingency surface standby divers' umbilical length should be only sufficient for them to resume the bellman's duties from the wetbell.

The Surface Standby and Contingency Standby Diver's Umbilical Length

The surface standby state of readiness depends on several factors, including the number of divers and whether the onboard gases are activated manually or automatically. Ultimately, risk assessment and diver safety will determine it.

Industry-recommended practices regarding standby diver arrangements are relatively straightforward:

1. If the wet bell has an automatic switchover to the onboard secondary supply, it is permissible to omit a bellman. In this scenario, the same standby diver best practice is followed as in a basket diving operation.

Industry-recommended practices:

> *"A standby diver is a diver other than a working diver who is dressed and with equipment immediately available to assist the working diver(s) in an emergency".*
>
> *"In a wet bell, it is acceptable that the secondary supply is provided from the onboard cylinders, provided that there is either one diver remaining in the wet bell to switch the supplies over manually or else that the switchover is automatic (for example, a shuttle valve)".*

2. If a bellman is present due to a manual switchover of the onboard secondary supply (or as part of a risk assessment), there is no need for a surface standby diver to be in immediate readiness, as the bellman serves as the 'standby diver'.

Industry-recommended practices:

> *"If a diver remains in the wetbell while the divers are working, the surface standby diver need not be dressed for diving, provided the equipment is available, and may undertake other duties within the dive team while the bell is in the water."*
>
> *"If the secondary supply is provided from the onboard cylinders and the switchover is not automatic, one diver must remain in the wet bell to manually switch the supplies if necessary."*

Regardless, the surface standby is either ready immediately or not; the deployment method and umbilical management remain unchanged.

Industry-recommended practices

> *"Divers deployed in rescue situations are permitted additional umbilical reach to carry out diver rescues. The length of the standby/tender umbilical must be physically restricted to ensure the diver cannot approach within 3m of a hazard, while still allowing the diver to reach beyond the working diver by 2m."*

When a wetbell is used without a bellman, a standby diver must be on deck and in immediate readiness. The standby diver will have an additional 2m of umbilical to ensure manoeuvrability during a rescue. Procedures must explicitly specify the route the standby diver takes to effect a rescue. The standby diver should exit the basket and deploy from the wetbell using the diver's swim line, following the working divers' (IPs) umbilical.

Based on lessons learned and experience, the following recommendations are considered safe working practices and should reduce risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- The vessel-specific umbilical excursion length charts should be calculated so that the standby divers' umbilical length exceeds the working divers' umbilical length from the wetbell by 2m.
  - The vessel-specific umbilical excursion charts should be consulted when planning the rescue procedure. If the surface standby diver is to commence the rescue from the wetbell, their umbilical should not pass through the basket, the basket stoppers, or be attached to the basket wire.
    - If the surface standby umbilical is routed through the basket and/or the guide, the additional friction for the standby diver and the surface tender will most likely hamper the rescue effort.
    - Umbilical management should be handled by the standby diver, who will secure himself in the basket with a screw-gate karabiner, then on the swim line, and finally in the wetbell. If he needs to deploy from the wetbell, the standby diver will pass through it.
    - The tender needs to assist the surface standby diver back to the wetbell.

- o If the standby diver's basket is close to the wetbell, the standby diver should be tended from the wetbell deployment area. Therefore, no calculation of differences in launch positions should be required.

Supervisory Considerations: Wetbell with a Permanent Bellman

When using a <u>wetbell with a permanent bellman</u>, there are two 'standby divers'—the bellman and the surface contingency standby diver.

Industry-recommended practices:

> *"If a diver remains in the wetbell while the divers are working, the surface standby diver need not be dressed for diving, provided the equipment is available and may undertake other duties within the dive team while the bell is in the water."*

During a rescue, up to four divers may be deployed. Two working divers, both potentially incapacitated; a bellman supporting the rescue; and a surface contingency standby diver who assumes the bellman's role.

Industry-recommended practices:

> *"Diving supervisors …appointed in writing, and the extent of their control documented"*
>
> *"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."*

The diving organisation's operations document for wetbell diving, together with its accompanying risk assessment, should address the following points when there is a permanent bellman and surface contingency standby diver:

- What are the gas panel arrangements for supplying four divers simultaneously?
- What are the communication arrangements for supporting four divers simultaneously?
- What are the supervisory arrangements for supervising four divers in the water simultaneously?
- What are the recovery arrangements and procedures for either the standby basket or the wetbell?

The following recommendations, based on lessons learned and experience, are considered safe working practices and are intended to mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- It is unlikely that one supervisor could safely supervise four divers at the same time; therefore, there should be either:
    - o A second supervisor on shift
    - o A superintendent or OM who is qualified, in-date, and available at short notice, with a diving organisation-issued letter of appointment detailing the extent of their control.
- Most air-diving panels are designed to accommodate up to three divers. Unless specifically designed for four divers, a separate panel, communication system, and gas supply will be required for the surface-contingency diver.
    - o There should be a separate panel and independent gas supplies for the surface contingency diver.

- If a separate panel and supervisor are used for the surface contingency standby diver:
  - The supervisors should be close enough to ensure safe, easy communication, with one supervisor communicating with three divers and the other with one diver. Communication between supervisors is crucial, as the surface contingency standby diver won't have cross-talk with the other divers.
  - The supervisor's LOA should be clear on who is overall in charge of the diver rescue.
  - Before the commencement of operational diving, the diver rescue exercise should include the deployment of the surface contingency standby diver and the two-supervisor set-up.

15.3 Wetbell Diving Operation: Gas Supplies

Each gas supply has a specific role in an emergency. A previous section of this report outlines best practices for supplying gases to divers to minimise risk.

Wetbell Surface Supplied Gas

The in-water divers are supplied from the surface via a main supply umbilical. The main umbilical terminates at the wetbell panel, which supplies each diver through their excursion umbilical.

Industry recommended practices:

> *"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 at least 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."*

Based on lessons learned and experience, the following recommendations are considered safe working practices and should reduce risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- The main umbilical should provide three separate supplies for the divers, rather than a single supply hose that splits at the panel. This is the recommended practice for closed-bell diving and should also be applied to open-bell and wetbell operations.
- Upon recognising a potential emergency, the diving supervisor's first action should be to shift immediately to an alternative gas source. Shifting to the secondary panel supply is a positive measure; although 'contaminated gas' may not be the cause or a contributing factor, the benefits are believed to outweigh any disadvantages.
  - The secondary panel supply is effectively an 'unlimited' source—compared with the bailout and OBG—making it advantageous when the incapacitated diver has a free-flowing BA.
  - The change to the secondary panel supply could enable the diver to retain reserve supplies, such as the bailout and OBG.
  - The OBG should be kept in reserve for the wetbell autonomous supply in the event of a main umbilical failure and for dome/canopy filling.
- The wetbell main umbilical termination panel should be positioned to provide a clear path for tightening the main umbilical and for umbilical lines to tear free from the bell surface, without risking damage to other equipment, such as OBG pipework.

Wetbell Onboard Gas (OBG)

The wetbell will carry emergency gas supplies. These are the onboard secondary supplies used if the wetbell's main umbilical is compromised or fails. A previous section of this report outlines best practices for supplying gases to divers to minimise risk.

Industry recommended practices:

> *"In a wetbell, it is acceptable that the secondary source is provided from the on-board cylinders, provided that there is either one diver remaining in the wet bell to switch the sources over manually or else that the switchover is automatic (for example, a shuttle valve)"*

IMO International code of safety for diving:

> *"A minimum of 30 minutes of on-board emergency gas at the maximum planned depth should be provided. This includes a breathing system for each diver, independent of their main and bail-out diving equipment."*

Note: Industry-recommended diving system inspection guidance notes don't specify a defined duration for the OBG, unlike the IMO requirement above; instead:

> *"If this is the method of supply, then it 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. The supply should also be sufficient to allow for all required in-water decompression."*
>
> *"Wet bell gas reserves will depend on the outfitting and the secondary gas supply source(s) to the divers. At a minimum, there will be a gas reserve on the wetbell to provide reserve in the event of main gas failure for the divers to be recovered to the surface without missing decompression stops…"*

Based on lessons learned and experience, the following recommendations are considered safe working practices and should reduce risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- There should be two 'secondary supplies', one from the supervisor's panel and the other on the wetbell. The diving organisation's procedures should clearly specify which secondary supply will be used and when.
- The diving organisation's rescue procedures should emphasise that there is a time limit when using the OBG during a diver rescue.
- The supervisor and bellman must be aware that if the incapacitated diver's umbilical has been severed or the mask or helmet is free-flowing, the bell panel gauges may register a lower pressure, thereby activating an automatic OBG system.

Wetbell Onboard Reserve Gas Supply

When surface-supplied divers use a wetbell, emergency breathing gas cylinders must be carried on the wetbell in case of primary gas failure or contamination. Divers must be able to access the cylinders quickly in an emergency. A previous section of this report outlines best practices for supplying gases to divers to minimise risk.

Industry-recommended practices:

> *"When a surface-supplied diving basket or wet bell is used, emergency breathing gas cylinders must be supplied in the basket or fitted to the wet bell in a standard, agreed-upon layout. This enables the divers to access the cylinders rapidly in an emergency".*

Note: Industry-recommended diving system inspection guidance notes do not include provisions for 'emergency cylinders' similar to those required in a basket.

Based on lessons learned and experience, the following recommendations are recognised as safe working practices and should reduce risks to ALARP. Diving organisations' procedures should specify the following, where practicable:

- A risk assessment may determine that the wetbell-carried reserve gas supply need not be configured the same way as a basket-carried reserve, because a safe haven is available within the wetbell dome; however, as a minimum.
  - There should be an open-ended hose of sufficient length to reach all areas of the wetbell, including a suspended diver in the dome, and to allow free head movement.
    - Although there is an air-filled dome and a quick connect, the open-ended hose remains readily accessible without removing the BA. The hose will generate positive pressure within the BA.
  - Be flexible, kink-free, and long enough to fit under the neck seal. (Photograph 19)
  - Be fitted with an in-line quarter-turn valve.
  - Use a karabiner or another method to ensure the hose remains within an IP's BA during ascent.
  - Be marked to indicate the maximum length that should be inserted under the neck seal into a BA.
- The other side of the first-stage regulator should be fitted with a ¼-turn valve and a quick-connect coupling that mates with a quick-connect on the diver's LP personal gas reserve hose. (Photographs 50 & 52)

15.4 Diving System Set-Up: Diving From a Wetbell to Achieve ALARP Risk Mitigation

It is assumed that the diving organisation complies with industry-recommended practices. During project planning, follow the hierarchy for manned intervention diving:

First: Eliminate the need for diving operations

Second: Use Remotely Operated Vehicles or Remote Intervention Techniques

Third: Use a manned diving technique.

If the diving risk assessment determines that the safest and most appropriate technique for manned diving is surface-supplied diving with a wetbell system, the following equipment and methodology at the worksite may be considered ALARP:

Rescue Exercise

1 Diver rescue exercise before operational diving commences. All supervisors agree on acceptable team competency and equipment fit for purpose.

The Surface Standby Divers Basket

1 Basket rated for and large enough for three men (minimum) @ 150kg each Plus 2x 70kg cylinders.

2 Basket to carry minimum of two emergency reserve cylinders with adequate open hoses for occupants.

3 Both cylinders fitted with a 1st stage regulator rated to maximum intended depth and temperature, one open-ended hose with an in-line ¼ turn, and another with a quick connect/disconnect that can be coupled into the diver medium pressure emergency reserve hose.

4 Both cylinder valve stems and octopus assemblies are to be guarded against accidental damage.

5 A swim line connected to the inner guidewires of the basket and wetbell.

6 Baskets to have mesh gates on both egress and access points.

7 Baskets should be, as far as reasonably practicable, enclosed with mesh.

8 Basket to carry a saw or shears capable of cutting a divers' umbilical.

9 The basket must have a pair of correctly sized fins for the standby diver.

10 Rated suspension strongpoints and any lifting equipment for two incapacitated divers.

11 Basket fitted with minimum of three strong points for divers to attach their umbilicals (Prevent them being pulled out of the basket if their umbilical if fouled on the wetbell)

The Launch And Recovery Systems

1 Two mutually independent launch and recovery systems.

2 Both LARS are to have a line-out meter

3 Both LARS to have chandeliers/limit switches

4 Both LARS have gates to prevent fall from height when the basket/wetbell are deployed.

5 The standby diver's LARS should be luffed inboard when diving alongside an asset

6 Both LARS areas are to be of an adequate size for two IPs in stretchers and 1st aid teams to work.

7 Consideration given to deployment of standby basket guideweight and potential fouling of wetbell

The Wetbell

1 Wetbell rated for and large enough for a minimum of three divers.
The size must allow for two divers suspended in the dome, with the bellman standing in the dome.

2 Wetbell to carry two emergency reserve cylinders.

3 Both cylinders are fitted with a 1st stage regulator rated to maximum intended depth and temperature, one open-ended hose with an in-line ¼ turn and another hose with a ¼ turn valve terminating at a QC fitting. both hoses is of adequate length to reach a standing diver in the dome.

4 Both cylinder valve stems and octopus assemblies are to be guarded against accidental damage.

5 A swim line connected to the inner guidewires of the basket and wetbell.

6 Wetbell to be fitted with an acoustic beacon.

7 Wetbell to have mesh gates on both egress and access points.

8 Wetbell to carry a saw or shears capable of cutting a divers' umbilical.

9 Wetbell to have a pair of correctly sized fins for the bellman.

10 Wetbell must have at least two rated, identified strong points for suspending incapacitated divers

11 The wetbell dome should have arrangements for any removed BAs to be stored/hung

12 Wetbell to have rated suspension equipment for each working diver that is of adequate length or adjustable to enable CPR/EAR in the dome with the IP head above the water.

13 Wetbell dome to have communications system and CCTV system for monitoring the diver and valve status.

14 The wetbell should have a swim-line installed to the worksite.(With appropriate weak link if required)

15 All umbilicals of adequate length to reach the standby divers tending point on deck

The Working Diver

1 Diver to wear a helmet c/w camera and light

2 Diver to carry an acoustic beacon.

3 Diver to wear a buoyancy compensator.

4 The diver is to wear a rescue harness under the personal gas reserve buoyancy compensator harness.

5 Diver to carry a rescue lanyard.

6 Diver personal gas reserve to have a quick connect on the low-pressure hose.

7 Air supplied by two independent sources, including the charging of any HP cylinders.

8 Divers to have crass-talk communications with all other divers-working, bellman, and surface standby.

The Diving Supervisor (when a bellman is in the bell)

1 Addition on shift diving supervisor to supervise the contingency standby diver when diving with a bellman.

The Surface Standby Contingency Diver (when a bellman is in the bell)

1 Standby diver to be clear of medical issues.
2 Standby diver to be clear of decompression penalties.
3 Standby diver to wear a variable volume drysuit (If working divers are kept in thermal balance with active heating system).
4 Standby diver to wear a helmet c/w light and camera. (Light to be energised from the surface)
5 The standby diver is to wear a rescue harness under the personal gas reserve harness.
6 Standby diver to carry a rescue lanyard.
7 Standby diver to carry a tool capable of cutting an umbilical: saw or shears, not a knife.
8 Standby divers personal gas reserve to have a quick connect/disconnect on the low-pressure hose.
9 Standby divers air supplied by two independent sources, including the charging of any HP cylinders.
10 Standby diver to have crass-talk communications with all working divers

The Surface Standby Diver (two working divers and no bellman)

1 Standby diver to watch a monitor and listen to diver-supervisor communications when on standby.
2 Standby diver to be clear of medical issues
3 Standby diver to be clear of decompression penalties.
4 Standby diver to wear a variable volume drysuit (If working divers are kept in thermal balance with active heating system).
5 Standby diver to wear a helmet c/w light and camera. (Light to be energised from the surface)
6 Standby diver to carry an acoustic beacon.
7 Standby diver is to wear a rescue harness under the personal gas reserve harness
8 Standby diver to carry a rescue lanyard.
9 Standby diver to carry a tool capable of cutting an umbilical: saw or shears, not a knife.
10 Standby divers personal gas reserve to have a quick connect/disconnect on the low-pressure hose.
11 Standby divers air supplied by two independent sources, including the charging of any HP cylinders.
12 Standby diver to have crass-talk communications with all working divers.

The Bellman

1 There should be a bellman.(regardless if there is an automatic onboard gas)
2 Bellman to wear a helmet c/w light and camera. (Light to be energised from the surface)
3 Bellman to wear a buoyancy compensator
4 Bellman is to wear a rescue harness under the personal gas reserve buoyancy compensator harness
5 Bellman to carry a rescue lanyard.
6 Bellman’s personal gas reserve to have a quick connect/disconnect on the low-pressure hose.
7 Bellman’s air supplied by two independent sources, including the charging of any HP cylinders
8 Bellman to have crass-talk communications with all working divers.
9 The bellman’s umbilical will need to be restrained in accordance with the vessel specific excursion charts/bailout duration.

15.5 Wetbell Rescue Procedure

Suitable procedures should be in place, based on the particular circumstances of the diving operation, to permit the rescue of a diver in an emergency: one-diver deployment, two-diver deployment, and rescue of the standby diver.

Hierarchy of Rescue

The diving organisation establishes procedures to identify a ‘hierarchy of rescue’ when diving from a basket. Nearly all diving organisations limit procedures to a surface standby diver deploying and conducting the rescue, which is the least desirable option, as it potentially exposes another diver to harm.

The hierarchy shouldn’t supersede the supervisor's assumption of the worst. It is always far better to send a standby diver unnecessarily than to fail to send him when needed.

The hierarchy of rescue when a diver or divers are deployed from a wetbell should be as follows:

First: Rescue by another diver already in the water.

Second: Rescue by the bellman hauling the IP to the wetbell.

Rescue by assisting an incapacitated (not unconscious or when utilising nitrox)

Third: Rescue by the bellman exiting the wetbell and retrieving the IP.

When the bellman leaves the wetbell, the surface standby will be deployed to take over the bellman’s duties in the bell.

Fourth If worst-case failure is realised, the surface contingency standby diver rescues two or three IPs

- 1st by hauling in the IP from the wetbell
- 2nd, by exiting the wetbell and retrieving the IPs

* The diving supervisors’ dynamic risk management assessment should include:

- Type of thermal protection worn. If the diver is wearing a variable-volume drysuit, there is a risk of inversion and an uncontrolled (rapid) ascent to the surface (or to the length of the umbilical deployed from the basket).
- If the diver is wearing buoyancy compensator equipment, there is a risk of an uncontrolled ascent to the surface (or to the length of the umbilical deployed from the basket).
- If the diver is working mid-water, there is a risk of descending to the length of the umbilical deployed from the wetbell, thereby compromising the planned decompression schedule and possibly exceeding the limit line or the maximum allowable PPO_2 for a nitrox bottom mix.
- Bottom mix. If the incapacitated diver is breathing nitrox, the diver should remain at depth until rescued by the standby diver.

Rescue Procedure with Rationale

This section suggests rescue actions, explains why they are taken, and provides considerations that the diving organisation may find useful when developing its diver-rescue procedures and rescue/drill risk assessments.

The primary aim of the following generic rescue guidance is to provide consistency and a systematic approach to rescuing an incapacitated diver during a wetbell diving operation. However, the applicability of the recommendations to any particular case can vary with circumstances, vessel, worksite, and LARS. Therefore, each diving organisation should assess how the recommendations apply to the specific circumstances of each diving system and implement the required measures accordingly.

There should be site-specific procedures for diver rescue, with all divers deployed in a wetbell and recovered in a basket. Procedures should be in place at the work site for the relevant recovery methods, including:

1. Where the standby diver is deployed in the standby diver basket and recovered in the wetbell with the IP(s).
2. Where the standby diver is deployed in the standby diver basket and recovered in the basket with two or three IPs.
    - The working divers' and bellman's umbilicals need to be of sufficient length to reach the deployment area when recovered in the standby basket.
    - If the standby divers' basket isn't rated or large enough for three (or four) divers, procedures should explain how and in what order IPs are recovered.
3. Bellman rescues IPs from the wetbell by pulling their umbilical and recovers the IPs in the wetbell.
4. Bellman leaves the wetbell, rescues the IPs, and recovers with the IPs in the wetbell.
5. Bellman leaves the wetbell, and the surface standby diver assumes the role of the bellman.

- There should be an accompanying DMP-approved procedure for EAR/CPR in a wetbell.

The following outlines actions for a single IP rescue back to the wetbell. There are several recovery scenarios when a rescue is initiated.

1. Supervisor Immediate Actions:

Although this section seems timely, the supervisor's actions will only take a few seconds to discharge.

1.1 Call an ALL-STOP on:

- Assets such as ROVs, vessels, cranes, downlines, and other equipment that could affect subsea conditions should be stopped immediately. Once it is confirmed that their movement did not cause or contribute to the event, the diving supervisor will call an All CLEAR for each piece of equipment.
- All energy sources to divers subsea tools from the surface should be isolated.

1.2 Change the supply gas to secondary panel gas for all divers in the water.

- Not all incidents will be caused by contaminated gas. However, shifting to the supervisor's panel secondary supply will be a positive action with no downside. If the topside supply is compromised, the gas sources will have been switched manually (Bellman) or automatically (Shuttle valve).
- Once on the secondary supply, the second diver should be instructed to flush their umbilical. This will remove any potential contamination in the umbilical from the previous primary supply, which may have been contaminated.
- If there is no topside secondary supply or the main umbilical is compromised, all divers must go onto bell OBG. The switchover is either automatic or manual.
    - Shifting from a surface supply to an onboard gas supply is not desirable unless absolutely necessary. Once the diver begins breathing from the on-board gas, there is a finite amount of time available because the gas supply is limited.
    - Core body temperature might drop due to the temperature of the inspired gas (the gas supply from the surface is warmed by the hot water within the umbilical bundle)
        - If the wetbell umbilical is compromised, the divers will lose their hot water and will no longer be in thermal balance. This will affect the bellman as well.

1.3 Instruct the second diver (now the rescue diver) to make their way to the incapacitated diver. If there is no second diver in the water, or there are two IPs in the water, instruct the bellman to attempt to pull the IP back to the wetbell.

- If available, the supervisor should instruct the ROV pilot to investigate and provide an overview. With an ROV on the scene, the supervisor can obtain an overview (if visibility is suitable) and identify potential causes. The ROV will aid the rescue diver by illuminating the scene. The supervisor can advise the rescue diver and dynamically assess any risk to the rescue diver.
- The supervisor should delegate the task of informing the superintendent, the control room, the bridge DMTs, and the medic, if they still need to be made aware of the situation.
- Assess whether it is safe to position a crane block near the site, especially when the divers are mid-water, to assist the standby diver in reaching and recovering the incapacitated diver.

Wetbell dive with bellman:

- If required, switch supplies manually and confirm action.
- Haul up the incapacitated divers' umbilical. When tight, give line-pull signals. If there is no reply, attempt to pull the incapacitated diver to the wetbell.
    - Dynamic risk assessment: If the IP is secured to the work site with a weak link and that weak link is broken, will the IP descend to an unacceptable depth, resulting in an unplanned decompression penalty or an unacceptable PPO_2?
- If the bellman cannot recover the IP, the supervisor should instruct the bellman to leave the bell. (The bellman should not leave the bell if their thermal balance is lost. Wait for the surface standby diver.)
    - o The bellman will need to release and deploy the bellman's umbilical.

1.4 The following applies to dives with and without a bellman. The supervisor should instruct the surface standby to dress in and prepare to deploy.

- The standby diver must be physically escorted to the basket to ensure that no slip, trip, or fall could jeopardise the rescue operation.
- The surface standby to don fins (if required) while descending in the basket.
- At depth, secure the karabiner to the soft line between the two deployment devices, release the umbilical, then secure the karabiner. Relocate it to the wetbell, secure the umbilical with a karabiner, and release the karabiner from the soft line. (Umbilical management must be maintained at all times.)
    - The surface standby diver should not pass through the standby basket or the umbilical guides. The friction and resistance encountered by the umbilical as it passes through a basket or a wet bell can negate the effectiveness of surface tender assistance if required during the rescue.
- As soon as the surface standby is in the wetbell, he should secure himself to the approved strongpoint as part of his umbilical management.
- Once at the wetbell, assume the role of the bellman.
- Whilst the standby diver is in the wetbell, the diving supervisor should conduct a dynamic risk assessment:
    - o Moving the vessel towards the incapacitated diver reduces the distance and the length of the umbilical deployed. If the vessel is moved, the rescue diver in the wetbell needs to monitor all umbilicals.
    - o Lowering either the guide weight or the guide weight and bell to assist the rescue diver. If the guide weight or the wetbell is moved, the rescue diver in the wetbell needs to monitor all umbilicals.
    - o Consideration must be given to any downline and to any swim line connected to the wetbell.
    - o Consider whether any lifting appliance is attached to an anchor point. This might have to be released.
        - If there is any risk that an umbilical from a diver deployed from the wetbell could become fouled, the vessel's move should commence only after a diver is in the wetbell to monitor and tend the umbilicals.

2. Rescue Divers In-Water Actions

This section assumes the incapacitated diver cannot return to the wetbell. Once the second diver, whether a bellman or a surface standby diver, reaches the IP, all divers take the same actions.

- The rescue divers' immediate actions upon reaching an incapacitated diver are set out elsewhere in this review. These actions should remain consistent, irrespective of the deployment method.

3. Recovery of the Incapacitated Diver to the Wetbell

This section assumes a scenario in which the IP cannot assist in their own rescue.

3.1 Recovering the IP to the Wetbell.

- With the incapacitated diver secured to the rescue diver via a rescue lanyard and the IP having a gas supply, the rescue diver is to return to the wetbell. The rescue diver should maintain positive physical control of the IP. This can be achieved by one or more of the following methods:
  - Walking to the wetbell (Wetbell or standby basket lowered to or near the seabed)
  - Walking to the guide weight (lowered to the seabed) and riding it to the proximity of the wetbell. (This method has 'Line of Fire' potential for divers and umbilicals) (Photograph 24)
  - The rescue diver and IP 'riding' the crane to the deployment device.
  - Use of an ROV to transport both divers to the wetbell (Photographs 22 and 23).
  - The rescue diver (second diver) ascends their own umbilical or the swim line hand-over-hand. If the rescue diver encounters difficulty swimming or climbing with the IP, the rescuer should slowly inflate the affected diver's buoyancy compensator.

    or

  - The bellman hauls up the rescue diver's umbilical. The IP is attached to the rescue diver.

    or

  - The surface tender hauls up the surface standby diver's umbilical. The IP is attached to the surface standby diver.
    - Choking a rescue lanyard to the IP's umbilical and attaching the karabiner to the IP's dorsal D-ring enables the IP to be recovered upright.

3.2 Securing the Incapacitated Diver in the Wetbell (or standby basket)

- Once the incapacitated diver is in the wetbell, the rescue diver secures the IP to the lifting assembly and detaches the IP from the rescue lanyard.
- Swap the pneumo supply (if used) to the reserve gas supply carried by the deployment device.
- Blowdown the dome to remove the water.
- Secure all umbilicals, cut the swim line, and prepare to leave the bottom.

4. Recovering the Incapacitated Diver from Depth to the Deployment Area

4.1 Regardless of the position in which the incapacitated diver is secured in the wetbell, the rescue diver must:

- Maintain the gas supply to the IP.
- Ensure that all umbilicals cannot become fouled (this risk will be exacerbated if the IP is recovered in the standby basket with the umbilical at the wetbell)
- Maintain the IP's airway.
- Stabilise the IP's head and spine (if possible)
- Maintain positive physical control of the IP when near and at the surface, and prevent his arms and legs from flailing and causing further injury.

SURFACE SWIMMER RESCUE

16 SURFACE SWIMMER RESCUE: RECOVERED BY DAVIT OR RECOVERY CRADLE

This section outlines operational and rescue actions and their rationale. It provides good practice that the organisation may find helpful when developing surface-swimming procedures, rescue drills, exercises, and their accompanying risk assessments.

This section outlines rescue actions, explains their objectives, and provides considerations that the organisation may find useful when developing its surface-swimmer rescue drills, exercises, procedures and risk assessments.

The main goal of this generic rescue guidance is to ensure consistency and a systematic approach to rescuing an incapacitated surface swimmer. However, the way the recommendations are applied can vary depending on circumstances. Therefore, each organisation should assess how the recommendations' requirements align with its specific conditions and implement measures to meet those requirements.

Organisations should formulate rescue procedures for each foreseeable scenario within the rescue hierarchy; many actions should remain consistent regardless of who performs the rescue. The rescue procedures should include the following general guidance, suitably amplified or amended by individual organisations to account for their particular situation: team size, available equipment, and the worksite. Surface swimmers are used offshore, inshore, and during inland operations. Tasks include:

- Work on floating hoses.
- Work on and around SBMs.
- Stinger checks during pipelay activities.
- Work in the splash zones.

Such tasks are often carried out from a small craft or by rope access. Surface-swimming operations seem more common in warmer regions, such as the Gulf and Southeast Asia, than in colder regions.

Hierarchy of Operation

It is assumed that the organisation adheres to industry-recommended practices. During the project planning phase, follow the hierarchy of manned intervention.

First: Remove the requirement for surface swimmer operations.

Second: Utilise Remote Intervention Techniques (Such as working directly from a small craft).

Third: Use an appropriate manned diving technique. (Risk assessed).

Fourth: Use a surface swimmer.

The rationale for avoiding surface-swimming operations where practical and preferring manned diving is:

1. A surface swimmer has an unprotected airway and is considerably more susceptible to drowning (Photograph 72) due to overexertion, panic, an inability to cope with rough seas, or exhaustion. Drowning while using hard-hat diving equipment is rare. If the swimmer becomes unconscious, the airway remains unprotected.
2. Verbal or audio communication between the swimmer and the supervisor is less effective than diving communication.
3. The swimmer has no camera, so there is no monitor, recording device, or black box. The supervisor has less control over the task than during a diving operation.

Hierarchy of Surface Swimmer Rescue

The organisation's procedures should define a 'hierarchy of rescue' for surface swimmer operations. This hierarchy shouldn't supersede the supervisor's worst-case assumption. It is always better to send a standby swimmer unnecessarily than to fail to send one when needed.

The rescue hierarchy for deployed surface swimmers should be as follows, assuming a small craft cannot assist immediately.

First: Rescue by another swimmer already in the water.

Second: Rescue by assisting an incapacitated (not unconscious) swimmer by the surface tender, hauling on the IP's lifeline until the IP is back at the deployment area. (This could be a boat, a basket, a ladder, a davit)

or

Directly by a rescue boat (with low freeboard)

Third: Deployment of the standby swimmer.

16.1 Rescue Equipment: Surface Swimming

Several industry-recommended practices relate to surface swimming operations. These specify the equipment requirements; however, the practices are not aligned with them.

Generally, the organisation should treat surface swimming as a diving operation. A standby swimmer, specific PPE, safe lifeline excursion lengths, a recovery drill, and any small craft used should meet the same requirements as those for supporting a diving operation, including equipment for rescuing an incapacitated swimmer.

The following recommendations are safe working practices intended to reduce risks to ALARP levels. The organisation's procedures should specify the following, where practicable:

Surface Swimmers' Lifeline

Note: The term 'lifeline' is used in the offshore industry and can refer to various setups. During work at height, climbing, or in restricted areas, a lifeline provides access and freedom of movement; in diving, this setup is called a 'jackstay'. In surface swimmer operations, a lifeline is a rope connecting the surface tender to the swimmer's harness.

- There are significant differences in permissible excursion lengths between surface swimmers and divers.
  - When surface-swimming operations are a potential consideration during a project, surface-swimmer excursion charts should be prepared alongside diver excursion charts and should follow the same approval process.
  - The surface swimmer's lifeline should be marked for distance and secured at both ends, as if it were a diver's umbilical.
- Industry-recommended practices require the surface swimmer to wear a full-body harness.
  - This should be an industry-compliant diver rescue harness. (Photograph 15)
- The surface swimmer's lifeline should be attached to the harness's dorsal D-ring (Photograph 72) or connected to both shoulder D-rings using a Y-shaped bridle behind the swimmer's head.
- The swimmer's lifeline should be secured with a screw-lock karabiner.
    - If the swimmer is recovered by the lifeline, the dorsal attachment streamlines the swimmer's body.
    - If the swimmer is recovered by the lifeline, the dorsal attachment helps keep the IP's head above water.
    - The Y bridle gives the swimmer head support during retrieval to the recovery area.
  - The lifeline should be secured only to the swimmer, and the swimmer should always be in a position that allows immediate recovery.
- The organisation conducting the surface swimming operations should investigate the use of a camera and hard-wired communication with the swimmer. In this case, the lifeline could be either a cable or a cable attached to a rope lifeline.

Surface Swimmers' Buoyancy

- Industry-recommended practices require the surface swimmer to wear a life jacket or a buoyancy aid.

  - The risk assessment should identify a life jacket that offers the highest level of protection for staying afloat and for turning incapacitated swimmers face up. A Type 1 PFD. (Photograph 74)
  - The PFD selection should include an integral spray hood or another method of protecting an unconscious swimmer's airway.
  - The PFD should have a crutch strap to prevent it from riding up on the swimmer. (Photograph 74)
  - The buoyancy device should not impede the rescue diver from attaching a rescue lanyard to the IP's harness.
- A (Type 1) PFD with head support will: (Photograph 74)
  - Provide some protection to the IP's airway during rescue.
  - Assist the rescue swimmer when stabilising the IP's head.
  - Provide the IP with head protection if recovered from an MOB rescue cradle.
- The organisation should assess the most appropriate method for attaching davit wire to the swimmer's harness when the swimmer is wearing a PFD. This should be confirmed and practised during the pre-task recovery drill.
  - A PFD will limit the number of easily accessible D-rings. It is most likely that the only available D-ring will be the dorsal.
- The rescue swimmer should have sufficient buoyancy to perform the rescue without impeding it. The rescue swimmer should be able to position the IP in front of them for the rescue. (Photograph 77)
- The swimmer should not attach any tools to themselves:
  - The additional weight may affect buoyancy or how the swimmer sits in the water
  - The tool or lanyard can foul items and prevent an IP from being immediately recoverable

Surface Swimmers' PPE

- The risk assessment should specify the type of gloves the surface swimmer should wear to protect against hazards in the splash zone. Splash zone hazards and task hazards may differ from those in any diving operations at the same work site. The rescue swimmer will also require the same level of protection for their lower arm.
- Unless the surface swimmer stands at the work site, they should always wear swim fins. Without fins, the swimmer might overexert themselves, panic, or struggle in rough water, leading to drowning.
  - Swim fins improve efficiency, reduce energy expenditure, and assist swimmers when using a buoyancy aid. The risk assessment should specify the required type of swim fins, as various styles and features are available. Diver's fins may not be suitable for use in the splash zone. Additionally, the risk assessment should specify the type of fins to be worn, ensuring the standby surface swimmer has the same type available in case of a rescue. (Photograph 81)
- The risk assessment should consider surface pollution, such as toxic substances (e.g., hydrocarbons), and biological hazards, such as sewage discharges, which can cause ear infections or illness.
  - A swimmer's airway (and ears) is not protected in the same way as a diver's is.
  - The rescue swimmer needs to be provided with any necessary control measures, including additional PPE.
    - There may be a requirement to verify that the swimmer is up to date with their vaccinations.

Note: Many energy sources in living organisms, including viruses and bacteria, are included within LSRs.

Surface Swimmers' Rescue Lanyard

- Each surface swimmer and standby swimmer should have a rescue lanyard (Photograph 13).
  - The specification and use of the rescue lanyard are the same as those for a diver.
  - The rescue lanyard can be attached to the swim line, provided nothing impedes the swimmer from being hauled back along it while connected.
- If the surface swimmer needs to attach themselves to the worksite for stability, there should be a weak link between the attachment and the swimmer (including magnets). The surface tender should be able to break the weak link by pulling on the swimmer's lifeline to effect recovery. (Photograph 25).

Surface Swimmers' Swim Line

- The surface swimmer should install a swim line (if a downline is not in use) from the deployment area to the worksite.

  - Provides the swimmer with direct access to the deployment device or area
  - It provides the rescue swimmer with access to and from the worksite in current or choppy-sea conditions.
  - It provides the rescue swimmer with a guide to the work area and, ideally, to the incapacitated swimmer.

Surface Swimmers Face Mask

- Industry-recommended practices allow the surface swimmer to wear a face mask as PPE. Diving organisations' risk assessments and procedures should clearly specify:
  - The reason or hazard for which the face mask is used.
    - The surface swimmer is forbidden from submerging their head for the task (it becomes a diving operation)
    - The most likely reason a mask is worn is to protect the eyes from water and any potential hydrocarbons or other harmful contaminants it may contain.
    - The face mask should not be used as PPE for the task, as a diver's face mask will likely not comply with international standards for impact resistance, optical class, chemical resistance, UV protection, and sparks.*
- The standby surface swimmer should always wear an appropriate face mask to prevent saltwater and potential contaminants from entering the eyes and nose during a rescue.
  - There are EN166-compliant, waterproof goggles that could be used for work and swimming.

*Note: A diving mask is made from tempered mineral glass. It is designed to break into small, blunt fragments for safety. Diving masks are not impact-protective and do not meet the EN166 standard for safety eye protection.

Ancillary Rescue Equipment

- Some organisations' practice is for the surface swimmer to carry a flare. The organisations' risk assessment and procedures should clearly specify whether a flare is to be used near an asset with a hydrocarbon inventory. (This also applies to any small craft.)
- Industry-recommended practice is for the surface swimmer to carry a personal indicator strobe light. The organisation's risk assessment should clearly specify whether a strobe is to be used near an asset with light-sensitive sensors. (This also applies to any small craft.) A SOLAS-approved Type 1 PFD will have a light. The swimmer should have a head torch on their helmet.
- The first-aid kit for a surface-swimmer operation should comply with diving-industry best practice, including oxygen administration and airway management. Divers who have completed a general first-aid course rather than a diving-specific course may need to demonstrate competency in the use of all on-site diving medical equipment, particularly airway management equipment and O_2 administration, which are not covered in the general first-aid course.
- Given the higher risk of near-drowning or secondary drowning during surface-swimmer operations, procedures should specify suitable medical facilities, preferably a hospital, to which the injured person can be transferred.
  - All near-drowning victims should be admitted to a hospital as soon as possible because pulmonary oedema, pneumonia, and other complications may develop many hours after an incident.
- The swimmer and the standby swimmer should each carry a knife capable of cutting the lifeline. Knives should be worn on lanyards; each knife should have one cutting edge and a blunt end. All knives should comply with the organisation's knife policy and be approved by the supervisor.
  - The diving organisation should issue a safety knife (Photograph 77.2) to the swimmer and the standby swimmer for cutting the lifeline. Wave motion during surface-swimming rescue operations will increase the risk of injury or PFD damage from an open-bladed knife (Photograph 77.1).
- The organisations' risk assessment should also consider these LSRs, particularly when committing a surface rescue swimmer; there is a potential that the following LoF hazards could be the cause of the rescue:
  - Line of Fire: Hazardous marine life
    - Surface swimmers and rescue swimmers are more likely to encounter sea snakes and coelenterates (such as Portuguese man-of-war and box jellyfish) than divers are.
    - A surface swimmer or rescue swimmer is more likely to be exposed to sea urchins than a diver. During surface swimming, sea urchins are not always underfoot, but they can still cause injury anywhere on the body if forced against an asset surface.
    - A surface swimmer and a rescue swimmer are more likely to be in an environment where marine animals (such as sharks, killer whales, and seals) might attack than a diver is.
  - Line of Fire: Potential of sunburn to the face
    - Sunlight is harmful to health in both the short and long term.
    - Sea water and assets can reflect and/or intensify ultraviolet radiation.
- If the swimmer requires stability, an approved weak-link device should be used. (Photograph 25)
- The swimmer should not attach themselves to the work site using a magnet if the magnet's weight could disrupt the PFD buoyancy or prevent the swimmer from remaining upright in the water.
- The organisation's risk assessment should consider the use of hard-wired communications. The cable could serve as a lifeline or be integrated into the rope lifeline. The earpieces could be installed in the ear protection worn with the head protection. Alternatively, the swimmer could wear a neoprene wetsuit hood with built-in headsets. The hood would also help prevent ear infections.
- In warmer climates, all swimmers and tenders should be well hydrated with electrolyte drinks and protected from the effects of the sun and sun reflection from assets and the sea surface.

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16.2 Surface Swimmer Recovery Methods

Surface swimmer recovery from the sea surface to the deck is very similar to SRP diving recovery methods; however, it also involves additional safety considerations.

In all surface swimmer recovery situations, the following should be considered:

- The IP's (and the rescue swimmers') airway is not protected, and consideration is needed when connecting the IP to or placing the IP in the recovery device.
  - Wave motion is typically greater near a vessel or static object due to wave reflection. This typically results in the immediate recovery area having a complex interference pattern and being choppier than elsewhere. This needs to be considered in dynamic risk assessment during the operation.
- The rescue swimmer and IP don't have a hard-wired communication link. Communication is by voice between the rescue swimmer, IP and surface support.
  - Voice communication can be difficult when in the water, with waves lapping against the ears and a mouthful of seawater every time you speak.
- Maximum allowable environmental conditions should be documented and complied with. Typically, parameters will be considerably more stringent than for diving operations.

Industry-recommended practices:

> *"There must be a suitable means of access to and egress from the water as well as means to recover an injured or completely incapacitated swimmer safely. Suitable emergency response equipment must be available at the worksite location and ready to use".*
>
> *"A swimmer should not be deployed into or recovered from the water if the height or the freeboard is greater than 1 metre without there being a suitable, dedicated means of safe recovery available. This should have been identified by the preparation of a site-specific risk assessment for swimmer deployment and emergency recovery".*

The following recommendations are safe working practices intended to reduce risks to ALARP levels. The organisation's procedures should consider the following, where practicable:

16.2.1 Recovery by Harness using a Davit (or other Lifting Appliance)

Industry best practice allows a surface swimmer to be recovered by a rescue harness on a davit or similar approved lifting appliance. If this method of recovery is used:

- The recovery davit should meet the same standards as a davit used to recover an incapacitated diver during SRP operations; however, the SWL need not match that of a fully dressed diver. The davit should be approved for man-riding and certified accordingly.
  - A suspension trauma-relief strap should be available for incapacitated personnel (Photograph 28).
  - The harness should be the same standard as a diver's rescue harness.

16.2.2 Recovery Stretcher using a Davit (or other Lifting Appliance) (Photographs 29 and 69)

Industry best practice allows a surface swimmer to be recovered by a recovery stretcher. If this method of recovery is used:

- The recovery stretcher should meet the same standards as when used to recover an incapacitated diver during SRP operations; however, the SWL may not need to match that for a fully dressed diver. Any davit or lifting device should be approved for man-riding and certified accordingly.
- This method should be rigorously risk-assessed, as it may not be suitable if an unconscious IP is on the stretcher with an unprotected airway. Approval should be sought from the organisation's medical adviser.
- The stretcher used should be purpose-designed for waterborne recovery, not a stretcher for topside first-aid.

16.2.3 Recovery Cradle (Photographs 68 and 75)

Industry best practice allows a surface swimmer to be recovered by a recovery cradle. If this method of recovery is used:

- The small craft should be risk-assessed for stability before using a cradle. When lifting an IP, the personnel bringing the IP inboard must be on the same side of the small craft. A small monohull craft might not be suitable.
- This method should be rigorously risk-assessed, as it may not be suitable when an unconscious IP is in the cradle with an unprotected airway. Approval should be sought from the organisation's medical adviser.
- As with use during an SRP diving operation, this method doesn't stabilise the IP's head or broken bones and could further exacerbate pain and injuries.

16.2.4 Recovery Directly into Small Craft with Low Freeboard

Industry best practice allows a surface swimmer to be hauled from the water to a platform that is one metre or less above the water. If this method of recovery is used:

- This method needs to be drilled and incorporated into a recovery exercise.
- Following a risk assessment, this method may be acceptable for recovery into a low-sided vessel, such as an RIB or a small rigid workboat. The risk assessment should address the method and the safety of personnel performing the hauling-in, particularly when freeboards approach one metre and the IP is arching over the gunwale. Approval should be sought from the organisation's medical adviser.

16.2.5 Recovery by Divers Deployment Device (or Man-Riding Work Platform)*

If a surface swimmer is deployed from a diving vessel, the swimmer and the rescue swimmer are likely to be deployed and recovered using a diver's deployment device, usually a basket. If this recovery method is used:

- The basket should only be deployed into the water enough to allow the swimmer egress and access.
    - The wire should be marked up accordingly to reflect the maximum allowable deployed wire.
- The surface swimmer and the rescue swimmer should be tended from the basket to ensure the safe lifeline excursion length is maintained.
- There should be voice/audio communications with the tender in the basket. Preferably hardwired. This allows hands-free operation.
- There should be suitable securing arrangements in the basket to prevent an IP from falling out on ascent.
- In warmer climates, the basket/work platform should be fitted with tarps to provide shade for the tender.
- Unlike diving, first aid, CPR, and O_2 administration could potentially be initiated in the deployment device; therefore, the risk assessment should consider the availability of appropriately trained tenders and suitable equipment.
- The swim line should be routed through a running shackle on the deployment device and tended from the deck.

Note:

*If a non-diving basket is used, such as a suspended platform or gondola, approval from the organisation's lifting authority should be sought. Immersion in seawater and potential dynamic forces may damage the apparatus. The lifting of divers into and out of the water using DESIGN-compliant diver launch-and-recovery systems, such as a diving bell or basket, may be considered routine lifts. However, all other lifting operations involving personnel should be considered non-routine.

16.3 Surface Swimmer System Set-Up to Achieve ALARP Risk Mitigation

The Surface Swimmer

1 Surface swimming can be physically challenging. Therefore the identified swimmer should be an in date diver
2 Swimmer to wear a helmet c/w camera and comm and head torch.
3 Swimmer to wear an in date diver rescue harness under the PFD
4 Swimmers to wear a PFD with crotch straps and designed with head support to keep an IP upright
5 Swimmers life line to be attached to dorsal D-ring or both shoulder D-rings.
6 Swimmer to carry a rescue lanyard.
7 Swimmer to use. A divers weak link if required for stability
8 Swimmer to carry a safety knife proven to cut the life line
9 Swimmer to wear lower arm protection separately risk assessed for hazards in the splash zone
10 Swimmer to wear swim fins if working in the water or safety boots if standing on asset
11 Swimmer to wear protective clothing/suit adequate to prevent injury from identified hazards
12 Swimmer to wear a ‘diving’ mask to protect eyes/nose from salt water and contamination ingress
13 Swimmer to have change of eye protection for task if RA identifies eye injury hazard.
14 Swimmer to have a swim line installed between deployment area and work site
15 Swimmer to connect lanyard as a jackstay to the swimline and ensure that he is immediately recoverable
16 Swimmer shouldn’t carry a flare or strobe if working in a 500mz or hydrocarbon area
17 Swimmer shouldn’t have tools attached to themselves.

The Standby Swimmer

1 Surface swimming can be physically challenging. Therefore the identified swimmer should be an in date diver
2 Standby Swimmer to wear a helmet with head torch.
3 Standby Swimmer to wear an in date diver rescue harness under the PFD
4 Standby Swimmer to wear a PFD with crotch straps and designed with head support to keep an IP upright
5 Standby Swimmer life line to be attached to dorsal D-ring or both shoulder D-rings.
6 Standby Swimmer to carry a rescue lanyard c/w scaffolders safety clip
7 Standby Swimmer to carry a safety knife proven to cut the life line and a divers knife
8 Standby Swimmer to wear lower arm protection separately risk assessed for hazards in the splash zone
9 Standby Swimmer to wear swim fins
10 Swimmer to wear a ‘diving’ mask to protect eyes/nose from salt water and contamination ingress
11 Swimmer to wear protective clothing/suit adequate to prevent injury from identified hazards

16.4 Surface Swimmer Rescue Procedures

Suitable procedures should be established, taking into account the specific circumstances of the surface swimmer operation, to enable emergency rescue.

There are several recovery options for a surface swimmer:

1. Use of a davit connected to the swimmer's rescue harness, either directly (Photographs 27, 65, 66 & 67) or via a chest spreader (Photographs 63 & 64). The same principles apply as in a diver recovery by davit.
2. Use of a davit with a rescue stretcher (Photographs 29 and 69)
3. Use of a MOB recovery cradle (Photographs 68 and 75)
4. Use of a partially submerged divers' deployment device.
5. Use of small craft with a very low freeboard (Subject to risk assessment)

Note: Industry recommended practice. *A swimmer should not be deployed into or recovered from the water if the height or the freeboard is greater than one (1) metre, unless a suitable, dedicated means of safe recovery is available*. This statement appears to apply to a standard operating procedure rather than to an emergency procedure or situation.

The scenario below describes a typical surface swimmer rescue. This remains generic until the IP reaches the device for removal from the water. If a rescue is initiated, regardless of the recovery method:

1. Supervisor Immediate Actions:

Although this section seems timely, the supervisor's actions will only take a few seconds to discharge.

1.1 Call an ALL-STOP on:

- Assets such as vessels, cranes, downlines, and other equipment that could affect the swimmer or the swimmer's work site should be stopped immediately. Once it is confirmed that their movement did not cause or contribute to the event, the diving supervisor will declare an All CLEAR for each piece of equipment.
- All of the swimmers' tools with an energy source should be isolated.

1.1 Follow the hierarchy of rescue.

- Unless the IP is unconscious or so incapacitated that they cannot protect their own airway, the IP must be assisted back to the recovery area by a rescue swimmer. (Photograph 77)

2. Rescue Swimmer's In-Water Actions:

2.1 The supervisor and rescue swimmer should both confirm that it is safe to approach the IP.

2.2 On reaching the IP:

- The rescue swimmer should attach themselves to the IP using a rescue lanyard.
  - This secures the IP (the lifeline might have been disconnected or severed, or might need to be cut/disconnected for rescue)
  - Ditch the swimmer's weight belt and any attached tools.

2.3 Immediate In-Water Assessment of the IP

- Upon reaching an incapacitated swimmer, the rescue swimmer's immediate actions are the same as for any injured person: ABC. The standby swimmer and any other swimmer should, at a minimum, hold first-aid certification. The rescue diver must administer first aid without the supervisor's guidance. Actions should remain consistent.

As with all first-aid: ABC

Airway. Ensure, as far as reasonably practicable, that the IP has an airway.

- IP should be in a chin-up position to maximise the chance of spontaneous breathing. (Photograph 77)
- If the swim line is taut, the rescue swimmer should be able to steady the IP for assessment.

Breathing. Check for breathing.

- It won't be possible to give CPR; at best, the rescue swimmer might be able to give rescue breaths and hope for spontaneous breathing. If both swimmers are pulled back to the recovery area, the rescue swimmer might be able to perform mouth-to-mouth resuscitation.
- During retrieval by lifeline back to the recovery area, if the IP cannot protect their airway, the rescue diver must do so to prevent water from entering the lungs.

- If the buoyancy aid has a spray hood, it should be deployed.

Circulation. Check for major haemorrhaging.

- Any major haemorrhage should be stabilised.
- Improvise a tourniquet using a lanyard or rope, or apply pressure to a pressure point during retrieval.

3. Retrieval Phase (Worksite to Recovery Location)

3.1 The rescue swimmer prepares for retrieval to the recovery area/device via their lifeline (Photograph 77):

- The rescue swimmer should ensure the lanyard is attached to a suitable point on the IP's harness, ideally at the shoulder or dorsal D-ring.
- The rescue swimmer should position themselves behind the IP and stabilise them.
- The rescue swimmer should, as circumstances dictate, support the IP's head (Photograph 77) and protect and maintain the IP's airway.
- The rescue swimmer should route the IP's lifeline under his own armpit. This prevents the lifeline from hitting him in the side of the head.
- When instructed, the surface support crew should retrieve the swimmer(s) to the recovery area or device by hauling in the rescue swimmer's lifeline, which is attached to the rescue harness's dorsal D-ring.

4. Arrival at the Recovery Location and Recovery to a Safe Area

In all methods of recovery:

- An approved lift plan is required if the swimmer is to be lifted by a davit or a cradle. All man-riding lifts require a lift plan and a risk assessment.
- The surface crew should have prepared and deployed the lifting arrangement.
- The surface tender should support the rescue swimmer with his lifeline so he can control the IP on the surface whilst the IP is attached to or placed within the recovery system/device.

4.A. Recovery by Davit to Connected to the Swimmer's Harness

- The recovery by Davit, secured to the diver's harness at either the dorsal or thoral D-rings, is very similar to a diver recovery described elsewhere in this report.
- The rescue swimmer will need to connect the davit securing device to the organisation's approved lifting point on the IP's harness and disconnect the rescue lanyard.

4.B. Recovery by Davit in a Rescue Stretcher

- The surface support team will have lowered the stretcher and steadied and orientated it using taglines.
- The rescue swimmer will guide the IP into the partially submerged rescue stretcher (Photographs 29 and 69).
  - If a spinal injury is suspected, efforts should be made to stabilise the IP's head while on the rescue stretcher. If sea conditions permit and the swimmer is breathing and not at risk of vomiting, it may be possible to float a spine board under his body. This would be used to stabilise his C-spine before lifting him from the water. This method has been successful with injured swimmers who have suffered cervical spine injuries in swimming pools.
  - Consideration needs to be given to the IP's open airway.
- The rescue swimmer will disconnect the rescue lanyard.
- The rescue stretcher can then be recovered to the deck. The taglines will remain in place to prevent excessive movement and safely guide the stretcher to the deck.

4.C. Recovery by MOB Recovery Cradle

- The surface support team will have lowered the recovery cradle (see Photographs 68 and 75)
- The rescue swimmer should consider ditching any items on the IP that could foul the cradle and interrupt the rescue during the rolling phase.
- The rescue swimmer will disconnect the rescue lanyard.
- The rescue swimmer will guide the horizontal IP alongside the cradle, ensuring the hoisting ropes are clear. The surface crew will recover the IP.
  - Consideration needs to be given to the nature of the IP's injuries, cervical alignment or support and the IP's open airway.

4.D. Recovery by Divers Deployment Device (or Man-riding Work Platform)

- The device should be lowered into the water just enough to aid entry.
- The IP should be brought into the device and secured.
- The tender should conduct an immediate assessment of the IP and apply 1st-aid principles.
- All lifelines should be confirmed as inboard and secured to prevent fouling on the guideweight and wires.
- The device should be recovered in accordance with the tender instructions.

4.E. Small Craft with a Very Low Freeboard

- The IP, or the IP and rescue swimmer, should be hauled alongside the small craft.
- The rescue swimmer should disconnect the rescue lanyard.
- The IP should be brought alongside the small craft, with their back to the vessel.
- With two people each holding a shoulder strap, the IP should be hauled up and into the craft.
- As the IP's head is clear of the gunwale, someone should steady the IP's head and nec.k
- The IP should be put directly into a stretcher.
  - If the IP is on a small craft, it will need to be relocated to a mother vessel or a quayside.

5. Arrival at the Recovery Site on Deck/Quay

The actions upon the IP's arrival at the deployment area differ for a swimmer and a diver, as there will be no requirement for hyperbaric treatment or removal of diving equipment.
There should be a f

Once the rescue swimmer and IP arrive at the deployment area:

- Action: One team member should be responsible for filming or documenting the actions, including the timeline.
- Action: The rescue swimmer will no longer be involved. Keep out of the way and let the topside team attend to the casualty assessment, immediate treatment, and handling.
- Action: One team member should be assigned to support the IP's neck and spine to keep it aligned and maintain the IP's airway.
    - The IP should be placed directly into a suitable stretcher.
    - Avoid moving the head/neck.
    - Fit a cervical collar as soon as possible.
        - Some cervical collars still allow enough head movement to cause further injury.
        - Continue to stabilise the casualty's head even after a collar is fitted. This can be achieved by placing a hand on either side of the head and gripping the IP's collar. (Try to keep the ears clear so the IP can hear.)
        - This action also prevents the IP from automatically answering questions by nodding or shaking their head.
    - Supervise the O_2 administration and, if required, fit the appropriate airway device.
- Action: The PFD, harness and clothing should be removed to minimise the IP's movement. To prevent movement, equipment should be cut off using Tuff-Cut scissors.
- Action: After initial first aid, the IP should be taken to the pre-arranged aid area, either the vessel's sick bay or ashore, as directed by the organisation's medical adviser.

DIVER RESCUE: EXTENDED UMBILICAL

17 DIVER RESCUE: EXTENDED UMBILICAL

This section outlines operational and rescue actions and their rationale. It provides good practice that the organisation may find helpful when developing procedures for diving with extended umbilicals, rescue drills and exercises, and their accompanying risk assessments.

The primary aim of this generic rescue guidance is to ensure consistency and a systematic approach to rescuing an incapacitated diver during extended umbilical operations. However, the way the recommendations are applied can vary depending on circumstances. Therefore, each organisation should assess how the recommendations' requirements align with its specific conditions and implement measures to meet them.

Organisations should formulate rescue procedures for each foreseeable scenario within the rescue hierarchy; many actions should remain consistent regardless of who performs the rescue. The rescue procedures should include the following general guidance, suitably amplified or amended by individual organisations to account for their particular situation: team size, available equipment, and the worksite.

The term Extended Umbilical refers to operations in which an IWTP is used to extend the umbilical length beyond normal operating limits. This may be necessary when platform overhangs, flare towers, lifeboats, bridges, and similar structures restrict access to the worksite. (Photographs 94 and 96)

A diver access study will determine the required umbilical length and contribute to assessing which method of umbilical management should be used. Extended umbilical diving can be used in all diving techniques; however, it is uncommon during SRP diving.

There are two methods:

1. Active or manned tending at the IWTP (Photograph 96)
2. Passive or unmanned tending from the IWTP (Photograph 94)

The umbilical set-up for both methods is the same. The only difference is that the active tending technique involves a diver at the IWTP. However, the methods used to rescue an incapacitated diver differ.

17.1 Rescue Equipment: Extended Umbilical Operations

This section highlights equipment and procedural considerations for operational diving and rescue during extended umbilical diving operations. How the system is set up can affect the outcome of a rescue.

- An IWTP is typically slewed out between 60° and 90° to the vessel's side. The distance varies; however, the vessel's roll is exaggerated at the IWTP, making it physically exhausting for a diver to remain there. It is also reasonably common for divers to report nausea (seasickness). The diver is always fighting the DAF.

- It should be noted that during all diving operations, diving organisations do not comply with the IOGP Life Saving Rules:
  - Safe Mechanical Lifting - *"I never walk under a suspended load".* Divers are often within the drop cone of a deployment device, the guideweight, and the IWTP, all of which are suspended loads. In closed bell diving operations, it is common for a 'place of safety' to be under the suspended load, the bell.
  - Line of Fire - *"I position myself to avoid moving objects".* The deployment device and IWTP are constantly moving. Divers must time their entry and exit to avoid being struck by a moving object. This can be particularly challenging during egress and when accessing the IWTP, given its additional DAF.

IWTP Lifting Appliance and Plan

Industry-recommended practices:

> *This [the IWTP] can be suspended from a cherry picker, crane or working platform on the vessel ... It is preferred but not essential that the IWTP be deployed on a man-riding lifting device."*

Industry-recommended practices permit the use of a non-man-riding lifting appliance to suspend the IWTP for both active and passive tending; however, a man-riding lifting device offers safety advantages during operational and rescue dives.

- The project risk assessment will conclude that, in all cases, it is safer to use a man-riding lifting appliance. Using a non-man-riding appliance is not ALARP. The lifting appliance used to deploy the IWTP should be tested, certified and up to date for man-riding:
  - A man-riding lifting appliance is examined more frequently than a non-man-riding appliance. A man-riding lifting appliance should be subjected to a thorough examination at intervals of no more than 6 months, compared with a non-man-riding appliance every 12 months. Although the IWTP is in water, it is safety-critical that the lifting appliance does not mechanically fail.
    - Man-riding lifting appliances have stringent braking requirements.
    - A DESIGN-compliant diving deployment device with divers on board is treated as a routine lift; all other man-riding lifts are non-routine. All subsea lifts are blind lifts. The IWTP lift plan should comply with the requirements for a non-routine, blind personnel lift.
    - A diver's deployment device has stringent braking requirements and a guideweight that serves as a secondary device if the deployment device's wire were to fail. An IWTP does not have a guideweight, and a non-man-riding lifting device won't have the same brake requirements as a man-riding appliance.
  - The IWTP is in water, but it still supports divers and their umbilicals. Lifting regulations and codes don't exempt man-riding just because it's happening underwater.
    - Although an 'in-water' fall is of low consequence, a failure of the lifting apparatus, its wire, hook or rigging at the attachment point on the IWTP could be fatal to the diver if the IWTP descends uncontrollably. The umbilical passing through it will take the diver down as well until the diver impacts the IWTP. IOGP Life Saving Rules, Safe Mechanical Lifting: "*organisations should provide equipment which is designed and certified specifically for lifting people*". There is no exemption for divers.

- There may be life-threatening circumstances during a rescue when the IP must be recovered directly from the IWTP to the deck. This will only be achievable using a man-riding lifting appliance.
  - During the planning stage of the project, the lifting of the IWTP directly onto the deck should be risk-assessed and planned. (This would only be achievable using a suitable basket.)

Type of IWTP

Industry-recommended practices:

> *"An IWTP can be located mid-water or near the seabed and is a separate device, such as a basket or hoop, deployed from the vessel, in addition to the deployment device. This can be suspended from a cherry picker, crane or working platform on the vessel.*

Industry-recommended practices permit the use of a hoop as an IWTP for both active and passive tending; however, a hoop has safety advantages and disadvantages in operational and rescue dives.

Based on lessons learned and experience, the following recommendations are considered safe working practices and should mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

IWTP Basket (Photograph 97)

Industry-recommended practices permit the use of a basket as an IWTP for both active and passive tending; however, a basket has safety advantages and disadvantages during operational and rescue dives. Based on lessons learned and experience, the following recommendations are considered safe working practices and should mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- A basket allows a tender, during active tending to secure themselves against the vessel's roll and subsequent heave and currents.
  - A basket should always be used for active tending diving operations.
- A basket provides a rescue diver with a means to secure an IP during a double rescue.
- A basket can provide a tender and the working diver with a place of safety during lifting operations.
- Although not an industry-recommended practice, a basket allows for emergency cylinders, providing a rescue diver with a potential gas supply for an IP. This is particularly advantageous during a double rescue.
  - If a basket is used as an IWTP, it should be equipped the same way as when used as a deployment device.
    - This provides rescue options, such as securing an IP in the basket using an air supply from the basket-carried reserve, while the standby diver rescues the second IP.
    - An umbilical cutting tool should be in the IWTP basket.
  - During an incapacitated diver rescue, an IWTP basket can be slewed to the deployment device with the IP and the rescue diver inside, reducing distance and time.
- A basket used as an IWTP should be purposely designed and built as an IWTP.
  - An IWTP basket does not need to fit within a LARS, so there are no size or weight restrictions.
  - There should be full access and egress at both ends, with secure gates.
  - As there is no guideweight, there is no requirement for guidewire guides, etc., that add fouling hazards.
  - The ITWP basket should not have a single lift point but rather a four-legged bridle at each corner.
  - Consideration should be given to the SWL of the lifting points and rigging in light of the additional DAF.

IWTP Hoop (Photograph 95)

- A hoop doesn't allow a tender diver, during active tending, anywhere to hold the hoop or against currents.
- A hoop doesn't provide a tender or the working diver with a place of safety during lifting operations.
- With a hoop, there is no option to recover an IP directly from the IWTP.
- Although not an industry-recommended practice, a hoop doesn't allow for emergency cylinders, which would provide a potential gas supply for an IP. This is particularly advantageous during a double rescue.
- A hoop can be designed and manufactured to be heavier than a basket; combined with a lower surface area, it can help reduce deviation from the vertical during vessel moves and in current.
- It is very difficult for a bellman or a surface standby diver to stand on an IWTP hoop and haul up on either an IP's umbilical or the rescue diver's umbilical because of the hoop's movement. Rescue from the IWTP is a step in the hierarchy of rescue.
- A hoop should not be used for active tending and has disadvantages in a rescue compared with a basket. It should be used only for passive tending, following a robust risk assessment that includes the type of deployment device used.

Deployment Device to IWTP Swim Line, Setup and Length

Industry-recommended practices:

> *"When using the IWTP, the swim lines should have sufficient tensile strength and be durable material, such as 6 mm Ø wire rope, 18 mm polypropylene rope or climbing rope."*
>
> *"If there is only one Working Diver, then there will only need to be one swim line."*

Consideration should be given to the material the swim line is made of, how and where it is connected, and how divers' umbilicals are secured to it. Based on lessons learned and experience, the following recommendations are considered safe working practices and should mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify the following:

- Swimline between the deployment device and IWTP is safety-critical and therefore should:
  - Be made of appropriately sized, corrosion-resistant wire, with hard eyes at each end.
    - Ropes are not certified.
    - Ropes require splices or knots. Both are uncertified and lack an auditable standard.
    - Ropes and standard-size karabiners are a poor combination. In all cases, a scaffolder's safety hook should be used on the swim line. These travel well and are easy to operate with one hand. (Photograph 13.1)
    - The hard eyes should be fitted with stainless-steel safety locking devices, such as appropriately sized karabiners. The karabiners should be captive, included in the PMS, and counted in the overall swimline length calculation.
    - Wire swimlines are negatively buoyant. If, during the rescue, the IWTP is slewed into the deployment device with the IP and the rescue diver, the swimlines will sink and will not pose an entanglement hazard to the divers or the deployment device.
  - The wire length shall be taken from the vessel-specific, approved extended umbilical drawing.
  - A swim line should be established between the IWTP and the work site. This swim line will be a rope with an engineered weak link. To ensure the engineered weak link breaks as designed, the IWTP swim line deployment device must be made of wire (stronger than the weak link and the worksite swim line). If the vessel moves outside the planned footprint, the load path runs from the deployment device to the engineered weak link via both swim lines and the IWTP.

- There should always be two swim lines in place, regardless of the number of working divers.
  - At a minimum, this provides the standby diver or the rescue diver with a separate swimline
  - Two swimlines add stability to the IWTP.
  - Two swimlines provide 100% redundancy if one swimline fails or is disconnected.
- The swimlines should be included in the PMS and assigned unique identification numbers.
- The swimline attachment points, usually the deployment device's guideweight and the IWTP, should be approved, tested, and clearly marked.
  - When the swimlines are installed, the IWTP lifting device should be telescoped or knuckled out to provide a lead on the IWTP. This helps maintain tension in the swimlines, which is important during a rescue.
  - If the swim line is secured to the deployment device's guideweight, the guideweight should be as close as possible to the deployment device's underside.
- When a basket is used, the attachment points of the swimlines should be on the centre line, at the same location from which dimension B is measured. This is easy with a hoop, but can be problematic with a basket.
  - Using the centre line removes guesswork when the swimline is connected at the basket entrance (which is where it is usually connected). This is important because the minimum excursion (C_{min}) is B + 2 m. Regardless of the basket used, the swimline length will remain the same.
  - Distance B + 2 m, the safety-critical requirement is to allow a diver, IP, or rescue diver to return directly to the deployment device without disengaging from the swimline.

- During a rescue, it is preferable to bring the IWTP to the deployment device rather than have the rescue diver traverse the swim line with the IP
- If the rescue diver cannot maintain buoyancy while traversing the swimline, the swimlines will sag as the diver's weight draws the IWTP and deployment device together.
  - Bringing the IWTP to the deployment device during a rescue poses potential Line-of-Fire hazards to both equipment and personnel.

Type of Deployment Device Used

Consideration should be given to the type of deployment device used during extended umbilical diving operations, as both the basket and the wetbell have safety advantages and disadvantages in a rescue.

- During extended umbilical diving:
  - The deployment device's guideweight cannot be lowered to assist the rescue diver as it is in normal operations, unless the IWTP is lowered as well.
  - It is unlikely that the vessel can be moved towards the IP to reduce the distance and, therefore, the time of the rescue, because the IWTP and its lifting device are close to an asset.

Based on lessons learned and experience, the following recommendations are considered safe working practices and should mitigate risks to ALARP. Diving organisations' procedures should, where practicable, identify:

Basket

- During passive tending, the surface tender can only recover the divers' umbilicals from the IWTP up to the karabiner on the swimline (distance B). Until the umbilicals are disconnected from the swimline, the surface tender cannot assist the rescue diver. The surface tender is less useful during a rescue than during normal operations when divers are deployed.
- During a rescue involving a second diver already deployed, the surface standby can assist from the working diver's deployment device.
  - The surface standby can deploy to the IWTP and assist both divers by hauling them back. This is much more effective from a basket IWTP than from a hoop.
  - The standby diver can remain at the working deployment device and assist the surface tender in hauling in the rescue divers and the IP's umbilical until the karabiner on the swim line reaches the attachment point. The standby diver then unclips both divers' umbilicals, allowing the surface tender to continue hauling both divers in.

Wetbell

- When using a wetbell, there is no surface support when coming up on umbilicals; therefore, a diver in the wetbell must assist the rescue diver bringing in the IP.
  - When using a wetbell, there should be a bellman, regardless of how the onboard gas is activated.
- During a rescue involving a second diver already deployed, the bellman can assist in the rescue:
  - The bellman can deploy to the IWTP and assist both divers by hauling them back. This is much more effective from a basket IWTP than a hoop.
- The bellman should have enough umbilical available to reach the IWTP without releasing all of their umbilical.
  - During 2-man and 3-man wetbell dives, the bellman should initially deploy to the IWTP to assist in the rescue, either by attempting to recover the IP directly or by assisting the rescue diver in returning the IP to the IWTP. The supervisor should know the severity of the incident and whether all of the bellman's umbilical is initially released.
- When using a wetbell with a bellman during an extended umbilical diving operation, the surface contingency standby diver should be on immediate readiness. A rescue during an extended umbilical operation will take longer than a rescue during normal operations.
  - During a two-man dive, the bellman will leave the bell and attempt to recover the IP from the IWTP, in accordance with the hierarchy of rescue. If unsuccessful, the bellman will deploy to rescue the IP. No one in the bell can come up on either umbilical or assist them back to the IWTP or the bell.
  - During a three-man dive, the bellman will leave the bell to assist the rescue diver with the IP from the IWTP (unless it's a double rescue). There is no one in the bell to come up the umbilicals.
  - In all bell runs, all umbilicals should be safely racked before leaving the bottom. Racking umbilicals when there is an IP and a rescue diver in the wetbell is very challenging and time-consuming. Therefore, the surface contingency standby should be at immediate readiness and deployed immediately to take over the bellman's role.

Divers Umbilicals

Further consideration is needed for divers' umbilical properties during extended umbilical diving operations. With additional umbilical deployed, additional swimlines, and an IWTP, there are more hazards of umbilical entanglement and fouling at the worksite.

A rescue when using extended umbilical techniques is slower and more complex than a rescue during a standard diving operation.

The choice of umbilical can play a large part in the rescue:

- During a wetbell dive, there is potential for two deployment devices, including an IWTP, all affected by vessel heave. There will be up to four divers, each with potentially different inherent umbilical properties, all influenced by current, wave action and vessel movement. When deployed by wetbell, there is no surface tender to take up slack in the umbilical. The bellman might be at the IWTP assisting with the rescue, so there will be slack umbilical around the IWTP.
    - A risk assessment should further assess the project's assessment of the type of umbilicals and reassess for suitability for a rescue. The type of umbilical assessed as most suitable for the project might not be the best choice during a rescue.
- When deployed by basket, a surface tender retrieves the slack umbilical. Although the surface standby diver might be at the IWTP assisting with the rescue, all slack umbilical will be retrieved once the umbilical is disconnected from the swimline.
- When deployed by wetbell, it is standard safe working practice to ensure all umbilicals are stowed before leaving the bottom. It is very unlikely that the bellman's umbilical will be stowed before ascent. If the IP is in a poor state, the supervisor will likely conduct a dynamic risk assessment to determine the urgency of treatment and the likelihood of umbilical fouling.
    - It may be beneficial for the bellman's umbilical to be negatively buoyant to reduce the risk of entanglement during ascent.

17.2 Extended Umbilical System Set-Up to Achieve ALARP Risk Mitigation

This section does not seek to repeat the other areas of this report. The recommendations apply only to the additional equipment used during extended umbilical operations.

It is assumed that the diving organisation complies with industry-recommended practices.

If the diving risk assessment determines that the safest and most appropriate technique for manned diving is surface-supplied diving with extended umbilicals, the following equipment and methodology at the worksite may be considered ALARP:

The Working Diver (Basket and Wetbell)

1 Dressed and equipped as described elsewhere in this report

The Standby Diver (Basket and Non-Bellman Wetbell)

1 Dressed and equipped as described elsewhere in this report

Surface Contingency Standby Diver (Wetbell Operation with a Bellman)

1 To be immediately ready to deploy

2 Dressed and equipped as described elsewhere in this report

IWTP Lifting Appliance

1 Certified, in-date man-riding appliance.

IWTP

1 Basket to be used for passive and active tending.

2 Basket equipped the same as if it were a divers deployment device (Emergency cylinders, Cutting tool etc)

3 Beacon fitted to IWTP

4 Certified strongpoints in the centre of basket for the swimline attachment. Marked accordingly(D1, D2)

Extended Umbilical Swimline

1 2x Wire swimline with hard eyes and screw gated karabiners. All in the PMS

2 Divers umbilicals to be secured to the swim line with scaffolders safety hooks

Divers Deployment Device: Basket and Wetbell

1 Equipped as described elsewhere in this report

2 Tested eyes on guideweight for swim line attachment. Marked accordingly (D1, D2)

Standby Divers Deployment Device

1 Equipped as described elsewhere in this report

Divers Umbilicals

1 All umbilicals should be re-risk assessed for their inherent properties in regard diver rescue. What is deemed the be umbilical properties for the diving operation might not be the best properties during a rescue.

17.3 Extended Umbilical Rescue Procedures

Suitable procedures should be in place, based on the particular circumstances of the diving operation, to permit the rescue of a diver in an emergency: one diver deployed, two divers deployed, and the standby diver's rescue.

Hierarchy of Rescue

The diving organisation establishes procedures to identify a 'hierarchy of rescue' for all diving techniques. Nearly all diving organisations limit procedures to a surface standby diver deploying and conducting the rescue, which is the least desirable option because it risks exposing another diver to harm.

The rescue hierarchy when a diver or divers are using extended umbilicals is the same as in standard diving operations, with the addition that the other diver in the water may be the diver carrying out active tending. In this case, the tender should attempt a rescue from the IWTP by coming up the IP's umbilical. If this is unsuccessful, deploy and carry out the rescue.

Extended Umbilical Drill, Exercise and Rescue Procedures

Industry-recommended practices:

> *"Diver recovery exercises should be undertaken so that one diver recovers the other from the full extent of their umbilical back to the basket or bell."*
>
> *"There should be site-specific procedures for a diver rescue in which all divers are deployed and recovered using a deployment device, with both active and passive tending, and that specify the type of IWTP to be used."*
>
> *"Suitable procedures should be in place, based on the particular circumstances of the diving operation, to permit recovery of a diver in an emergency."*

Exercise and diver-rescue procedures should be in place at the work site for the applicable recovery methods, and should include:

- Type of diver deployment device. (Basket or wetbell)
- Type of standby diver deployment device and its capacity (Usually a basket; Capacity usually 2)
- Type of IWTP.(Basket or hoop)
- Method of tending. (Passive or Active).
- Number of divers (2, 3 or 4)
- Capacity of DDC
- Number of Supervisors (1 or 2)
- Type of lifting appliance supporting the IWTP and its properties (man riding, non-man riding, AHC)

Industry requires that a minimum length of diver umbilical be deployed, Distance B +2 metres.

Industry-recommended practices:

> *"Distance B + 2 m is safety-critical to allow a diver, IP, or rescue diver to return directly to the deployment device without disengaging from the swimline."*
>
> *"This principle provides for the diver to return to the deployment device in an emergency or in poor visibility, and if they miss passing through the IWTP, they can still reach the safe haven of the deployment device without having to pass back through the IWTP or unclip their karabiner from the swim line."*

There should be a risk assessment, a documented drill and exercise, and a procedure for this scenario, particularly the procedure for safely recovering the deployment device with the divers' umbilical through the IWTP.

Note: The diver will always find the IWTP even in poor visibility—their umbilical passes through it.
Only a wetbell is a 'safe haven' as it has an air-filled dome. A basket is not a safe haven.

APPENDIX 1 INFORMATIVE REFERENCES/RELATED DOCUMENTS

ADCI	Association of Diving Contractors International. International consensus standards for commercial diving and underwater operations Ed 6.3
EN15333	Respiratory equipment - Open-circuit umbilical supplied compressed gas diving apparatus
EN16805	Diving equipment – Diving mask – Requirements and test methods
EN166	European standard for all types of personal eye protection
IMCA CPD	Module ADS 25 Guidance on Surface Swimmers
IMCA CPD	Module ADS 69 Umbilical Management
IMCA	Safety Flash 15-21
IMCA	Safety Flash 22-12
IMCA D14	IMCA International Code of Practice for Offshore Diving
IMCA D15	Guidance on Mobile/Portable/Daughtercraft Surface Supplied Systems
IMCA D22	Guidance for Diving Supervisors
IMCA D23	DESIGN for Surface Orientated (Air) Diving Systems
IMCA D40	DESIGN for mobile/portable surface supplied systems
IMCA D66	Guidance on Surface Swimmers
IMCA D67	The Effects of Underwater Currents on Divers' Performance and Safety
IMCA D78	Guidance on Diving Umbilical Management
IMCA D82	Guidance on Diving Operations in Support of Underwater Ship Husbandry
IMCA HSS033	Guidance on Occupational Health Programmes for Marine Contractors
IMO	International Code Of Safety For Diving Operations, 2023
IOGP 411	Recommended Practices for Diving Operations
KMDSI	Kirby Morgan
NORSOK U100	Manned underwater operations
U.S.N	Navy Diving Manual Revision 7
U.S.N	Navy Air Decompression Table Handbook Revision September 1995
RR451	Harness suspension: review and evaluation of existing information
RR1073	The provision of breathing gas to divers in emergency situations
RR762	Diving helmet impact testing to EN397
RR424	Performance of diving equipment
4 Seas Safety Ltd	https://www.academia.edu/37527396/Safety_Observations_Suitability_of_Commercial_Divers_Harnesses_2008_
4 Seas Safety Ltd	https://www.academia.edu/122357096/Commercial_Divers_Attachment_Method_to_their_Excursion_Umbilical_2024_update_
4 Seas Safety Ltd	https://www.academia.edu/122524430/Observation_Report_CCTV_MONITORING_and_RECORDING_during_OFFSHORE_DIVING_OPERATIONS_2024_

APPENDIX 2 PHOTOGRAPHS

The Surface Standby Divers Breathing Apparatus

Photograph 1	Photograph 2	Photograph 3	Photograph 4
Ridged diving helmet offering the best head protection: EN397. Can be used in any subsea situation and condition. Head & ears remain dry	BandMask. Soft neoprene and offers no head protection. Cannot be worn in contaminated or very cold waters for rescue. Hard shell 'protection' available. Head and ears get wet.	Hard shell that gives 'bump' protection. This attaches to the BandMask. This and other bump protection do not comply with EN397.	Typical FFM. No head protection, however various hard shells are available Head and ears get wet. Shouldn't be used where there is risk of contamination/infection or in very cold water.
Author 	Author 	Author 	Author 

The Rescue Diver and The Working Diver's Buoyancy

Photograph 5	Photograph 6	Photograph 7	Photograph 8
Typical commercial diving variable volume drysuit. This can be used for diver buoyancy. Note: No exhaust valves installed in lower limbs to prevent inversion.	Typical diving buoyancy compensator or 'STAB Jacket' (stabilisation). Note upper and lower exhaust valves.	Ankle exhaust on drysuit that helps prevent diver inversion.	LP port should only be used for a variable volume dry suit and not a buoyancy compensator KMDSI ⚠ WARNING The side block inflator port is intended for dry suits only. When using the side block low-pressure inflator port, only good quality hoses and fittings should be used and must incorporate an in-line flow restrictor to reduce gas flow in the event of hose failure. Any hose or fitting failure in this arrangement will subject the diver to a decreased air supply. Do not use the side block inflator port for any purpose other than attaching a dry suit hose. 
Northern Divers 	apdiving 	Apollo 	

The Standby Divers In-Water Thermal Balance

Photograph 9

Typical variable volume drysuit. If the working diver is wearing a hotwater suit serious consideration should be given to the standby wearing a dry suit in case of hotwater malfunction.

NorthernDivers

Photograph 10

If a drysuit is worn, the DPP should state the type of thermal protection required under the drysuit to maintain thermal balance in case of power failure.

NorthernDivers

Photographs 11 & 12

Typical hotwater suit and neoprene undersuit.

If the project risk assessment indicates that the standby can be kept in thermal balance utilising a hot water suit the standby diver should wear thermal protecting beneath in case of hotwater failure or donating his hotwater to an hypothermic incapacitated diver during rescue.

Northern Divers

Northern Divers

The Divers Rescue Lanyard

Photograph 13

Lanyard should be easily removeable with a karabiner both ends.

Karabiners should be screw-gate locking type.

Author

Photograph 13.1 (Above)

The standby divers rescue lanyard should be fitted with a scaffolders safety hook. These have a wider gate and easy to connect to thick ropes

Photograph14

Prior to recovery to the deployment device to the surface the lanyard can be used to keep the IP up-right during the recovery. If the IP is recovered from the harness 'hip' attachment it is likely the IP will invert

The Divers Rescue Harness

Photograph 15

Example of a divers rescue harness. This harness is donned first and the emergency reserve harness donned on top. The harness is EN15333 for lifting

Photograph 16

Examples of emergency reserve harness/jackets. These should be donned over a rescue harness. Some personal reserve harnesses are rated for lifting and comply with international standards, however they should have crotch straps fitted and used.

SMP

NorthernDivers

Poor condition no straps

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Use of the Pneumo as an Emergency Breathing Supply

Photograph 17

A well-dressed working diver with good pneumo management.

Adequate length for self-rescue and as a rescue diver.

Photograph 18 & 19

18.Pneumo hose with end fitting on a buoyancy jacket. If the pneumo is potentially to be used as an emergency breathing supply inserted under the neck dam, the end fitting should be removed.(It should also be confirmed that gas can flow through the end fitting when not connected)

19. A pneumo that isn't used in a buoyancy aid should have the end fitting removed or extended with an appropriate hose length.

The extension shown: red tape indicating distance inserted under the neck seal.

Author

Author18

Author 19

Use of Location Devices During Diving Operations

Photograph 20

Diver carried beacon:

A beacon should be considered as SCE not as a 'nice to have'.

Photograph 21

Diving organisations risk assessment should consider the type and positioning of any diver carried beacon. An unconscious diver will usually be in a head down position and rolled on the back due to the emergency reserve and helmet. This can be exaggerated if the diver is wearing a variable volume dry suit.

Author

TikTok

Author

Use of an ROV During a Rescue

Photograph 22 & 23

Diver being transported on a WROV. This diver is stood on the side and is holding on against the force of water created by the WROV speed. Ideally the tool tray would be extended, manipulator isolated and the diver stood at the front on the tray in view. If used during a recovery it should be practiced.

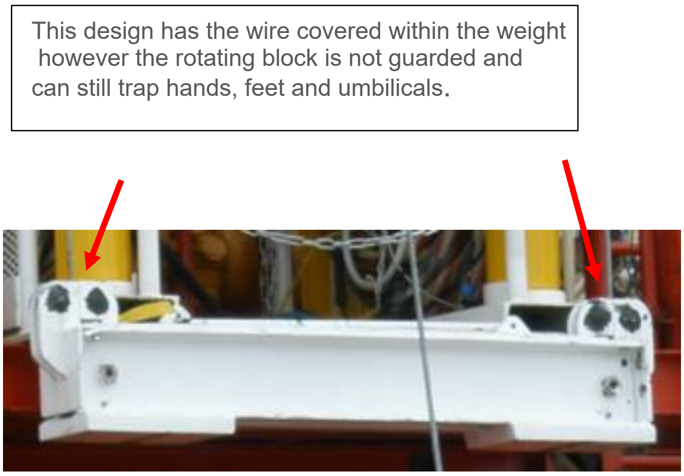
Use of the Guide Weight During a Rescue

Photograph 24

Diving organisations often state within rescue procedures that the guide weight is lowered and the rescue diver can use it to ascend with the incapacitated diver .Many guide weights are not guarded against line of fire from moving and rotating parts. These offer significant line of fire hazards to the diver and their umbilical.

Author

Author



Use of a Diver's Weak-link

Photograph 25

Typical weak link used by divers. These are designed to release at or before 70kg force is applied. The break point is 'Velcro' on the strap. The snap shackle is for diver use.

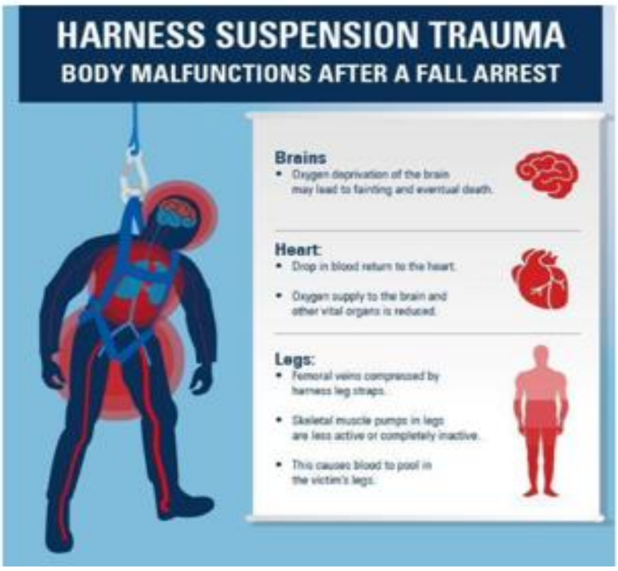
Author

Potential Suspension Trauma During a Diver Rescue

Photograph 26

IMCA recognise the dangers of suspension trauma. A diver being lifted by their harness can induce suspension trauma.

IMCA Safety Flash 22-21

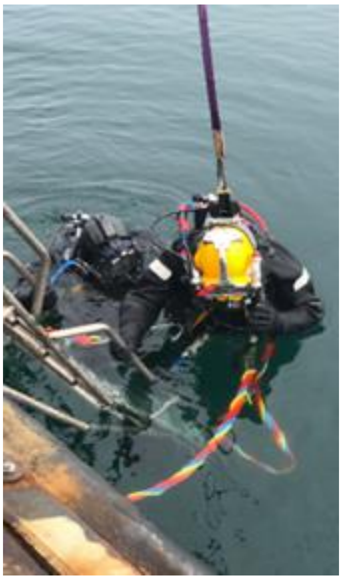


Photograph 27

Studies on the mechanisms of suspension trauma don't include a person wearing a bailout and helmet.

Internet

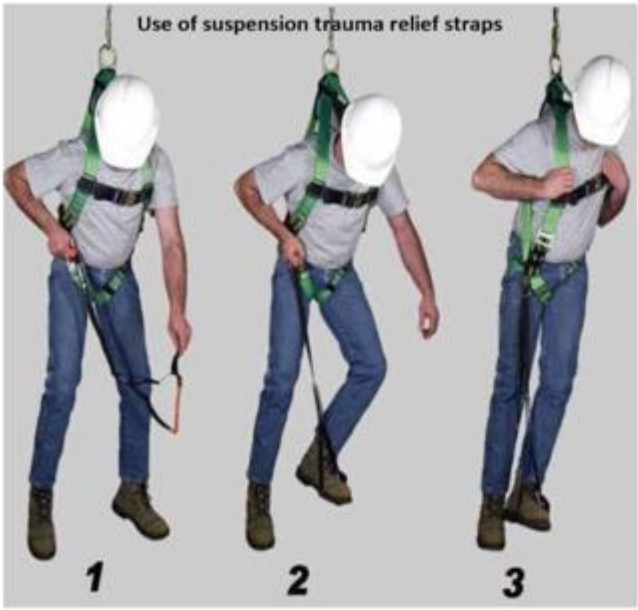
Author



Photograph 28

When someone is in suspension there should be suspension trauma relief straps available including during drills.

IMCA Safety Flash 22-21



Photograph 29

A Jasons cradle or rescue stretcher removes the possibility of suspension trauma and would in many cases utilise the same davit. The IP can then, if required, be lifted to shore or another vessel with minimum casualty handling.

Survival Systems International

Launch And Recovery System

Photograph 30

Fixed diving system on a DSV. Two baskets with shared A-frame. Baskets are not independent. If a guide weight or basket fouled a subsea asset during a degraded DP incident, there is a potential that the common A-Frame would be damaged. If damaged there is potential that baskets cannot be deployed or recovered.

Author

Photograph 31

Mutually independent LARS temporally installed on a vessel.

Author

Photograph 32

Independent LARS and basket temporally installed on a platform.

Good diver protection

Note the large seat and single cylinder.
Note poor access at rear of basket

Author

Photograph 33

Independent LARS and basket temporally installed on a DSV. Note the poor cage protection for the divers and two cylinders that are poorly located for balance and egress and access.

Author

Photograph 34

Deployment devices should have safety devices such as limit switch ('chandelier) fitted to prevent damage (over load) during recovery and luffing the A-frame. These are not commonly installed. They help mitigate human error.

(These are NORSOK & DnV requirements)

Author

Launch And Recovery System (Continued)

Photograph 35 & 36

Photographs show a poor example of LARS mobilisation. Both LARS and basket protrude from the vessel side.

If there was a DP incident and the vessel impacted a surface structure both LARS would be damaged any divers deployed could not be recovered nor could a standby be deployed..

Author

Author

Basket and Basket Carried Emergency Reserve

Photograph 37

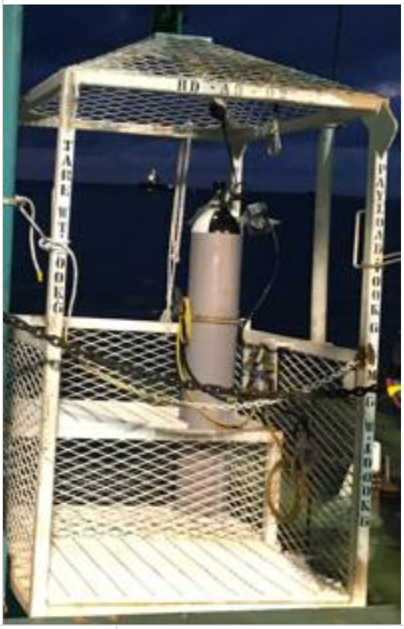
Two emergency cylinders installed diagonally. This method balances the basket CoG and gives each diver room to access a cylinder. When installed in the corners the cylinders block access to diver handholds. Note the poor fall protection around the LARS.

Author

Photograph 38

Single cylinder installed in a corner. Note the seat and floor area it uses. Note cylinder 1st stage not protected Note Chains to prevent fall from deck are inadequate Note Chain used to prevent diver from falling from basket

Author



Photograph 39

Two cylinders placed opposite each other just off centre.

Note the lack of diver protection

Note the lack of cylinder 1st stage protection

Note Good double gate system both sides of the basket

Author

Photograph 40

Two cylinders, both placed at the diver egress access area reducing the aperture a diver needs to bring in an incapacitated diver.

Note the lack of protection on the cylinder 1st stage

Author

Photograph 41

Two cylinders side by side. This set up will upset the basket CoG This set up limits egress and access when recovering an incapacitated diver.

Note the lack of protection on the cylinder 1st stage

Note the good mesh protection basket design.

Author

Basket and Basket Carried Emergency Reserve (Continued)

Photograph 42

Single cylinder in a corner

Note lack of protection for the 1st stage

Note overhand knot in LP hose and lack of security/protection

Author

Photograph 43

Note the good basket mesh protectio

Note how the 1st stage is poorly positioned

Author

Photograph 44

Note the good basket mesh protection.

Note the cut-away seat to allow the cylinder to be located.

Note how much floor space the seat takes up.

Author

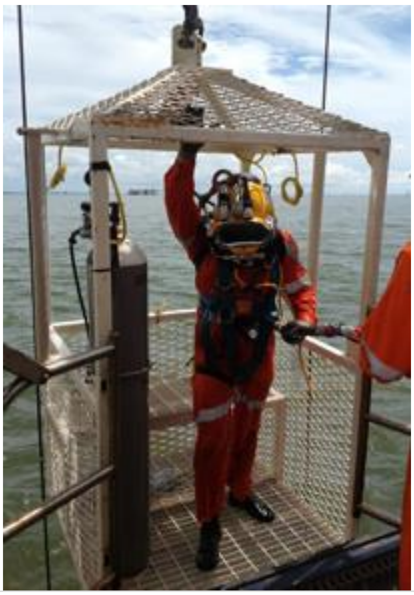
Photograph 45

Single cylinder. Note lack of 1st stage protection, lack of full side protection and poor fall protection.

Note how much floor space the seat takes up.

Note no basket to basket swim line.

Author



Photograph 46

Well balanced basket with reasonable access and egress. Note lack of full side protection, lack of cylinder valve protection and poor fall protection barrier.

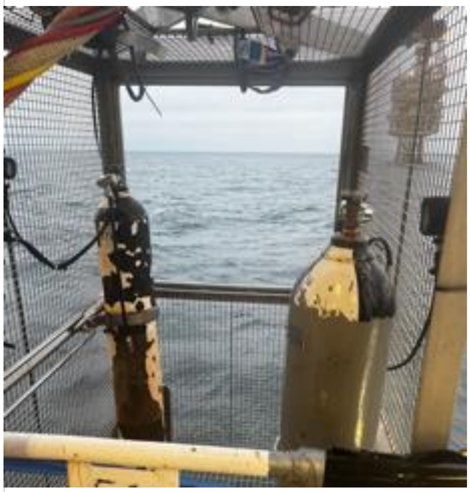
Note: Basket to basket swim-line.

Author

Photograph 47

Example of a well-designed dive basket. Divers are well protected, two emergency cylinders, well balanced, large opening for egress and access. The emergency cylinders are fitted with a QC fitting for connection to divers LP personal reserve hose and straight to the BA.

Author



Basket and Basket Carried Emergency Reserve (Continued)

Photograph 48

Poor set up of basket emergency reserve open ended hose (Green hose). The hose isn't immediately ready. Gas is put on line opening the ¼ turn valve.

Author

Photograph 49

Poor set up of basket emergency reserve open ended hose. The hose is not ready for immediate insertion into a divers BA.

Good example of the length and set up of the divers pneumo.

Author

Photograph 50

Excellent example of basket emergency reserve; Fittings protected, LP hose with QC fitting for connection straight in to divers personal reserve LP hose.

Open ended hose with in-line valve if required.

Author

Photograph 51

Author

INTENTIONALLY BLANK

Photograph 52

The emegency reserve can be put on line to the divers LP personal gas reserve via a QC fitting. The diver can continue to breath with the BA still donned and maintain communication if available.

The LP hose is of adequate length to allow the IP to be seated in the W position

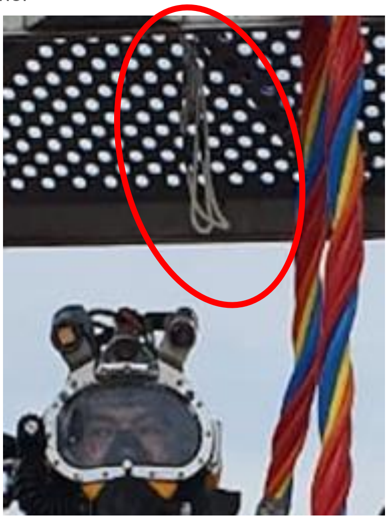
Author

Securing an Incapacitated Diver in a Basket

Photograph 53

Diver securing point in a basket. Industry guidance doesn't state how or where the diver is secured however by custom and practice the diver is usually secured by a rope and clip from the basket roof.

Author



Photograph 54

Attached to the rescue harness thoral D-ring. This is usually achieved by a spreader bar or two ropes. This potentially keeps the airway open however it might also put excessive weight on the neck.

Author

Photograph 55

Attached to the rescue harness dorsal D-ring.

The dorsal position brings the head forward and may obstruct the airway.

Author

Photograph 56

Diver rescue drill showing the IP held by two harness thoral D-rings without a spreader bar. This draws the harness together and restricts breathing.

The rescue diver should be supporting the IPs head. There is a potential both divers could be injured coming through the splash zone.

TikTok

Photograph 57

The 'W' position. Sitting will ease the strain on the heart. Sitting an IP on the floor they are less likely to hurt themselves if they collapse. When in a deployment device the rescue diver can easily proect them against injury when close to and transitting through the splash zone. The rescue diver can also give support to the IPs head and help maintain an airway

Internet

SRP / Daughter Craft Diving

Photograph 58

Basic SRP set up in a RIB.

Diver deployed by ladder and incapacitated diver recovered by Jason's cradle.

Author

Photograph 59

The basic SRP system with three-46 litre cylinders with one working diver and one standby diver. (Note that the panel and comm's box are not secured)

Author

Photograph 60

Purpose built daughter craft with SRP system.
The divers are deployed by ladder and an incapacitated diver recovered by davit.

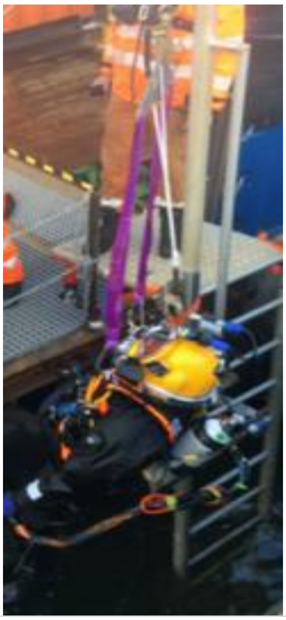
Author

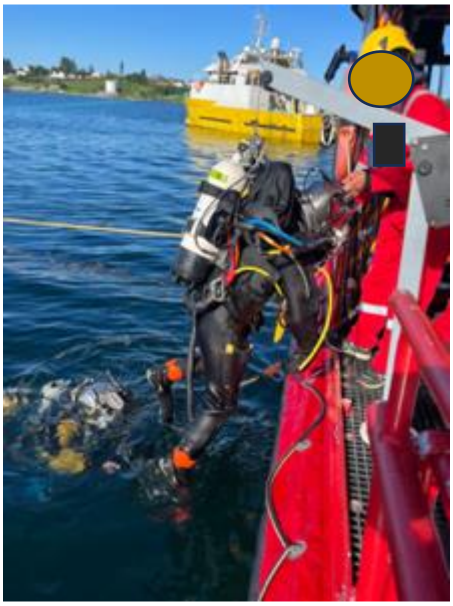
Photograph 61

This daughter craft system has twelve 46 litre cylinders with two working divers and one standby diver. The divers use nitrox and the standby is on air.

Author

SRP/Daughter Craft Rescue

Photograph 62	Photograph 63	Photograph 64
'Chest Spreader'. Used for lifting an incapacitated diver on two points of contact on the divers rescue harness.	Chest spreader used for thoral lift. Attached to front D-rings. This generally puts the divers head back and may assist in maintaining an open airway . This angle of recovery can make casualty handling on deck easier than a dorsal lift.	Chest spreader used for a dorsal lift. Attached to rear D-rings. This generally puts the divers head forward.
Author 		Author 

Photograph 65	Photograph 66	Photograph 67
Single point dorsal lift	Single point dorsal lift	Single point dorsal lift
Author 	Author 	Author 

SRP/Daughter Craft Rescue (Continued)

Photograph 68

The rescue risk assessment should consider if this type of recovery method is suitable for a fully dressed diver. When the diver is dressed he will not 'roll' within the ladder.

The risk assessment should also consider any strain imposed on the IPs neck during recovery. The neck cannot be supported.

This method might be more suitable for the recovery of an injured surface swimmer. This system might not be appropiate in 'V' hull vessels.

SurvivalSystems International

Photograph 69

If is available consider the use of a rescue stretcher. This will eliminate any suspension trauma risk and put the IP into the prone position.

If utilising this method of recovery the risk assessment should consider the type of personal reserve. A twin set will allow the diver to lay flat with head back and airway open.

This system can be used for the recovery of an incapacitated surface swimmer.

SurvivalSystems International

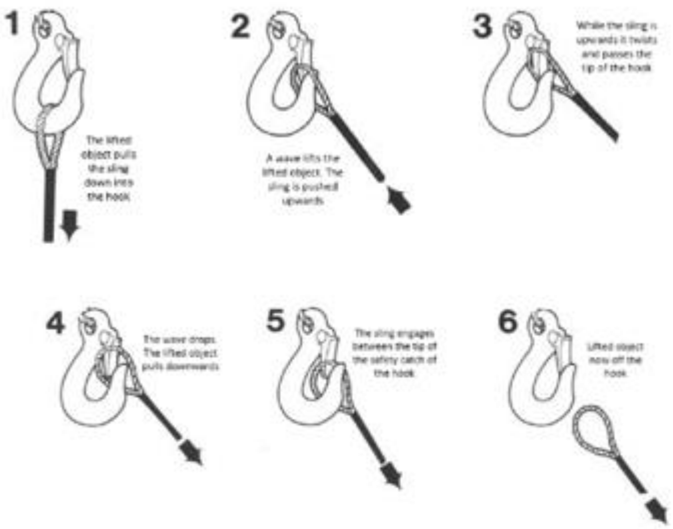
Photograph 70

In all cases where a diver needs to be secured there should be an approved dual-acting locking snap-hook.

This picture shows an intergrated non-locking hook attached to dual-acting locking snap-hook. Unfortunately the non-locking can easily become detatched as illustrated in the diagram.

Author

IMCA D60



Recovery of an Incapacitated Surface Swimmer

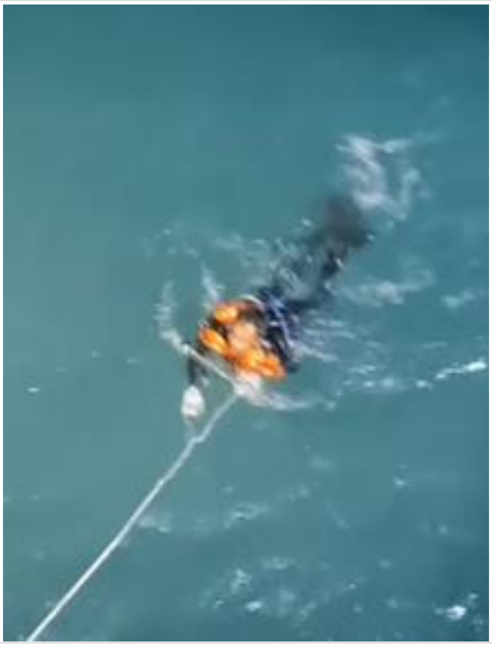
Photograph 72

This screen grab is taken from a video posted on social media.

Ignore the night time operation and lack of head protection. The life line is attached to a D-ring at waist level. The fully conscious swimmer is shown to be struggling keeping his head clear of the water. His buoyancy aid (work vest) is loose and he has become entangled in its straps.

He holds the life line as when pulled from the waist he was brought in sideways. He holds the lifeline to keep his head above water. This routine operation recover could have become a rescue.

TikTok



Photograph 73

The lifeline should be secured on the swimmers harness dorsal D-ring and not the waist/hip.

Ideally the PFD should be of a type that keeps the swimmer on their back if incapacitated.

The knife should have a rounded end or preferably a safety knife.

The swimmer should have a rescue lanyard.

IMCA CPD Unit 3 2021 ADS25

Photograph 74

Any PFD worn for surface swimming operations should offer the highest level of protection for staying afloat and turning an incapacitated IP onto their back / face-up position to protect the airway.
The PFD should have a crotch strap to prevent the PFD riding up and if possible a spray hood.

Billy Pugh

This style of PFD (Work vest) is an inappropriate choice for surface swimming activities.(See photograph 72)

HKO

Photograph 75

MOB recovery cradle. Consideration needs to be given to the swimmers equipment such as their knife and locator fouling the cradle.
Further considerations needs to be given to the rolling of the IP if there are spinal injuries, broken bones an IP with an unprotected airway.
This system might not be appropiate choice of rescue method on a small 'V' hull vessel.

CRQ

Recovery of an Incapacitated Surface Swimmer (Continued)

Photograph 76
Example of poor practices during surface swimmer activieties, apart from the obvious lack of life line, harness and ill fitting buoyancy aid.There is no standby swimmer, no emergency recovey method and no close cover with a boat.(IMCA contractor on an IOGP client site) He is also working under a suspended load in the Line of Fire.

Anonymous

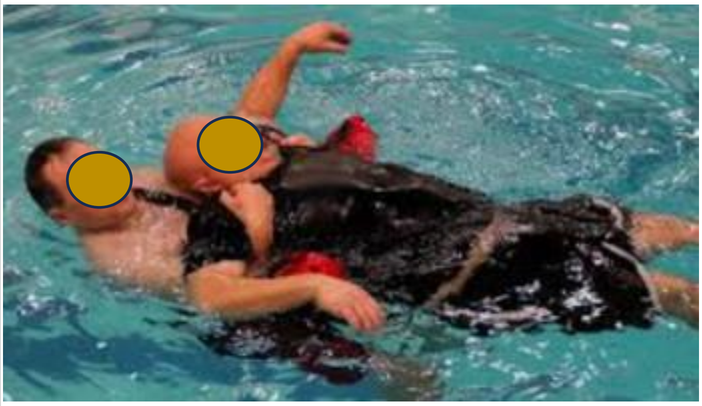
Anonymous

Anonymous

Photograph 77
Photograph demonstrates the way to retrieve a surface swimmer . The rescue swimmer positions himself behind the IP and is attached with a rescue lanyard to the IPs rescue harnes beneath their PFD. Both swimmers are retrieved to the recovery area by the rescue swimmers lifeline. Depending on the initial assessment of the IP the rescue swimmer is in a position to protect the IPs airway and/or stabilise the IPs head.
The rescue swimmer should not try to swim; he should concentrate on ABC whilst the support crew retrieve both swimmers to the recovery area/device.

Lifeguard University

Lifeguard University

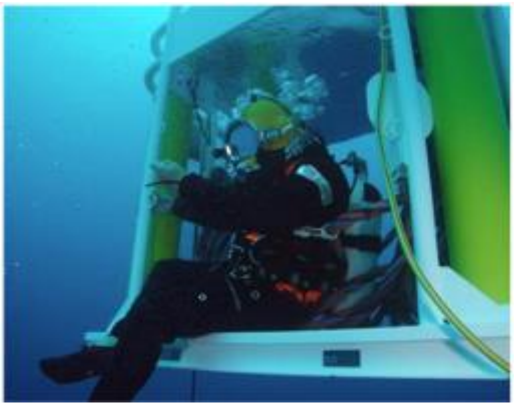


Photograph 77.1
Selection of industry standard knives.
These might not be suitable for swimmer operations due use during wave motion and whilst wearing a PFD.If the task requires a cutting tool its suitability will be assessed and issued for the specific task.

Photograph 77.2
The only foreseeable reason a swimmer will carry a rescue knife is to cut the life line or straps. Therefore an open bladed knife should not be required for personal safety.
A suitably sized and tested safety knife maybe more appropiate.

Internet

Securing an Incapacitated Diver in a Wetbell

22-21  

INTENTIALLY INCOMPETE.

INTENTIONALLY BLANK

77-80 WAITING ON QUALITY PHOTOGRAPHS

Odds & Ends

Photograph 81

Innovative design of fins allowing the standby diver to wear safety boots. The standby diver should have the same PPE as the working diver.

Left fin has 'bungee' laces

Right fin has paracord laces

Author

Photograph 82

The divers buoyancy jacket is inflated from the divers pneumo. In this arrangement the gas goes to the pneumo for depth readings and in case of emergency; it only inflates the buoyancy jacket when the valve is depressed . This diverts the gas from pneumo to jacket.

In an emergency the diver can breathe from the pneumo and still inflate the buoyancy compensator.

Author

Photograph 83

This photograph shows a QC/QD fitting in the divers LP personal gas reserve. The hose is too short to be effective during 'self-rescue' when connecting to a basket carried reserve.

This arrangement seems to be reasonably common in America.

TikTok

Photograph 84

Example of a typical diver rescue drill. The IP has been secured in the basket. However the IP is just stood there, the rescue diver isn't doing anything.

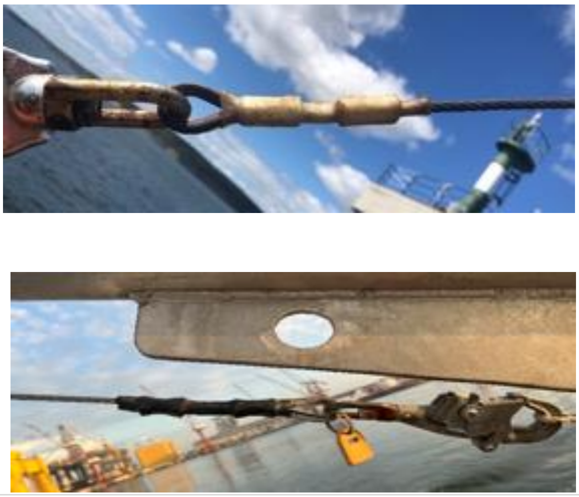
Author

Photograph 85

Examples of diver recovery winch wires that have heat shrink coating. These wires cannot have been visually inspected prior to use.

The heat shrink accelerates corrosion in the covered wire. Davit wires should comply with industry best practices.

Author



Photograph 86

Example of a standby divers umbilical with redundant D-rings from a previous job. These should be removed as they can foul during a rescue.

Author

Odds & Ends (Continued)

Photograph 87

Corrosion resistant hack saw. There should be a tool immediately available capable of cutting a divers umbilical regardless of diving technique

Author

Photograph 88

Corrosion resistant hose cutters. There should be a tool immediately available capable of cutting a divers umbilical regardless of diving technique

When cutting with hose cutters there should be a logical plan in the order of cutting.

Amazon

Photograph 89

FFM that has become detached from its hood. This was always a potential scenario and is probably the reason that baskets carry an emergency supply fitted with a mouth piece and regulator. FFM are now fitted with additional devices; ‘keepers’ that prevent this from occurring, however the mouth piece requirement remains (unless risk assessed as no longer required). If all divers wear a helmet the mouthpiece and regulator will not be required.

Photograph 90

Example of poor diver recovery.

TikTok

TikTok

TikTok

Umbilical Attachment for Safe Lifting of an IP

Photograph 91

Industry recommended practices state that a diver can be recovered by their umbilical.Therefore the umbilical, harness and linkage should be certified and tested and fit for purpose for lifting personnel.

Currently an umbilical binding, D-ring and karabiner are not required to be in the diving organisations PMS.

All lifting gear should be fit for purpose, certified and maintained.

Umbilicals should be secured to the harness by a fleeter (Chinese finger) and certified karabiner. Both should be in the PMS.

www.nova.sub.com

Photograph 92

Author

Photograph 92 continued

Without standards and auditable trail, umbilicals can be connected to divers harnesses by inappropiate, untested and dangerous methods.

Examples below and above show inappropiate bindings, D-rings and karibiner selection. If, in the unlikely event, that a diver is recovered out of the water by their umbilical, and the binding failed it would most likely result in a fatality as the umbilical will pull directly to the divers BA and the divers neck.

Author

Author

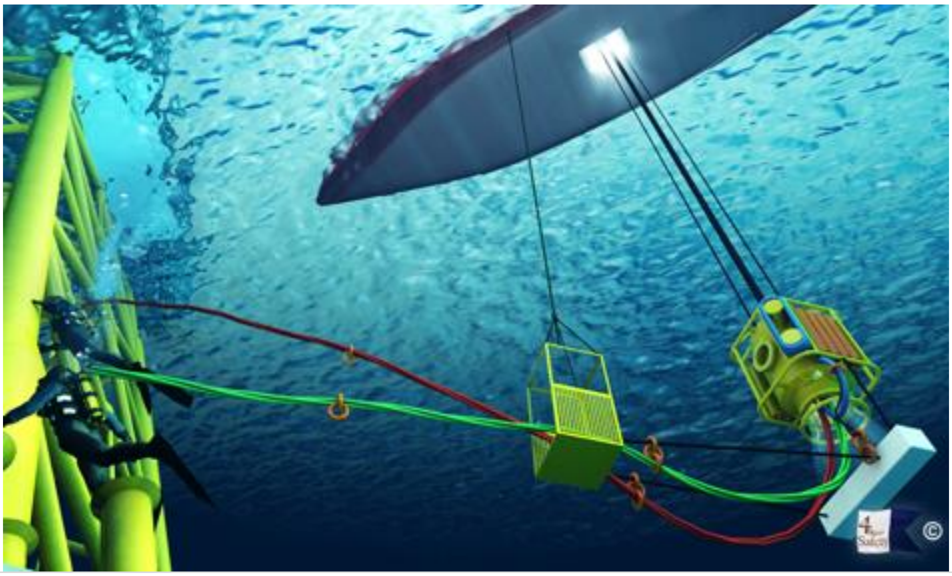
Author

Extended Umbilical Operations

Photograph 94

Diagram showing passive tending using an IWTP basket.

Author



Photograph 95

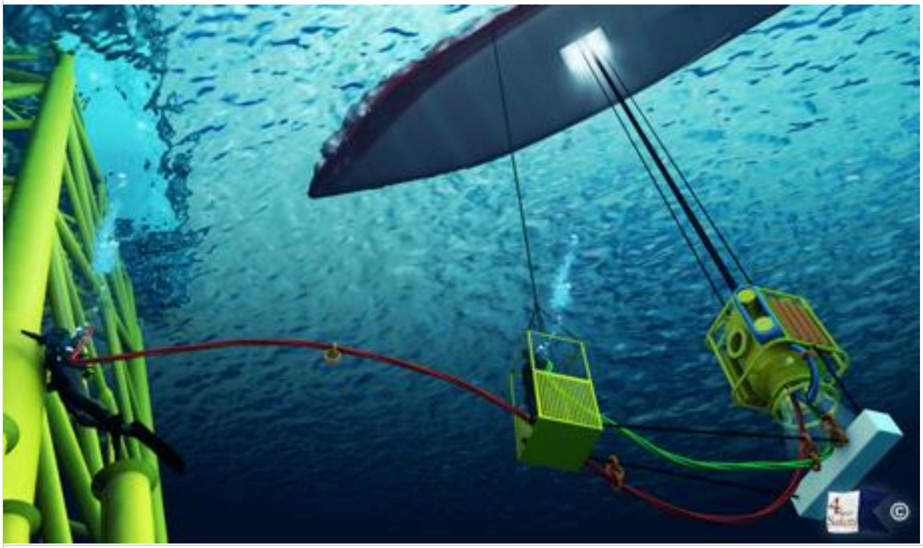
Diagram showing a diver passing through a hoop during passive tending operations.

IMCA D7

Photograph 96

Diagram showing active tending using an IWTP basket.

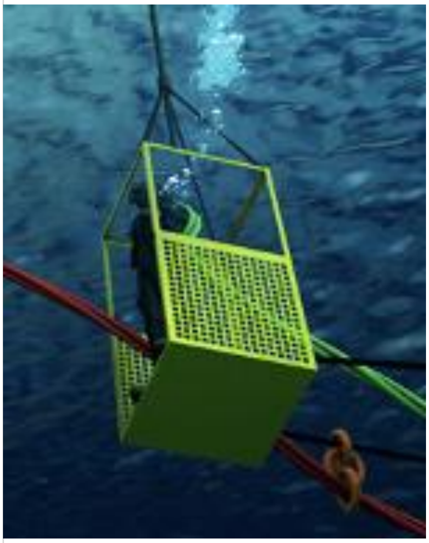
Author



Photograph 97

Diagram showing a diver active tending from an IWTP basket.

Author



APPENDIX 3 CHECKLISTS

Summary of incapacitated diver rescue recommendations that the diving organisation should consider including in their pre-dive checklists.

- The standby diver must wear a neck dam/neck ring assembly that fits and adjusts the helmet neck pad for proper fit during pre-dive checks. This should be a line item within the standby divers' pre-dive checklist.
- The rescue lanyard should be included in the diver's pre-dive checklists.
- The diver's pre-dive checklist should have a line item ensuring that the dorsal D-ring of the rescue harness is exposed and readily available for use.
- The pre-dive checklist should include an umbilical cutting tool. The check confirms that the item is in working order, ready to use, and readily accessible.
- The pre-dive checklist should state that there are four pairs of scissors (or an approved cutting device) and a towel at the worksite in the vicinity of the AED.
- Pre-dive checks should include confirming audio and verbal communications with the working divers and the supervisor, both in cross-talk and direct communication.
- The pre-dive checklist should include confirming that the emergency cylinder valve is open, the hoses are pressurised, and the inline ¼-turn valve is closed (trapping LP air between the QC fitting and ¼ turn valve)

APPENDIX 4 MEDICAL

Summary of incapacitated diver rescue medical-related recommendations that should be reviewed by industry and diving organisation influencers/enablers.

- DMAC001, or the diving organisation's equivalent, to include a line item if the diver was in suspension.
- DMTs (and supervisors) to have training in signs, symptoms and treatment of:
  - Suspension trauma.
  - Circum-rescue collapse
- DMP to advise on and approve methods for:
  - CPR / EAR in a wet bell dome.
  - The safest method of recovering an IP in a deployment device.
  - Suspending a diver during a harness recovery rescue.
  - Treatment for hypothermia and hyperthermia.
  - Diving organisation standardised Immediate Action on arrival at an IP in water.
  - Potential of two IPs and a tender in a two-man two-compartment DDC.
- Industry/Diving Organisation Influencers
  - Add tuff-cut scissors (or similar) to the AED pack
  - Add additional pairs of scissors to Equipment Held in the Diving Bell. One pair is insufficient.