Incapacitated Saturation Diver

Review:

Recovery and Care

Practices and Equipment

Rev 14

EXECUTIVE SUMMARY

Commercial diving is dangerous, and as such, considerable emphasis is rightly placed on the safety of the divers in the water and under pressure.

A company is guilty of corporate manslaughter or corporate homicide if how its activities are managed or organised causes a person's death, and this amounts to a gross breach of a duty of care it owed to the deceased. A substantial element of the breach can be put down to how the senior management managed or organised activities.

The jury in a case is charged with considering *'attitudes, policies, systems or accepted practices within the organisation*' along with health and safety guidance. This makes it clear that it is not just about following the letter of the law but going beyond this to look at the safety culture in an organisation. Also, under *The Act,* a company now faces the peril of failing to learn from corporate intelligence and leaving the possibility that today's near miss will become tomorrow's fatality.

One of the most dangerous situations a diver can face in the water is being injured, incapacitated or unconscious.

This can be the result of many causes, such as:

- Trauma
  - Physical [including electric shock]
  - Mental
- Underlying medical conditions
  - Heart condition
  - Stroke
- Temperature
  - Hypothermia
  - Hyperthermia
- Incorrect breathing gas (or no gas)
  - Anoxia
  - Hypoxia
  - Hyperoxia
  - Hypercapnia
  - Carbon monoxide
- Other
  - Contaminated bell]
  - Chemical contamination
  - Allergic reaction
  - CNS depressors [drugs and alcohol]

Diving contractor's procedures for recovering an unconscious diver are similar and have remained unchanged or unchallenged for several years. Medical knowledge has advanced over this period, and diving companies may not provide their divers with the best advice or duty of care.

If a saturation diver were injured and unable to self-rescue or was incapacitated, he would be rescued by the second diver in the water or the bellman. Ultimately, the incapacitated diver will be recovered and taken to the chamber system via the diving bell and 'recovery hoist' and given the appropriate first aid.

Diving teams should regularly practice diver recovery exercises. It is common that the exercise stops once the casualty is clipped onto the recovery hoist on the guide weight below the diving bell. This leaves out the most critical part of the exercise: what happens after the diver is hoisted into the diving bell and how he is safely managed back into the saturation chamber system.

All diving companies shall have a system and procedure for such eventualities. This is a legal and best practice requirement.

Diving involves people; therefore, the human element will always be there, and thus, the potential for accidents will always be present. Unfortunately, accidents do happen regardless of precautions and control measures taken.

An incapacitated or unconscious diver is a high consequence / low probability event.

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Revision History		
Rev	**Date**	**Change**
0	21st August 2012	JJ
1	7 October 2012	Issued
2	21st April 2013	Typo's and OGP lifting recommendations; Data Protection Act faces blanked out
3	15th August 2013	Added IMCA D24 rev 1 [March 2013] recommendations [from this original report] Added 2 x refs from IMCA D22 in 11.4
4	19th December 2013	Added a few bullets to 11.2 and corrected typo's. Added bullet 23 to recommendations
5	1st February 2014	Added point 24 of recommendations
6	25th April 2014	Added Note about the diver CPR illustrations and their origins Updated D14 and removed RIDDORs references. Added 'ice rescue'
7	8th May 2014	Added 'Note 3 Myers Bradley study Added to recommendations to depth of flood up
8	18th Sept 2014	Corrected Typo's Added recommendations Changed 3/11 to D18 Sorted flow chart on lockout hierarchy
9	13th January 2015	Changed front cover for 4 Seas Safety website
10	10th February 2015	Added comment from OGP478 on side mating bell Added small note in flow charts in 14.1 and 14.2
11	15th March 2015	Added DnV requirement for bell flood up Changed logo's on front cover Added new bell flood up photo
12	May 2022	Review: Changed font Tidied up Removed items where IMCA, IOGP and/or The HSE have implemented change Peer review and changes
13	May 22	Re-issued 13.2 Correction to reference
14	October 2024	Grammarly check

1. INTRODUCTION.

1.1 Terminology

- **Unconscious:** interruption of awareness of oneself and one's surroundings, lack of the ability to notice or respond to stimuli in the environment
- **Injured**: a body wound or shock produced by sudden physical injury
- **Unconscious and not breathing**: respiratory and cardiac arrest
- **Incapacitated:** lacking in or deprived of strength or power 'lying ill or helpless' 'out of action'

Note: The diver may be unconscious, incapacitated, conscious, or semi-conscious. "Incapacitated" will refer to all such categories throughout this report unless explicitly referring to another.

Note that the vast majority of diving companies call their diver rescues unconscious diver recovery, which always leads to CPR in the company's diving/emergency manual. It can be seen that the correct terminology is used; an unconscious diver doesn't require CPR.

A rescue can be broken down into five phases. These five phases are discussed throughout this report:

1. The bellman's pre-lockout actions and available equipment.
2. The bellman's lockout and the second diver's rescue actions.
3. Recovery of the incapacitated diver into the bell.
4. The first aid actions / CPR within the bell.
5. Recovery of the incapacitated diver into the saturation system.

1.2 Aim

This is to alert senior management and diving safety management whose procedures, equipment, recovery to the bell, and care of an incapacitated diver may be out of date and due for a company and diving industry review. Disseminate information on why it is essential to have the proper equipment, training, competencies, and procedures and to ensure appropriate systems, procedures, and practices are firmly in place.

This report is not intended as "doom and gloom" but hopefully assists diving managers in:

1. Identify the best working practice for recovering an incapacitated diver to the bell
2. Review suspension trauma and CPR in a diving bell
3. Identify best working practices and suggestions for diver recovery risk assessment and developing rescue procedures
4. Overview of diver recovery improvements since the previous version of this report was issued

1.3 Scope

Although based on North Sea practices and GB legislation, the recommendations are intended for international comment. However, the procedures are biased towards colder climates and deeper, colder depths.

The report is not concerned with 'who rescues who' or how many divers are involved. Its fundamental focus is on 'when' and 'why' specific actions are taken and the procedure that will aid the survival potential of an incapacitated diver.

2 DIVER RESCUE: LEGISLATION, GUIDANCE AND BEST PRACTICE

There is a plethora of documentation (regulations, industry guidance, and best practices) outlining the requirements for recovering an incapacitated diver back into the bell and ultimately back into the saturation system for medical assistance.

It is clear that equipping and training for an incapacitated diver rescue is a legal requirement in Great Britain, the UK sector of the North Sea, and best practice internationally.

Below are some of the relevant legislation, guidance, and best practices.

Legislation (Diving)

Diving at Work Regulations 1997
135 (e) adequate first aid equipment and lifting plant to enable a person in the bell to lift an unconscious or injured diver into the bell.

Norsok U100 7.2.4 Diving Bell
The diving bell shall be adequately equipped so the bellman can bring an unconscious or injured diver into the bell to a position where first aid can be administered.

IMO

This code has been developed to provide a minimum international standard for the design, construction,……engaged in diving operations.
3. be equipped with means whereby each diver using the bell can enter and leave it safely, as well as with means for taking an incapacitated diver up into a dry bell;

IMCA

ICoP D014 Rev 2 Section 4.9.4
Lifting equipment must be fitted to enable a person in the bell to lift an unconscious or injured diver into the bell in an emergency.

ICoP D14 Rev 2 Section 9.1
The diving contractor's operations manual should contain a section laying out the actions required of each diving team member…….in the event of a foreseeable emergency occurring during operations……..dealing with an injured or unconscious diver.

D010 Section 3 Safety Management
The Work scope should be considered, and provisions should be made for all foreseeable emergencies, e.g. ……..diver rescue, etc.

D024 Rev 3 Section 6.45
A closed bell diver rescue recovery system must be available so that the bellman can retrieve an unconscious or incapacitated diver into the bell.

IOGP

411 V2 2.15 Emergency Response Plan
Emergency response guidelines. 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.
Examples that should be considered and, if required, extended;
Recovery of an injured/unconscious diver from working depth to a safe place for treatment and consequential medical treatment

DnV

A partial-flooding system should be fitted to flood the bell to a pre-set level, which will assist the standby diver in re-entering the bell and recovering an unconscious diver.

3 CURRENT PRACTICES

The usual practice in the UK sector is to carry out a bell dive with a three-man bell team. However, many actions are similar for a bellman lockout and rescue or the second in-water diver, regardless of the actual events. The procedure below is similar to much of what is practised [to a point] during recovery drills. It is relatively irrelevant for this report whether a two- or three-man bell run is used, as the actions carried out and equipment used are being reviewed.

The recovery and any required resuscitation of a diver with respiratory and cardiac arrest in a hyperbaric environment presents problems that are not common in a normal atmospheric environment. The lack of space within the diving bell and the configuration of the bell interior within the spherical hull give rise to difficulties when positioning the diver over the central manway door.

Guidelines for essential life support prepared by the Resuscitation Council set out the sequences of resuscitation. This proves an action plan for the initial assessment and management of a lifeless casualty. All divers in the UK sector of the North Sea are required to be proficient in the delivery of CPR.

As help from external assistance is not possible during the early stages of a bell rescue and resuscitation, the rescue diver must be proficient in both.

Procedures have to be clear, as a fatality will result in the rescue divers feeling that it was their fault, leading to increased mental issues, blame and guilt. It might not only be a fatality in the bell; the other divers' lives could also be ruined.

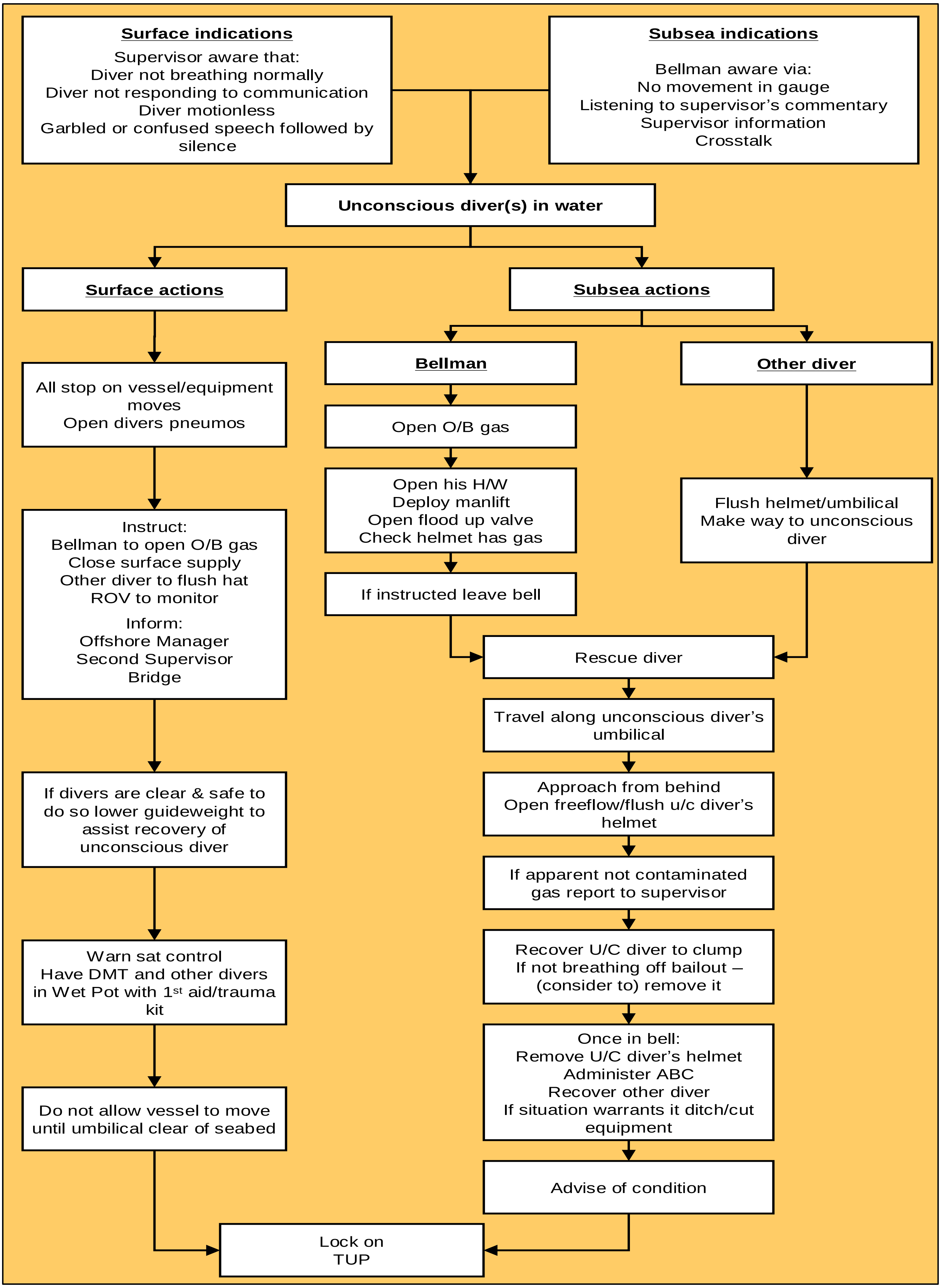
3.1 Bellman's action during a bell rescue

The following is taken from a commercial diving manual. Most contractors' manual procedures are similar. The wording and actions are usually a cut-and-paste from the previous manual, with only an update of the Resuscitation Council's latest recommended practices for CPR.

1. Deploy emergency recovery device into trunking [and open flood up]
2. On the Supervisors direction, lockout after checking own communications, gas and hot water
3. Deploy the bellman's umbilical
4. Check to make sure your umbilical is not tangled and follow divers' umbilical
5. Approach diver from behind if possible
6. Check that the helmet is still on. Open free flow, close reclaim at the hat. If there is no gas, open the bailout supply [Close free flow first]. Use divers pneumo if necessary.
7. Clip to divers harness using a short lanyard. Return to bell hand over hand up own umbilical.
8. Consider the use of clump weight as an aid to diver recovery
9. On reaching the bell, attach the diver to the karabiner clip on the recovery device [Consider removal of the bailout and tools from the incapacitated diver]
10. Bellman then enters the bell and hoists the incapacitated diver inside
11. Once the diver is safely in the bell, then remove the helmet. If necessary, leave the diver hanging from the hoist while starting resuscitation.
12. Do not blow water from trunking yet
13. Check to see if the diver is breathing
14. If not, insert GUEDAL airway
15. Inflate chest twice
16. Check carotid pulse
17. If no pulse commences, External Cardiac Massage
18. Give two chest inflations to 15 heart compressions. Continue until spontaneous breathing commences.
19. At the earliest convenience, the bellman should secure the flood valve, blow the trunking, and seal the bell while continuing CPR.

3.2 Diver rescue flow chart

The above procedure can (and should) be summed up in an easy-to-follow flow chart.



4. THE BELLMAN'S PRE-LOCKOUT ACTIONS

The following section breaks down the generic actions the bellman requires for a diver rescue, taken from a commercial diving manual, and comments on each rescue step in item 3.1 of this report.

4.1 Deploy emergency recovery device into trunking (and open flood up)

The recovery device should have been checked/deployed previously as part of the bellman's checks after the diver[s] initially locked out.

The flooding of the bell to allow the bell to be partly filled to assist the re-entry into the bell of an injured diver is a requirement within IMCA's DESIGN 24. The flood-up valve is opened to allow the bell to flood to a predetermined level. This will aid the bellman's return into the bell and greatly assist in recovering the incapacitated diver into the bell by 'floating him in'. However, the level of usefulness of the flood-up is generally overlooked, as revealed below:

Photograph 1

Flood up and 'goose neck' in a modern Drager designed bell. Flood up depth is below seat height and realistically will not aid the bellman with an incapacitated diver

Photograph 2

Flood up and 'goose neck' in an old bell. Flood up well below seat level. This has possibly been lowered due to a retro fitted scrubber motor. This change should have been risk assessed.

Photograph 3

Further example of typical bell flood up arrangement. Flood up depth is below seat height and will not significantly aid the bellman with an incapacitated diver

Photograph 4

Further example of typical bell flood up arrangement. Flood up depth is below seat height and will not significantly aid the bellman with an incapacitated diver

It is widely accepted that when an incapacitated diver is in a flooded bell, the hydrostatic pressure on his legs assists in keeping blood in his core, thereby aiding his recovery. IMCA recognise the requirement and importance of the flood-up level in IMCA D022; *".....or suspended from the man lift with his body in the water. The diver's body must remain in the water if the latter method is used. Water pressure is needed to keep the blood supply in the upper body and head."* None of the flood-ups pictured (Photographs 1 -4) will aid the bellman with floating or hydrostatic pressure on an IP.

It is a poor reflection on the diving community that industry / corporate memory has forgotten the importance of the depth of the bell flood up.
The diving industry was well ahead of other sectors concerning 'suspension trauma'. Although not explicitly named, it was undoubtedly identified, with the control measure being an appropriately flooded bell, taking the diver's weight in suspension.

The usefulness of the flood-up is generally overlooked as dive technicians retrofit electrics and find convenient places to fit additional scrubbers, Hypergas alarms, etc. With the size of survival equipment, the flood-up level either gets reduced or wasn't adequately designed in the first place.

Significant changes to the internal bell should be risk-assessed and potentially approved by the dive systems certifying body. Any reduction to the bell flood-up zone should, as a minimum, be subjected to a Management of Change and supporting risk assessment.

Incapacitated diver recovery procedures and risk assessment should consider:

1. The emergency recovery device should be deployed and left deployed to ensure it remains in a working condition
2. The design depth of bell flood up. This needs to be deep enough to assist in the rescue and deep enough to apply hydrostatic pressure during certain phases of the rescue
3. The design depth of bell flood up; has the flood up goose-neck changed to prevent new equipment being flooded?
4. Can the flood-up valve be easily reached from the trunk?
5. Are there safe guards to prevent a supervisor controlled venting of the bell, from flooding the bell deeper than the designed flood up depth?
6. Depth of flood-up should be added to IMCA D24 DESIGN

4.2 When instructed, lockout after checking communications, gas and hot water

Communications and gas (on primary and secondary) should have been formally checked during pre-dive bell checks. Hot water should have been checked at depth, and all equipment should be ready to lock out for rescue.
Few 'professional' divers, when acting as bellmen, thoroughly check their standby equipment. They should:

- Soap the face plate to stop it from 'fogging up'
- Don the Bandmask, adjust the spider straps and check the zip
- Breathe off the Bandmask on the primary supply (which is usually a supply from the bell pressurisation gas or a dedicated supply)
- Close the primary supply at the hull valve and confirm that the bellman's on-board or secondary gas supply operates at the predetermined pressure set on the regulator (and if fitted, alarm sounds)
- Remove the band mask and reconfigure the valves as per company procedures, ready to lock out.
- Deploy and check the diver recovery hoist
- Check fins fit and adjust as required

Incapacitated diver recovery procedures and risk assessment should consider:

1. Diving contractors should endorse the use of 'at depth' bell checks as many divers consider being bellman as 'a day off'. The use of a formally recorded checklist 'at depth' will ensure that the supervisor has shown best practice and should protect him in any accusations of negligence in an accident enquiry. There should be no 'custom and practice', everything should be formally approved procedures
2. The bellman's hot water should be continuously flowing to ensure that there is no delay in the bellman locking out (If, when the bellman's hot water is flowing it 'robs' the diver of hot water; the hot water flow/volume is insufficient for safe diving operations
3. Are the bellman's 'hat' checks and equipment checks robust? Are there any 'work-arounds' or 'legacy practices' that need formal intervention and change to procedures and checklists? (IMCA SF 05-19)
4. A BandMask does not offer the same thermal balance properties as a helmet. In deeper, colder water does the bellman require inspired gas heating (hot water shroud) and any additional hot water supply to his head?
5. Procedures should state that the bellman's supply should be closed downstream of the regulator and the umbilical bled down. This is to mitigate against the potential risk of the bellman locking out and only breathing the remaining gas in the umbilical. If the supply is shut and the umbilical purged he will have to open his supply immediately he dons the mask.
6. Do the contractors pre-dive checks on the bellman's breathing apparatus follow the manufacturers recommendations? (For example; KMDSI Checklists A2-3, A2-4, A2-5)
7. Does the BandMask fit the bellman's facial profile? Since 2012 (Bulletin 02-2012) KMDSI have produced different sized hoods and face seals. KMDSI recommend "For safety and comfort it is very important to obtain a correctly fitting face seal and hood combination."
8. Is the diving contractor permitted by regional legislation and industry best practice to allow a diver in the water without a diver worn emergency reserve? (bellman lockout)

5 THE BELLMAN'S LOCKOUT AND SECOND DIVER'S RESCUE ACTIONS

5.1 Deploy bellman's umbilical

The bellman's umbilical is stored outside the bell and should be fitted with a quick-release system (as per IMCA D024 DESIGN). The bellman's umbilical is rarely released at depth as part of a drill or training matrix. It is considered too time-consuming to re-stow or potentially damaging to the equipment if the bell is recovered with the umbilical deployed.

Incapacitated diver recovery procedures and risk assessment should consider:

1. The buoyancy properties (negative, neutral or positive) of the bellman's umbilical needs to be considered. A buoyant umbilical might foul the bell/wires and/or provide too much up lift to the bellman and as negative buoyant umbilical might foul debris..
2. The DPP and Dive Plan should have stated the maximum umbilical length, IMCA D22 requires the deployed umbilical to be as short as possible and the properties of the umbilical to be risk assessed (buoyancy)
3. How is the bellman's umbilical secured:
    - For maximum allowable excursion (Is umbilical un-racked and measured?)
    - How is excess umbilical secured? (Does it interfere with release or potentially foul guide-weight)
4. Working divers safe umbilical lengths are measured from the centre of the trunk. How is the bellman's 'off-set' allowance calculated (Umbilical measured from different location than divers)?
5. The tide direction and strength needs to be considered when deploying the bellman's umbilical
6. Are there procedures to ensure that the deployed bellman's umbilical cannot foul the DSV thrusters (or foul the guide-weight preventing guide-weight recovery)when the bell is recovered? (The umbilical will not be re-stowed in an emergency)
7. Does the diving drill matrix include release and deployment of the bellman's umbilical?
8. How is the bellman's umbilical secured, is it a quick release or is it bungees that need cutting?
9. Serious consideration needs to be given to how the bellman's umbilical is routed from its storage position to the bell internal;
    - Does it allow for the stage to be lowered?
    - Does it allow for pinch point between bell and independent stage/guide weight? (SF 06-12)
10. The contractors procedures should identify a 'hierarchy of rescue'. It is undesirable to lock the bellman out. The hierarchy should be:
    - Rescue by another diver already locked out
    - Rescue by another diver in the bell on their equipment
    - Recover the IP from within the bell by coming up on their umbilical
    - Recovery of IP from the guide weight/stage by the bellman coming up on the IPs umbilical
    - Final and least desirably bellman deploying their umbilical and leaves the stage (with no bailout)

5.2 Ensure the bellman's umbilical is not tangled and follow the diver's umbilical

The diving bell will be heaving, and if the umbilical is floating, it will get fouled on the bell, as space to rack the bellman's umbilical on the bell is usually tight due to the bell cursor. It is often not coiled correctly with 'french turns'; therefore when deployed it will most likely contain twists..

Incapacitated diver recovery procedures and risk assessment should consider:

1. How is the Bellman's umbilical racked? It should be put on the quick release horns in the same manner as the working divers, with french turns, to prevent twists and tangles.
2. Depending on the distance the IP is away from the bell procedures should consider the supervisor moving the vessel towards the IP
3. The bellman / rescue diver should give a running commentary for the duration of the rescue. This will assist the supervisor when conducting a dynamic risk assessment and if cross-talk is available it will reassure the IP

5.3 Check IPs helmet is still on, open free flow, close reclaim

The bellman should have received information about the likely causes of why there is an incapacitated diver via information relayed by the second diver in the water or information gained from the ROV team via the Supervisor. In reality, the actual circumstances of the event dictate the required actions.

If the Supervisor witnessed an incident or circumstances led him to believe that the IP diver's condition was caused by physical trauma, then there would be no reason to change gas supplies; the supervisor would not need to open the secondary supply, nor would Bellman need to open onboard gas or for the rescue diver to open the IP's bailout.

Changing from the main supply to either on-board gas, or in particular, the diver's bailout, is not a desired event if it is not necessary. As soon as the diver is breathing from on-board gas or bailout supply, there is a finite time as both gas supplies are limited, and his core body temperature will drop significantly due to the temperature of the inspired gas (The gas supply from the surface is warmed by the hot water within the umbilical cluster)

If a contaminated gas incident is suspected, the supervisor should switch supplies in dive control and purge the contaminated gas from the umbilical. However, to speed things up, going on to bailout is the safest and quickest method of getting clean and breathable gas to the diver. The higher ppO_2 of his bailout mix may also aid his recovery.

Once the incapacitated diver is breathing from their bailout, the rescue diver has a finite amount of time to get him back to the bell.

Incapacitated diver recovery procedures and risk assessment should consider:

1. The supervisor should know how long it takes for the diver to 'flush their helmet' of any potential contamination. The contamination source could be the reclaim volume tank. The calculation should take into account the length of the divers umbilical and amount of bell umbilical, this includes all the bell umbilical on the winch drum. There could be in excess of 450m. Guess work isn't acceptable. The minimum time should be known by either trial or calculation.
2. If the diver is put onto the bell OBG the supervisor should know how long it will take to flush any contaminants from the divers umbilical. Guess work isn't acceptable. The minimum time should be known by either trial or calculation.
3. There should be a set of 'immediate action' checks carried out by the rescue diver. These should be documented and drilled with a standard report to the supervisor of the IPs condition and condition/status of his equipment. This should be methodical and simple to follow such as:
    - Report that the rescue diver has secured the IP with a rescue lanyard
    - Report obvious signs of physical trauma
    - Check if breathing (and if hat is flooded)
    - Check bailout contents gauge
    - Check status of bailout valve
    - Check status of free-flow/by-pass valve
    - Check hot water
4. If the diver is unresponsive consider dumping the IPs hot water .
5. Jettison any tools that may be on the IPs harness (and carried by the rescue diver)
6. The rescue diver should have the same level of PPE to protect against identified hazards, including chemical hazards, pollution hazards and construction hazards. A Bandmask does not offer the same protective qualities as a helmet.

5.4 ...If no gas, open bailout supply use divers pneumo if necessary

The supervisor should have opened the gas supply to the incapacitated diver's pneumo. However, a reason he could be incapacitated is that he has a parted or partially severed umbilical and is not getting any gas. In this situation, going on to bailout or using the rescue diver's pneumo is the only available solution.

Incapacitated diver recovery procedures and risk assessment should consider:

1. Consideration needs to be given to the source of the IPs and rescue divers pneumo gas supply. They should not be common to the breathing gas
2. Consideration needs to be given to the end of the pneumo hose. The end usually has with a ¼" female JIC fitting. This fitting will be difficult to slide under a neck dam seal and could cause injury to the diver. IMCA D23 requires a "length of hose which is rigid enough to be pushed up inside the neck seal of a diving helmet" on the emergency cylinder in a dive basket, which is carrying out the same function.
3. The use of the pneumo as an emergency supply should be subjected to a system and site specific audit to ensure there is adequate flow and delivery rate
4. Consideration required if a stab jacket is used. The pneumo will have a QC fitting that may not allow gas flow when disconnected from the stab jacket
5. Consideration should be given to the improving how the diver gets the gas, such as an effective design that allows rapid and secure supply, preferably via a quick connect and not by inserting the end into the helmet.
6. Procedures should state how the umbilical is secured so it cannot come out of the divers helmet during the recovery phase.
7. Contractors should ensure that pneumo lengths are adequate length so a rescue diver can insert their pneumo into the IPs helmet and still have sufficient room to manoeuvre
8. Procedures should ensure that one of the 'immediate action' checks is that the IPs by-pass valve is closed before opening their bailout
9. Procedures may be different depending on the type of emergency reserve worn, the actions will be different (Rebreather and cylinder bailout). Procedures must be specific to the type worn.

5.5 Clip to divers harness using a short lanyard

This should be the first action the rescue diver carries out on arrival: securing the IP .

Divers usually, but not always carry a short lanyard for this purpose. However there are no official or approved lanyards; they are usually home-made or supplied by the diver.

Photograph 5

Photograph 6

Photograph 7

Variety of in service rescue lanyards

Incapacitated diver recovery procedures and risk assessment should consider:

1. Lanyards should be supplied by the diving contractor
2. There should be a company standard for the rescue lanyard design and where it is worn (in particular the type of safety clip used should be risk assessed)
3. Pre-dive checks should record that every diver carries an approved rescue lanyard

5.6 Return to bell hand over hand up own umbilical

The rescue diver should return to the bell with the IP secure via the lanyard. The easiest way to return is by climbing along their umbilical. If there is a bellman within the bell they will be coming up on the IPs umbilical to ensure it doesn't foul. If the rescue diver is the bellman, care has to be taken so that both umbilicals don't become fouled. At this point, depending on where the vessel is working and if it is safe to do so, the supervisor should move the vessel towards the incapacitated diver. This will decrease the distance between the diver and the bell and thus speed up the rescue time. The divers could be 70m away from the bell.

5.7 Consider the use of guide-weight/stage as an aid to diver recovery

The supervisor should have considered this sometime before. The clump weight and the bell should be lowered to assist a seabed rescue [and monitored by an ROV if available].

Some diving systems have the clump/guide weight permanently attached to the bell. Thus, the above point about using the clump weight as an aid to diver recovery is a generic statement and not necessarily a vessel-specific procedure.

Lowering the guide weight or bell on a new DSV with a PLC / HMI bell handling system may also cause issues. It may not be as simple as the second supervisor lowering the guide weight or bell. The dive tech may have to be brought to dive control to remove settings to allow the set limits to be overridden or reset. This all takes time during an emergency situation where time is crucial.

Incapacitated diver recovery procedures and risk assessment should consider:

1. PLC over-rides for lowering independent guide weights/stage
2. Guarding of moving parts of the guide weight to prevent damage to divers or their equipment

5.8 On arrival at the bell, attach IP to the carabiner on the recovery device

When the rescue diver and IP reach the bell, the IP should be secured to the recovery system as soon as possible due to vessel and bell movement. Vessel heave can be severe when on the guide weight; an incapacitated diver could be seriously injured if they are not secured and controlled.

When attaching the incapacitated diver to the recovery device, there are two areas on a harness where the carabiner and recovery system can be attached:

- Dorsal; behind the neck; this is a single point of attachment and will make the incapacitated diver's head fall forward, potentially blocking his airway
- Thoral: in front of shoulders/chest, this is a double attachment and requires a 'chest spreader'. This attachment should allow the incapacitated diver's head to fall backwards, opening his airway; however, if the diver is still wearing his bailout, it can easily foul the edge of the trunk

Note: It is rare that a diver recovery exercise goes any further than this stage due to the pain caused by the harness.

Below are photographs of two types of diving harnesses attached to thoral and dorsal lift points; note the angle of suspension and position of the diver's airway.

Photograph 8

Dive Dynamics dorsal lift

Photograph 9

Dive Dynamics thoral lift

Photograph 10

Hydrospace dorsal lift

Photograph 11

Hydrospace thoral lift

Note; no spreader beam was available for the thoral lifts at the time of these trials.

Incapacitated diver recovery procedures and risk assessment should consider:

1. Contractors procedures should state that all divers shall wear a 'lift harness' underneath their bail out harness and/or stab jacket.
2. Contractors should risk assess and state where the umbilical is connected to; Lift Harness or Bail-out Harness? In a rescue it is better for the umbilical to be attached to the Lift Harness.
3. Contractors should state in procedures, and drill, where the recovery device is attached to the harness. (and if a chest-spreader is to be used) (IMCA recommend divers exercising advantages/disadvantages of different D-rings)
4. Contractors procedures should consider if the IPs bailout is removed prior to entry (reduce weight) or if it is left on. If removed consideration needs to be given to the procedure if the IP is still breathing from the bailout

6 RECOVERY OF THE INCAPACITATED DIVER INTO THE BELL

There are two scenarios:

1. Rescue by bellman
2. Rescue by another diver (either from the bell or was already locked out)

Contractors' rescue procedures usually only state that the bellman can rescue the victim. However, within the contractors' hierarchy of rescue, there should be a rescue procedure for each scenario.

6.1 Bellman then enters the bell and hoists the incapacitated diver inside

The bellman enters the bell and recovers the incapacitated diver into the bell by floating him (assuming that the bell flood up is of useful height/depth) just enough so his head is out of the water in the now flooded bell. The bellman removes the incapacitated diver's helmet and slips / cuts his bailout harness off. (He should close the divers supply) The incapacitated diver should be neutrally buoyant.

To utilise the thoral lift points effectively, it is imperative to use a chest spreader to avoid crushing the diver's chest and restricting breathing.

Incapacitated diver recovery procedures and risk assessment should consider:

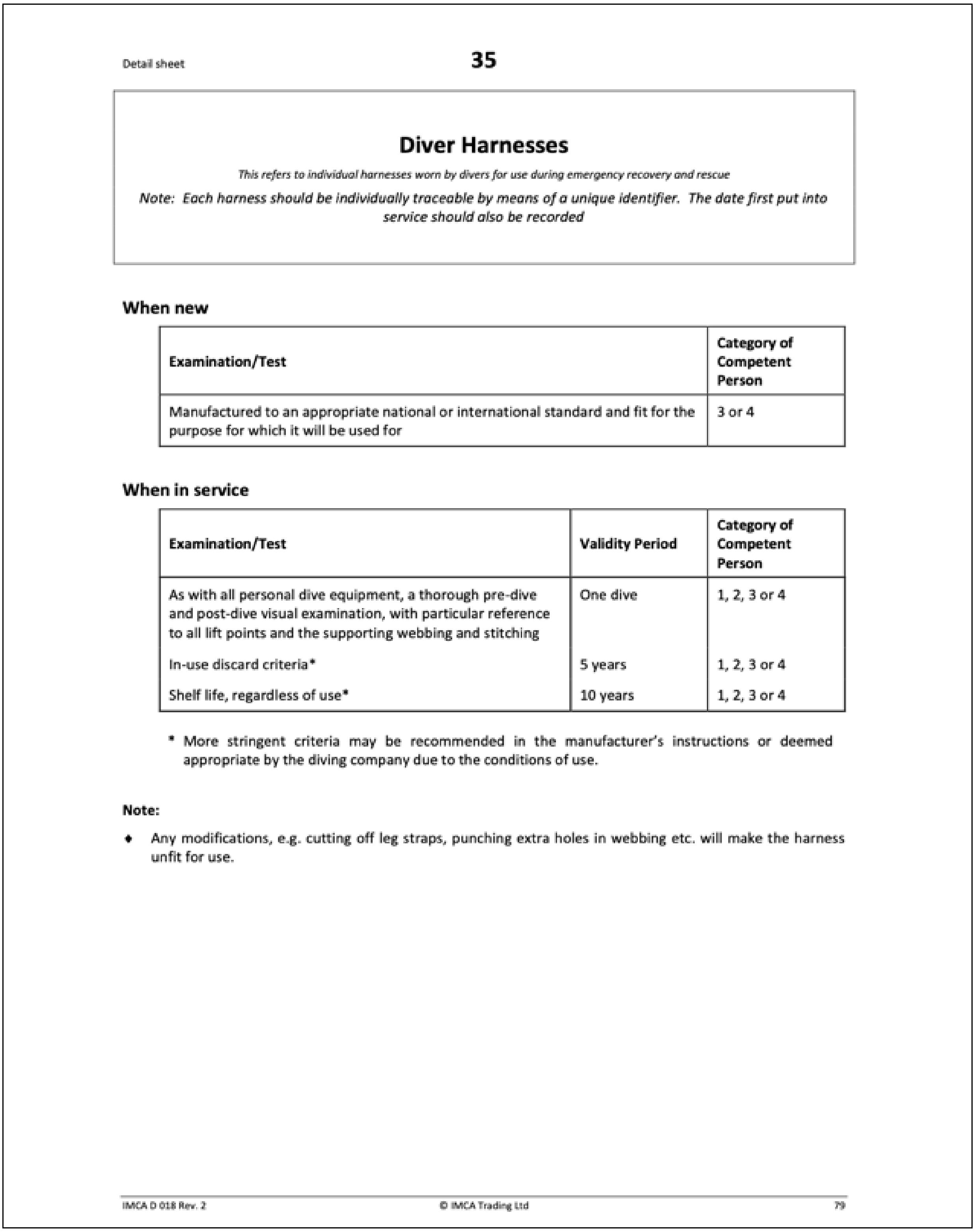
1. The bellman should initially keep his breathing apparatus donned until the IP is inside the bell so he can see what is happening underwater if the IPs equipment snags. There may also be a scenario where the bell becomes flooded over the design depth if there is a supervisor controlled vent line
2. The contractor should carry out lifting trials on the type of harness worn and check the angle of approach to the trunk. Harnesses should be a standard type across the fleet.
3. Consideration needs to be given to where the recovery device is located, above the trunk, above the seat or CPR position.

6.1.1 Harness compliance

Previous issues of this report identified that divers harnesses were not fit for purpose nor complied with legislation. These issues were raised at IMCA SMTT Committee meetings (20-08-08,17-03-09, 22-07-09) leading to the issue of IMCA Information Note 03-10 Periodic Examination of Diver Harnesses Later IMCA added Detail Sheet 35 to IMCA D18 .

This updated report assumes that all IMCA and professional diving contractors will comply with this requirement.

Figure 1



Detail sheet **35**

Diver Harnesses

This refers to individual harnesses worn by divers for use during emergency recovery and rescue

Note: Each harness should be individually traceable by means of a unique identifier. The date first put into service should also be recorded

When new

Examination/Test	Category of Competent Person
Manufactured to an appropriate national or international standard and fit for the purpose for which it will be used for	3 or 4

When in service

Examination/Test	Validity Period	Category of Competent Person
As with all personal dive equipment, a thorough pre-dive and post-dive visual examination, with particular reference to all lift points and the supporting webbing and stitching	One dive	1, 2, 3 or 4
In-use discard criteria*	5 years	1, 2, 3 or 4
Shelf life, regardless of use*	10 years	1, 2, 3 or 4

* More stringent criteria may be recommended in the manufacturer's instructions or deemed appropriate by the diving company due to the conditions of use.

Note:

- Any modifications, e.g. cutting off leg straps, punching extra holes in webbing etc. will make the harness unfit for use.

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7 THE FIRST AID ACTIONS/CPR WITHIN THE BELL

7.1 Once the diver is safely in the bell, remove the helmet. If necessary, leave the diver hanging from the hoist while starting resuscitation

This is a very generic statement. A diver may appear unconscious, but this does not necessarily mean that he requires "mouth-to-mouth" resuscitation; he could very well be breathing. First-aid treatment advice within diving contractors' manuals is usually outdated.

It can be seen that a diver wearing a 13kg helmet (Photograph 12) and or carrying a 32kg bailout (Photograph 13) is a poor practice. Therefore, it would be wise to assume that hoisting an incapacitated diver into the bell while wearing these additional loads would cause further injury. Either directly (Neck injury)or indirectly (suspension trauma). Hoisting a diver into a dry bell should not be encouraged as there is a significant risk of further injury.

Photograph 12

13kg Diving Helmet-

Photograph 13

32kg Bailout (Without addition of lead)

Incapacitated diver recovery procedures and risk assessment should consider:

1. Any first aid or medical advice within the contractors incapacitated diver recovery procedures should be approved by the contractors appointed hyperbaric doctor. This includes:
    - To remove or not remove the bailout
    - When to remove the helmet
    - How best to provide CPR
2. Consideration needs to be given to where and when the IPs helmet is removed.
3. Consideration needs to be given to the bell flooding up by a supervisor controlled vent line.

7.2 At the earliest convenience bellman to secure the flood valve, blow the trunking and seal the bell while continuing CPR

7.2.1 External chest compressions in a diving bell

CPR is a method by which the rescue diver can manually assist blood around the diver's body who has respiratory and cardiac arrest. This is affected by ventilations and chest compressions, in the recommended ratio, to maintain perfusion of the vital organs. This is usually done with the patient lying in the supine position.

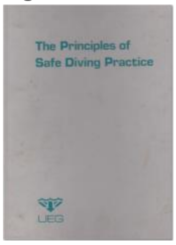
Without further treatment, the heart will not restart. Chest compressions work to promote the forward flow of blood. They provide only about 30% of the normal cerebral perfusion when performed correctly.

Because a diver recovered into a diving bell will be in an upright position and tend to move away from the compression force [Figure 3 & 4) the normal technique of external chest compression may not be practicable. This is impossible to do in a two-man bell run but possible in a three-man run

If the diver in respiratory and cardiac arrest is left suspended and CPR is continued in a dry bell, the CPR will most likely kill him. The blood will pool in the IPs lower limbs and not return due to gravity and being suspended in their harness. Any additional weight, such as the bailout, just makes the harness tighter and even less chance of blood returning to the heart.

There are three methods of CPR usually stated within diving contractors' manual or has become 'custom and practice' within the diving industry. The illustrations originated, rather ironically, in '*The Principles of Safe diving Practice'* (circa 1984) which was a report to industry by the UK Department of Energy (forerunner of the UK Health and Safety Executive) the Association of Diving Contractors (the forerunner of IMCA) and UEG-part of the Research and Information group for the Underwater Engineering Industries.

Figure 2



The following is from a commercial diving manual: based on - *The Principles of Safe diving Practice'*

1. Grip the patient's diving suit with one hand on each side under his arms, at the level of a line through the lower third of his breastbone. Place one knee on the lower half of the breastbone and pull him to your knee rhythmically every two seconds, stopping every six times to inflate the chest.
2. Place your arms around the patient and join your hands behind his back, using the point of your shoulder to compress the lower end of the breastbone as above.
3. Sit opposite the patient and place your foot on the lower end of his breastbone, compressing his chest against the bell wall.

With all these techniques, aim for a maximum depression of the lower third of the breastbone by 40 - 50 mm. This can be difficult to judge with the baggy fit of most suits, and care should be taken to ensure that overzealous techniques do not damage the patient's chest wall.

Note flood-up levels in the bell:

- Figure 1-waist deep wearing a bailout and suspended. Flood up is inadequate to 'float' the diver.
- Figure 2-chest deep, wearing a bailout and suspended. Flood up is inadequate to 'float' the diver.

The bellman will be placing the diver at considerable risk as blood will not return past the pressure of the harness leg straps.

Figure 3

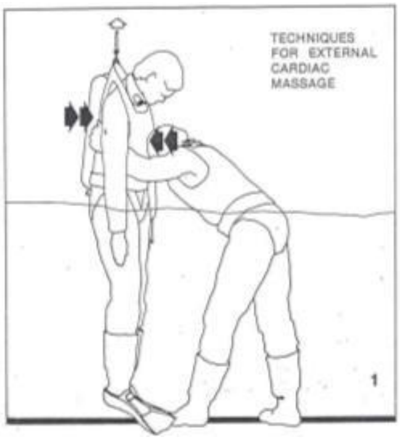


Figure 4

Various studies have shown that CPR within a diving bell is well documented. In the Myers-Bradley study most resuscitation techniques with the patient in the upright position failed to attain adequate compression pressure.

7.2.2 Update: External chest compressions in a diving bell

Earlier issues of this report and this update identify that current CPR delivery practices within a diving bell are unsuitable. These issues were raised at IMCA SMTT meetings (in April 2014, a working group (established in July 2014) and published in IMCA Making Waves (September 2014)

The IMCA meetings and publications prompted industry (diving and medical) interest, and other reports on the topic followed, including the Indian Journal of Occupational & Environmental Medicine, International SOS (in conjunction with the NHS) and NUI developing a compact chest compression device (NCCD) that can be used in a diving bell (and chambers). The NCCD was developed with support from GASSCO, Equinor, Vår Energi, AkerBP, Subsea7, TechnipFMC and Innovation Norway.

Figure 5

Researchers aim to find more effective CPR methods for deep sea divers who suffer cardiac arrest

Posted Wednesday, 6 October 2021

A hyperbaric diving bell used by deep sea divers carrying out work on the ocean floor has been installed at Royal Derby Hospital, as researchers investigate how to carry out more effective CPR in confined spaces.

The study team is led by Dr Graham Johnson, Emergency Medicine Consultant at UHDB, in collaboration with International SOS. They are analysing the current methods of resuscitation which are used in small spaces, especially inside diving bells, to find ways to make these more effective.These methods are being tested on a manikin in full diving gear inside the bell.

Article from NHS University Hospitals of Derby and Burton website

The development of the NCCD has led to at least one Client mandating their use on their assets during saturation diving operations and strongly recommending their use during air diving operations.

Figure 6

TotalEnergies

LOGISTICS & SUPPORT — TO OPERATIONS

Diving Safety Flash

SF N°1 2022

NUI'S COMPACT CHEST COMPRESSION DEVICE (NCCD)

When Every Minute Counts

by Rachel Brown (published in ADCI bi-monthly revue UNDERWATER NOV/DEC 2021)

The need for a better way to perform CPR in a diving bell was presented by medical researchers during The Bergen International Diving Seminar in November 2019, where the best current practice was to use the head or knee to perform chest compressions – and then there was a new technology on the horizon. NUI AS, based in Norway, has developed, and recently released the Compact Chest Compression Device (NCCD), in response to this industry safety demand. "We developed the NCCD, a low-cost, small, compact and lightweight gas-powered mechanical chest compression device, that is tested for use in hyperbaric environments (300 msw/30 bar) with heliox atmosphere," said Fredrik Bærheim, HSEQ Advisor at NUI AS, the project manager for the development of the NCCD. "The NCCD can be used while the diver is hanging in a vertical position and while submerged in water."

A sudden unexpected cardiac arrest (SCD) is a major global public health issue, accounting for up to 20% of deaths in Western societies. Rapid and good cardiopulmonary resuscitation (CPR), combined with a defibrillator (AED) are essential and improve the chance of survival. Without good CPR after a cardiac arrest, brain damage will occur after just 5 minutes, and the chance of survival decreases by about 10% per minute from the onset of cardiac arrest without treatment. There is often a lack of both good CPR knowledge and an availability of an AED in the workplace.

Saturation divers live and work in small compact compartments, under hyperbaric pressure, using diving bells and hyperbaric chambers. There have been reported cases of fatal SCD during saturation diving. The space in the diving bells and chambers is very limited, and manual CPR is challenging, and in some situations, impossible. There is a need for mechanical chest compressions during CPR in general, as well as in hyperbaric compartments.

NCCD is powered by compressed gas already available. It

The NCCD (piston unit) will also function while submerged in water. "The NCCD uses compressed gas already available in hyperbaric systems and diving bells. It is designed to run on 10 bar gas pressure that is default in the Build-in-breathing-systems (BIBS)," Bærheim explained.

Underwater Operational

One of the most groundbreaking features of the small device is that it can function fully submerged in water because it has no electrical components. "The NCCD is successfully tested fully submerged in water," Bærheim said. "The NCCD is delivered with 450 cm long hoses in total and can then be used on a diver outside a diving bell, still in the water. We don't think that use outside a bell is going to be a common use case, but in some cases it might be necessary. The NCCD can be used in all wet and moist areas where compressed gas is available. A standard portable diving bottle can be used."

NCCD Rental Concept

The NCCD can be rented from NUI on a yearly basis from clients anywhere in the world. The NCCD will be replaced yearly in the rental period, so there is no additional cost for maintenance. "The rental concept is easy. Companies contact NUI (post@nui.no) for a rental agreement. The requested number of units is then sent to the customer that pays a yearly rate per unit," Bærheim said. "Once a year, new units are sent to the customer, and the old units are sent back to NUI for service. The yearly rate covers units and maintenance."

For Diving Support Vessels (DSV), NUI recommends at least one unit in each bell, one in each TUP-chamber that can also be used in the chamber system, and one training unit. The operational units are sealed, and the seal should not be broken unless an emergency occurs. If used in an emergency, NUI should be notified, and a replacement unit will be shipped as quickly as possible. The training units are clearly marked and can be used as needed.

Instruction video of how to use the NUI Compact Chest Compression Device (NCCD)

https://youtu.be/8JEB4K7llvw

From January 2023 all Diving Bells shall be equipped with a NCCD during TOTAL ENERGIES saturation operation (a training unit should also be on board for the training of the divers).

For Air Diving Operation the NCCD is strongly recommended by LSO/UWO.

Attached with this Safety Flash: NCCD instruction of use, NCCD User Manual and NCCD rental agreement

CONTACT

[redacted]

Total Energies Diving Safety Flash N°1 2022

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Incapacitated diver recovery procedures and risk assessment should consider:

1. Any first aid or medical advice within the contractors incapacitated diver recovery procedures, including how to best deliver CPR in the bell, should be approved by the contractors appointed hyperbaric doctor. This includes:
    - How to deliver-suspended and up-right or supine?
    - When to start CPR? (CPR should not be interrupted for more than 10 seconds (USN))
    - Are rescue breaths administered? (No longer taught but possibly relevant to a diver)
2. If CPR is to be carried out in the bell:
    - Ensure that procedures state that all CO_2 scrubbers are running and the PPO_2 is increased in the bell.
    - Consideration should be given to recovering the bell partially flooded to keep hydrostatic pressure on the IP and prevent suspension trauma on the IP if supported by their harness (Consider SWL). A side-mating or dual access bell negates the need to remove the water from the bell when locked on to the system
    - Procedures should consider the recovery with both a two-man and a three-man bell team
    - If administering compressions when the IP is seated; The height of the seat is should be RA
    - The risk assessment should consider if the bell is flooded the available 'gas volume' will be dramatically reduced; leading to the potential of a rapid increase in CO_2 build up.
3. The risk assessment and procedures should consider the bellman cutting the IPs umbilical and jettisoning equipment, this will be quicker than racking the IPs umbilical

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8 SUSPENSION TRAUMA

Intentionally suspending someone in the diving bell or lowering them back into the saturation system (bottom mating bells) is inevitable. Still, the risks of suspension trauma need to be recognised and formally assessed. Current 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

Everybody who is suspended in a safety harness runs the risk of shock and unconsciousness due to insufficient blood flow. Unconsciousness can become life-threatening after only a few minutes. Shock, caused by lack of blood flow, occurs when blood accumulates in the lower parts of the body as a result of muscles in the legs relaxing and the so-called 'muscle pump' stopping.

The heart is a positive displacement pump. It can push blood out into arteries but cannot suck it back up through the veins- hence the need for quite a large positive blood pressure [Hence flooding the bell to assist in providing hydrostatic pressure on the lower limbs].

To maintain this function, the suspended diver must keep his legs moving. This will improve blood circulation and prevent the accumulation of blood in the legs. If a diver is conscious but incapacitated, he could easily lose consciousness if suspended while the bellman recovers the second diver and closes the door.

Injury, pain shock and possibly stress caused by accident can exacerbate suspension trauma.

The most important step in treatment is to consider and risk assess the possibility of suspension trauma. Despite low blood pressure, the classic shock condition can lead to acute right ventricular failure. There are cases of victims dying a few minutes after they have been rescued. Although not appropriate, the term 'rescue death' has been accepted. The diving industry may have unknowingly already killed divers in this way.

Therefore, propping up the upper body and carefully increasing blood volume is recommended.

The danger of the casualty remaining suspended for more than a few minutes is recognised in European law within the Working at Height Regulations.

Venous pooling is the accumulation of blood in the veins due to gravity. Some venous pooling when a person is stood up is normal. Muscular action in moving the limbs, together with one-way valves in the veins, normally assists the return of the blood in the veins back to the heart. If the legs do not operate, excess blood accumulates in the veins, which are capable of considerate expansion and, therefore, considerate capacity [again, this is why the bell has to be flooded].

Retention of blood in the venous system reduces the circulation of blood volume available. The body reacts to this reduction by speeding up the heart rate to maintain sufficient blood flow to the brain. If the blood supply is significantly reduced, this reaction will not be effective. The body will abruptly slow the heart rate, and blood pressure will diminish in the arteries. The circulatory system is disturbed. During excessive venous pooling, cardiac output and arterial pressure fall, which may critically reduce the quality and quantity of oxygenated blood flowing to the brain, and the patient may faint.

The warning systems given before fainting, such as palpitations, nausea, dizziness, sweating and confusion, are known as pre-syncope. When a person is upright, for example, standing or suspended in a harness, blood has to be forced against gravity to the head, which requires special blood pressure regulation. The body does not take kindly to anything interfering with its blood circulatory system, such as venous pooling. It sets off intended compensatory reactions at the first signs of imbalance, pre-syncope symptoms. The body is now in a state of orthostatic shock. Loss of consciousness (if not suspended, they would now have collapsed onto the floor; reinstating blood to the brain) assures that a suspended person will not be moving their legs, so venous pooling will increase, reducing the circulating blood volume even further.

In addition, any restrictions on the femoral arteries and veins caused by the harness (and potentially still wearing a 34kg bailout) could contribute to venous pooling. Thus, the detrimental effects are increased. These include not only a potentially fatal reduced blood flow to the brain but also the effect on other vital organs, such as the kidneys. The kidneys are also susceptible to blood oxygen levels, and failure due to excessive venous pooling is a real possibility.

Unless the bellman follows a particular procedure, the effects of venous pooling and syncope are likely to lead to death, as the brain and kidneys are deprived of vital oxygen. Moving the patient to the horizontal position [a natural reaction] is likely to cause a massive return of deoxygenated (and possibly toxic) blood to the heart, which is unable to cope, causing cardiac arrest.

Various factors can exacerbate the onset of the effects. These include the shock of experiencing the event that caused them to be rescued and suspended in the first place, the injury itself, the harness comfort level, and possibly their psychological state.

8.1 Management of suspension trauma

Prevention is better than cure. This adage applies very aptly to the management of suspension trauma. Ideally, systems of work and rescue procedures plans should state that no one is in a position where they are likely to suffer suspension trauma.

A good start is to ensure that the harness is appropriate. This does not guarantee that a person suspended motionless in a harness will be exempt from suspension trauma, but it should at least delay the onset.

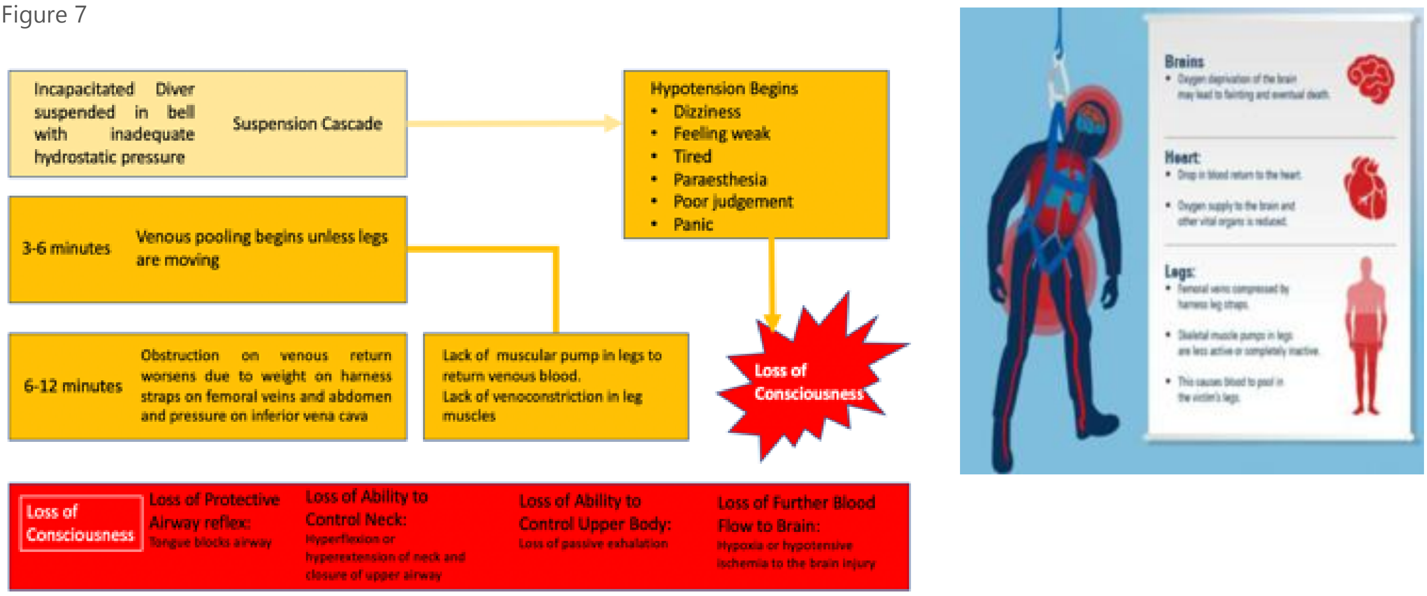
Most diver rescue drills are terminated before the diver is hoisted out of the water and into the bell, the reason being that the pain and discomfort of being suspended even for a minute or two cannot be endured- even by a fit, healthy diver.

Persons suspended in a harness will be at increased risk if they experience any of the following:

- Pain
- Dehydration
- Hypothermia
- Shock
- Fatigue
- Blood loss

Realistically, a rescued diver could quite easily be suffering from all of the above.

Figure 7



8.1.1 How long?

Studies reviewed by Paul Sneddon in his report for the HSE show an average time to symptoms of 5-10 minutes and an average time to unconsciousness of 8- 20 minutes.

The average time from loss of consciousness to death is 8-20 minutes. It is impossible to say how long anyone will last. All the test subjects were considerably younger and lighter than the average diver. Subjects wore various harnesses, tested to EN standards, and underwent a 100kg torso test.

For test purposes, a diver is calculated to weigh 150kg. In addition, the subjects in Paul Sneddon's report would not have just completed a six-hour dive and possibly be suffering from dehydration, fatigue, blood loss, hypothermia, pain, or the reason for their being incapacitated (possibly hypoxia, anoxia, hyperoxia, or trauma).

Rescuers can quite quickly kill a suspended patient and, in the past, have probably done so. The blood pooled in the legs gradually becomes toxic and hypoxic in the same way that a crush injury does, and, if suddenly released back into the torso, can cause kidney failure.

Even if the person was conscious throughout, there is a substantial risk of death when rescued.

Incapacitated diver recovery procedures and risk assessment should consider:

1. Are divers aware of the signs, symptoms, prevention of, and treatment for suspension trauma?
2. Are divers aware of 'toxic shock'?
3. Depth of bell flood-up (Discussed elsewhere)
4. Procedures should ensure that time in suspension is kept to an absolute minimum, if suspended the bell should be flooded.
5. Procedures should consider the additional weight of the diver and equipment while suspended and the pressure exerted on the divers upper legs by the harness
6. During a non-bellman rescue consider recovering the rescue diver before the IP. This will:
   - Reduce the amount of time in suspension
   - Allow continuous CPR without requiring to stop to recover the rescue diver
   - Allows two divers in the bell to attend to the IP
7. Consider recovering the bell flooded (easier in a side mating bell) depending on SWL

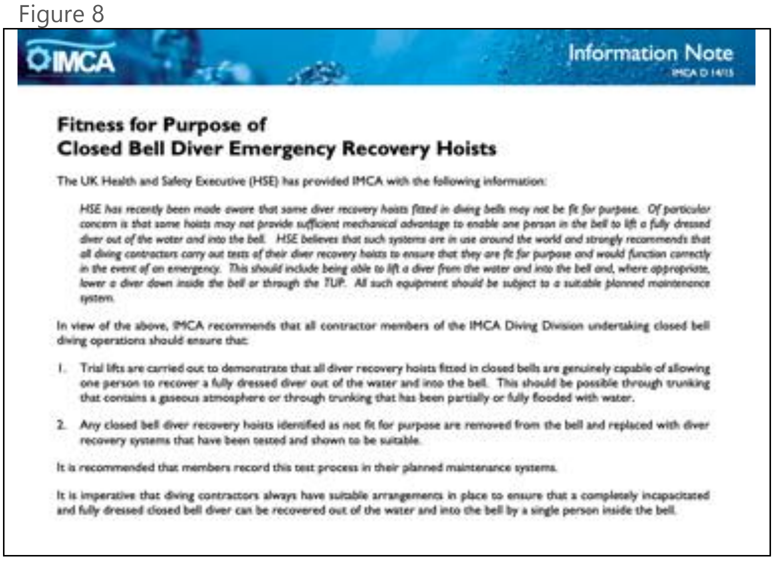
9 DIVER RECOVERY EQUIPMENT

Previous issues of this report identified that divers bell recovery equipment was not fit for purpose nor complied with legislation.

These issues were raised at IMCA SMTT Committee meetings leading to the issue of :

- IMCA Information Note 04-15 Fitness for Purpose of Closed Bell Diver Emergency Recovery Hoists issued on behalf of the HSE
- IMCA added Detail Sheet 36 Lifting Appliances and Equipment used in Closed Bell Diver Rescue Recovery Systems to IMCA D18

Figure 8


IMCA Information Note IMCA D 14/15

Fitness for Purpose of Closed Bell Diver Emergency Recovery Hoists

The UK Health and Safety Executive (HSE) has provided IMCA with the following information:

HSE has recently been made aware that some diver recovery hoists fitted in diving bells may not be fit for purpose. Of particular concern is that some hoists may not provide sufficient mechanical advantage to enable one person in the bell to lift a fully dressed diver out of the water and into the bell. HSE believes that such systems are in use around the world and strongly recommends that all diving contractors carry out tests of their diver recovery hoists to ensure that they are fit for purpose and would function correctly in the event of an emergency. This should include being able to lift a diver from the water and into the bell and, where appropriate, lower a diver down inside the bell or through the TUP. All such equipment should be subject to a suitable planned maintenance system.

In view of the above, IMCA recommends that all contractor members of the IMCA Diving Division undertaking closed bell diving operations should ensure that:

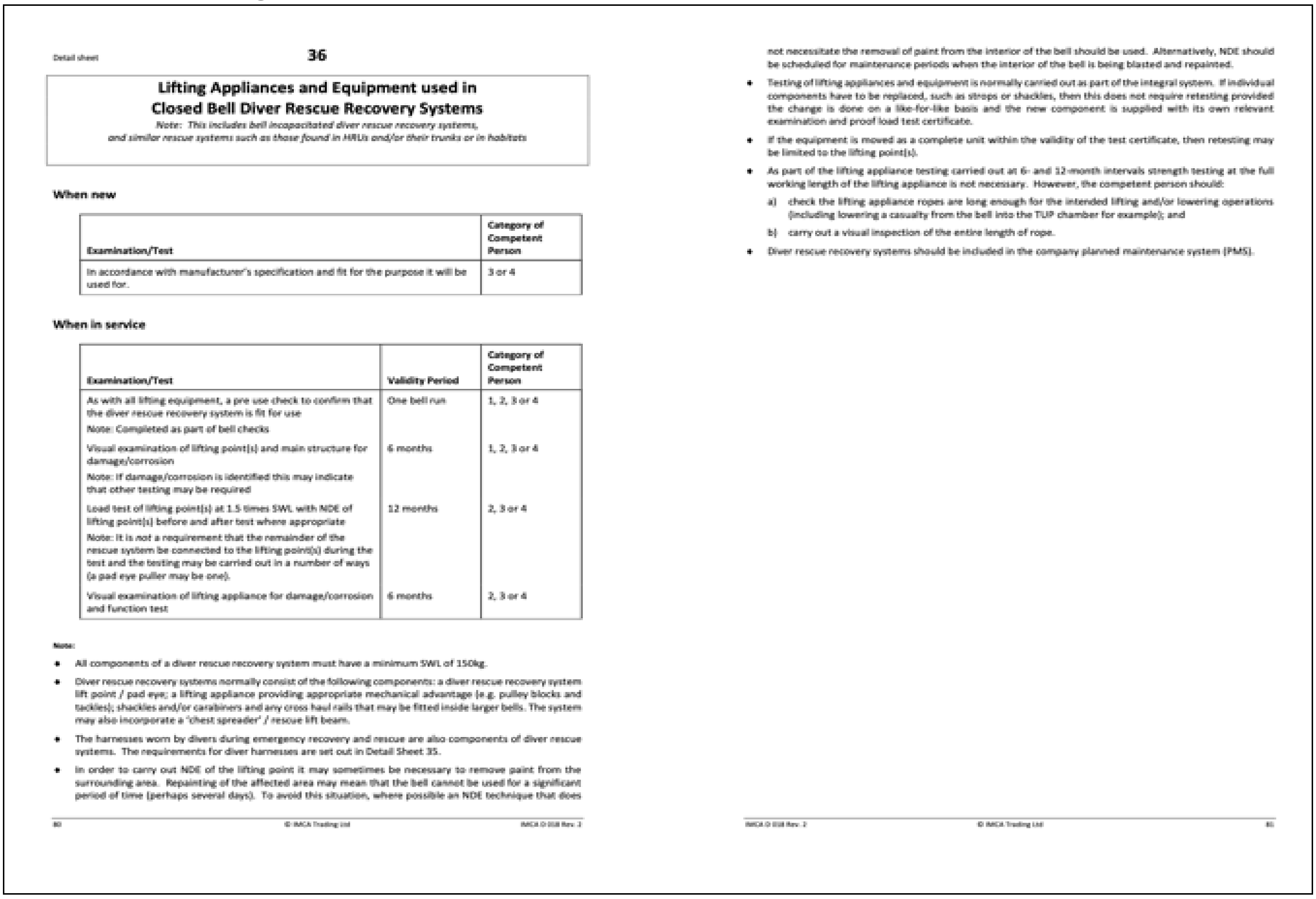
1. Trial lifts are carried out to demonstrate that all diver recovery hoists fitted in closed bells are genuinely capable of allowing one person to recover a fully dressed diver out of the water and into the bell. This should be possible through trunking that contains a gaseous atmosphere or through trunking that has been partially or fully flooded with water.
2. Any closed bell diver recovery hoists identified as not fit for purpose are removed from the bell and replaced with diver recovery systems that have been tested and shown to be suitable.

It is recommended that members record this test process in their planned maintenance systems.

It is imperative that diving contractors always have suitable arrangements in place to ensure that a completely incapacitated and fully dressed closed bell diver can be recovered out of the water and into the bell by a single person inside the bell.

IMCA D14/15

Figure 9


Detail sheet 36

Lifting Appliances and Equipment used in Closed Bell Diver Rescue Recovery Systems

Note: This includes bell incapacitated diver rescue recovery systems, and similar rescue systems such as those found in HRUs and/or their trunks or in habitats

When new

Examination/Test	Category of Competent Person
In accordance with manufacturer's specification and fit for the purpose it will be used for.	3 or 4

When in service

Examination/Test	Validity Period	Category of Competent Person
As with all lifting equipment, a pre use check to confirm that the diver rescue recovery system is fit for use Note: Completed as part of bell checks	One bell run	1, 2, 3 or 4
Visual examination of lifting point(s) and main structure for damage/corrosion Note: If damage/corrosion is identified this may indicate that other testing may be required	6 months	1, 2, 3 or 4
Load test of lifting point(s) at 1.5 times SWL with NDE of lifting point(s) before and after test where appropriate Note: It is *not* a requirement that the remainder of the rescue system be connected to the lifting point(s) during the test and the testing may be carried out in a number of ways (a pad eye puller may be one).	12 months	2, 3 or 4
Visual examination of lifting appliance for damage/corrosion and function test	6 months	2, 3 or 4

Note:

- All components of a diver rescue recovery system must have a minimum SWL of 150kg.
- Diver rescue recovery systems normally consist of the following components: a diver rescue recovery system lift point / pad eye; a lifting appliance providing appropriate mechanical advantage (e.g. pulley blocks and tackles); shackles and/or carabiners and any cross haul rails that may be fitted inside larger bells. The system may also incorporate a 'chest spreader' / rescue lift beam.
- The harnesses worn by divers during emergency recovery and rescue are also components of diver rescue systems. The requirements for diver harnesses are set out in Detail Sheet 35.
- In order to carry out NDE of the lifting point it may sometimes be necessary to remove paint from the surrounding area. Repainting of the affected area may mean that the bell cannot be used for a significant period of time (perhaps several days). To avoid this situation, where possible an NDE technique that does not necessitate the removal of paint from the interior of the bell should be used. Alternatively, NDE should be scheduled for maintenance periods when the interior of the bell is being blasted and repainted.
- Testing of lifting appliances and equipment is normally carried out as part of the integral system. If individual components have to be replaced, such as strops or shackles, then this does not require retesting provided the change is done on a like-for-like basis and the new component is supplied with its own relevant examination and proof load test certificate.
- If the equipment is moved as a complete unit within the validity of the test certificate, then retesting may be limited to the lifting point(s).
- As part of the lifting appliance testing carried out at 6- and 12-month intervals strength testing at the full working length of the lifting appliance is not necessary. However, the competent person should:
  - a) check the lifting appliance ropes are long enough for the intended lifting and/or lowering operations (including lowering a casualty from the bell into the TUP chamber for example); and
  - b) carry out a visual inspection of the entire length of rope.
- Diver rescue recovery systems should be included in the company planned maintenance system (PMS).

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IMCA D18 DETAIL SHEET 36

10 LOWERING AN INCAPACITATED DIVER (BOTTOM MATING BELL)

Industry requires all personnel to deploy personal fall protection measures where the risk of injury from a fall from height exists. When a bottom mating bell is locked onto the saturation system, and the doors open, the occupants are 'working at height'. There are several hazards:

Divers working at height with no fall protection

When ordering a new DSV or chartering a vessel of opportunity, diving contractors should be able to justify their decision to order a diving system with a bottom mating bell rather than a side mating bell, which would have eliminated the need to work at height.

If work at height cannot be avoided (bottom mating bells), the next step in the hierarchy of control is to implement control measures to prevent falls.

In this hierarchy of control for working at height, collective protection that prevents the risk of falls is given priority over PPE (fall arrest equipment) and other measures that can only minimise the height and consequence of a fall. There is no protection in a bell, so a guard rail/barrier is higher in the hierarchy than fall arrest equipment. Treat the cause, not the effects.

Lowering a diver on a single fall with no secondary

Being lowered through the trunking is different from 'working at height'. When working at height, the structure supporting the worker is the primary means of support. As a result, a person working at height only requires one point of contact to connect the fall prevention equipment.

Working at Height Regulations addresses system failure, so 'recovery after a system has failed' is still a problem that has to be addressed. i.e. What happens if the system binds up while the incapacitated diver is in the trunk/manway or a component catastrophically fails?

When being lowered through the trunking, there is only one piece of equipment and one supporting structure; therefore, a secondary system should provide 100% backup. This is how rope access techniques work. The rope access worker is 'dangling' and, therefore, not supported by the structure as his primary means. Therefore, rope access techniques require two independent attachment points and independent systems.

It is also important to note that diver harnesses are 'lift harnesses' and are not fall arrest harnesses. Therefore, when the inner door is open on a bottom mating bell, everyone in the bell is working at height. To lower an incapacitated diver, all the divers in the bell should be wearing a fall arrest harness or have mitigated the risk of injury due to a fall in another way. Harness use is defined by the standards they were manufactured to.

Potential for dropped objects

When working at height, there is always the potential for dropped objects. Using the 'DROPS' calculator, just about any piece of equipment falling out of the bell will be, at best, reportable. Divers in the wet pot below will assist in recovering the incapacitated diver back into the system. These divers are at risk from dropped objects.

Incapacitated diver recovery procedures and risk assessment should consider:

1. Risk assessment required for:
    - Divers working at height in a bell
    - Divers working on a slippery deck next to an unguarded drop
    - Type of sole on the divers boot and its grip co-efficient
    - Lowering an incapacitated diver on a single device with no back up
2. Items in the bell should be assessed against the DROPS calculator for potential severity
3. Procedures should identify that an IMCA D18, Detail Sheet 35 compliant harness is not a 'working at height' harness
4. A side-mating or dual access bell negates the need to work at height and/or lower an IP

11 DUTY OF CARE

11.1 DMT v 1st Aider

Earlier issues of this report identified flawed current practices regarding DMT levels in the bell. These issues were raised at a Diver Recovery working group in July 2014.

The flaw in the DMT manning levels related to the possibility that the bell team DMT(s) could be the IP and a diver 1st aider was not trained and competent to use all the equipment within the DMAC 15 bell first aid kit, namely equipment pertaining to (advanced) airway management:

- 2 Oropharyngeal airways size 3 and 4 (e.g. Guedel type)
- 1 or 2 correctly sized Supraglottic airways with catheter mounts and filters

IOGP 411 Recommended Practices for Diving Operations version 2, Appendix I Saturation Diving now identifies this:

> - All bell occupants to be competent in the use of all equipment to be held in a Diving Bell specified in DMAC 15

11.2 Bottom mating bell v Side mating/dual door diving bell

Earlier issues of this report identified that side mating/dual door bells are inherently safer regarding:

- Lowering an incapacitated diver and increasing the possibility of suspension trauma and further injury
- Divers working at height with no fall protection devices
- Potential of dropped objects from the bell to the TUP chamber

A side mating/dual door additionally:

- Allows good homogenisation/mixing of gases, decreasing the potential of an unconscious bellman on bell checks
- A patient can be immobilised by stretcher sooner within any incident
- A bell can remain flooded to assist in patient recovery, hypothermia and hydrostatically
- If a diver[s] were unconscious in the bell, there are no issues with raising the bottom inner door (collapsed on the door)
- Decreased bell turnaround times (single bell vessels)

IOGP 478 Performance of saturation diving emergency hyperbaric evacuation and recovery V2 now identifies this

> **7.1 Evacuation of divers from the diving bell**
>
> For evacuation of divers from the diving bell, a dual entry Submersible Decompression Chamber (SDC) should be considered that provides access to the SDC in the event of a blocked internal door (unconscious or paralysed divers in the bell).

12 CONTROL MEASURES SUMMARY & POTENTIAL ACTIONS TO IMPROVE DIVER RECOVERY

It is expected that offshore worksites will have in place operating procedures and practices implemented as a result of a formal risk assessment process.

An appropriate risk assessment process is required for all stages of a diving project and should include all bell emergencies. The relevant offshore personnel must be included at all the stages of the risk assessment process.

Accidents, ill health and incidents are seldom random events. The immediate cause may be human or technical failure, but they usually arise from organisational failings, which are the responsibility of management.

Potential Hazard / Consideration	Control Measure / Potential Action / RA Questions Summary
1. Depth of bell flood up	• Review the depth of flood up within the bell . Depth needs to allow the bellman to: ○ 'Float' the diver ○ Depth to be adequate that weight on crotch straps doesn't induce suspension trauma • Depth should not allow scrubbers, survival suits or electrics to be submerged • Consideration needs to be given to loose items within the bell • Is there a 'goose-neck' fitted to prevent over flooding? • Check original, class-approved, bell drawings to see if the flood up depth has been altered.
2. Supervisor controlled bell vent.	• Ensure that there are engineering controls that prevent a Supervisor controlled surface venting of the bell to stop at the designed flood up depth.
3. Bellman access to flood up valve	• The flood up valve should be accessible from the trunk. There should also be a hull isolation valve, if both valves aren't accessible from the trunk, procedures should state the valve positions.
4. Inadequate 'at depth' bellman equipment checks	• Ensure breathing apparatus and gas checks comply with manufacturers operating procedures • Check that all bellman's checks are formalized and there are no 'work-arounds' or non-documented custom and practices.
5. Bellman's diving equipment-thermal balance	• Risk assess if there is a requirement for a rescue with no hot water available-Develop 'hierarchy of rescue' • Consider the effects of cold-water shock on a diver wearing a BandMask • Ensure procedures state that the bellman's hot water supply is always flowing. This ensures that there is no delay in lockout and ensures that the hot water flow/volume is adequate for all divers
6. Bellman's diving equipment-PPE	• Check if local legislation allows a diver (Bellman) to lock-out without an emergency reserve • Risk assess site conditions to ensure that the bellman has at least the same PPE protection that the working diver has. Consider polluted water, chemicals and construction • Check the face fit and size of the BandMask. KMDSI introduced different size hoods and sealing faces in 2012. One size might not fit all.

Potential Hazard / Consideration	Control Measure / Potential Action / RA Questions Summary
7. Incorrect buoyancy properties of bellman's umbilical	• The buoyancy properties of the bellman's umbilical should be risk assessed (IMCA requirement). A buoyant umbilical might foul the bell/bell wires and provide too much up thrust to a deployed bellman. A negative buoyant umbilical might foul assets or seabed debris
8. Amount of bellman's umbilical deployed	• The DPP should state umbilical lengths, these should be kept as short as practicable, the working divers umbilical length dictates the bellman's umbilical length. • Umbilical management procedures should state how the bellman's umbilical is measured and secured for length. • Consideration needs to be given to the off-set distance of the bellman's umbilical • Consideration needs to be given to how the excess umbilical is secured and how it interacts with the quick release system
9. Bellman's umbilical quick release system and racking of umbilical	• Consider if the umbilical is actually 'quick release'. • Ensure that if there is additional securing devices such as bungees or rope that it has been risk assessed, MoC etc. Avoid the use of a knife. • If there is additional securing devices consider re-engineering the quick release • Ensure that there are procedures for racking the umbilical to ensure that it is racked correctly and deploys with minimum twists etc. • Do procedures and risk assessment consider bell recovery with the bellman's umbilical deployed? i.e. fully deployed after a real rescue. Consider the fouling of guide/wires and vessel thrusters and ROV
10. Routing of the bellman's umbilical on the bell	• Consideration needs to be given to the route of the umbilical from the storage position to the bell internal: ○ Is the umbilical clear of pinch points between bell and stage/guide weights ○ Are all moving parts of the guide weight guarded ○ Consider if heave compensation introduces additional risk ○ Can the bellmen deploy straight to the IP or does he have to re-route before leaving the stage?
11. Bellman's gas	• Do bellman's gas checks adequately check that all safety devices work? Depending on configuration this could be OBG coming on line automatically or proving the bellman's secondary (Common with divers primary) is protected (IMCA D24 Section 6 Item 6.35) • If the bellman breathes from the bell pressurization gas, either as primary or secondary, and that gas line is also a supervisor controlled valve: Are there adequate engineered control measures to protect the bellman when breathing from that supply?

Potential Hazard / Consideration	Control Measure / Potential Action / RA Questions Summary
12. Bellman deployment and recovery drills	◆ Is locking out of the bellman in the drill matrix? If so: o Are there procedures o Is there a risk assessment? o Is this included in the divers competency? o Do drill procedures/competence require release of bellman's umbilical? o Is the bell hacksaw ready for immediate use? o Does the bell's communication allow the bellman to hear the diver and supervisor ? ◆ Are divers actually competent to use a BandMask? Training isn't competency ◆ During diver rescue drills it must be stressed that in a real life emergency; all equipment is disposable. No one cares about the cost of a cut umbilical; ditched helmet and bailout; nor vessel scheduling. The number one priority and over-riding concern is the preservation of life
13. Hierarchy of Rescue. The default rescue should not be the bellman locking out and rescuing the IP	◆ Procedures should state the preferred Hierarchy of Rescue, specific to team size and bell configuration. Consider: o Rescue by another diver already locked out o Rescue by another diver in the bell on their equipment o Recover the IP from within the bell by coming up on their umbilical (consideration on weak-link) o Recovery of IP from the guide weight/stage by the bellman coming up on the IPs umbilical o Final and least desirably bellman deploying their umbilical and leaves the stage (with no bailout) ◆ Are procedures part of diver and supervisor familiarisation process? ◆ Are procedures posted/immediately available in dive control? ◆ Procedures should state that whenever there is a working diver in the bell (three man bell run) they are the rescue diver, not the bellman. Therefore their equipment should be ready to lockout.
14. Contaminated gas and flushing the umbilical	◆ Do procedures state how long a diver should flush a helmet for to know that all contamination has been removed from the umbilical? o Flushing entire umbilical from vessel for secondary supply (450m) o Flushing divers umbilical for OBG (70m)

Potential Hazard / Consideration	Control Measure / Potential Action / RA Questions Summary
15. Initial assessment and action by rescue diver of IP	• Do procedures state the immediate actions a rescue diver carries out when reaching the IP? • Do procedures state the immediate report a rescue diver communicates to the supervisor, when reaching the IP? • Do procedures state the actions of the supervisor? • Do procedures state that the rescue diver jettisons any tools etc that they or IP have attached to their harness? (Potential fouling hazard) • Do procedures consider the type of bailout worn? Cylinder style and rebreathers will have different reports and different actions
16. Use of pneumo	• Does pneumo give adequate flow and volume as a breathing gas? • Does pneumo supply come from a different supply than reclaim supply? • Consider adding a length of softer hose to the end of pneumo so can be easily inserted under neck seal and end JIC fitting cannot cause injury (same as IMCA D23 Section 5 Item 2.3 Emergency Air…. a length of hose which is rigid enough to be pushed up inside the neck seal of a diving helmet. • Do procedures state the length of pneumo required and securing arrangement so it can be inserted and not accidently pulled out during rescue? (rescue diver and IPs pneumo length) • Consider Q/C fitting • Is use of pneumo included in procedures, training matrix, competency and is it risk assessed? • Consideration needs to be given to the use of a pneumo during an emergency (not just IP rescue) if a Stab jacket is worn. There will be a quick connect fitting that connects to the stab jacket when in use may not allow gas flow when removed from the jacket
17. Rescue lanyard	• Are lanyards supplied by the contractor? • Are lanyards approved? • Are lanyards a set type, length and standard to the company? • Do pre-dive checks ensure each diver has a lanyard? • The lanyard can be used on the IPs umbilical and attached to the harness dorsal D-ring to help align the diver in the trunk for entry

Potential Hazard / Consideration	Control Measure / Potential Action / RA Questions Summary
18. Lowering of stage/guide weight to assist in recovery of rescue diver and IP	• Does a PLC controlled stage/guide weight allow the lowering or are there over-rides required? If so are they procedurised and personnel competent to do it? • Are procedures specific to the type of stage/guide weight? • Are all moving parts of a guide weight guarded against umbilical/finger entrapment? • Are there rescue procedures for open water and another for near assets? • Company procedures may state that there is a minimum stand-off from assets and seabed, is there an MOC for over-riding this in an emergency?
19. Use of stab jacket (Diver worn buoyancy vest)	• Has the use of a stab jacket been adequately risk assessed? (i.e. maximum upward excursion) • Do procedures identify the actions of a rescue diver when the IP (and possibly the rescue diver) are wearing a buoyancy vest?
20. Diver recovery man-lift	• Consideration should be given to providing a second pulley system in the case of bells where more than one diver may be locked out and require recovery • Does the man-lift really comply with IMCA 18 Detail Sheet 36 ? • The contractor should carry out their own lifting trials on the harness and decide where best to attach the man lift. Different harness lift points give different angles of lift. • Harness type should be standardised across the fleet • Is there sufficient rope/fall length for worst case or is there another man-hoist available in the system? • Are there instructions for use in the bell and is it clear that the man-hoist is for lifting of personnel only and is not used for lifting equipment into the bell or opening the bottom door? • Are there procedures and risk assessment available for using the man-riding equipment, in particular the lowering of an IP into the system? • Consideration should be given to where best locate the recovery device anchor point
21. Bell report on IP	• Consideration should be given to a standardised verbal assessment given by the rescue diver to the supervisor immediately the IP has breathing apparatus removed. Procedures should have required the vessel medic to be in dive control listening to the report. The medic can then commence assisting the bellman with required treatment. • Bell first aid kits should be easy to access in an emergency. Risk assess how easy it is to access the contents of the first aid kit. Consider that the bell will be flooded and the lack of shelving in a bell. A tool roll type kit that can be hung, might be useful.

Potential Hazard / Consideration	Control Measure / Potential Action / RA Questions Summary
22. Working at height	◆ Are there procedures supported by a robust risk assessment for divers working at height when the bell is locked on and bottom door open? ◆ Does the PTW include divers working at height? ◆ Is there adequate fall protection? (That follows the hierarchy of control when working at height) ◆ Has there been an assessment for slip? Has footwear been assessed for slip co-efficient?
23. Dropped objects	◆ Are there procedures and risk assessments for passing equipment in/out of the bell when mated? ◆ Are there procedures and risk assessment to prevent dropped objects? ◆ Have all potential dropped objects been assessed for their consequence potential against the DROPS calculator?
24. Supervisor actions during an emergency event	◆ Is there a formal documented unambiguous statement from senior management that allows the on shift supervisor to act in a dynamic way during an emergency to preserve life? ◆ Is there a formal documented unambiguous statement from senior management that allows the on shift supervisor to jettison / dispose all equipment if necessary? No one cares about the cost of a cut umbilical; ditched helmet and bailout; nor vessel scheduling. The number one priority and over-riding concern is the preservation of life ◆ Does the supervisors LOA allow the supervisor to act out with company procedures?
25. Competency	◆ Are divers competent in delivering CPR in the bell? ◆ Are divers aware that suspending a diver and delivering CPR is futile/dangerous? ◆ Are divers aware of suspension trauma? ◆ Are all divers formally competent in the use of all medical equipment in the DMAC 15 first aid kit and competent to perform advanced airway management? ◆ Are divers and supervisors competent with the diver held transponder? ◆ Are the following in the diver competency matrix? o Delivery of CPR in the bell o Locking out and releasing bellman's umbilical o Breathing off a pneumo o Locking out on primary supply and allowing secondary supply to activate (proving that any protection devices work)

Potential Hazard / Consideration	Control Measure / Potential Action / RA Questions Summary
26. Diver rescue procedures	Do diver rescue procedures consider: ◆ Bell and bell valves ◆ Size of bell team ◆ Potential of a double rescue and hierarchy of recovery (who gets recovered first) ◆ Length of umbilical deployed ◆ Buoyancy properties of each umbilical ◆ Removal of IPs hot water and boots immediately before hoisting into the bell? ◆ Type of bailout worn ◆ If stab jacket is worn ◆ Type of bell stage/guide weight ◆ Height of seating in the bell ◆ Best position in the bell to deliver CPR (approved by company hyperbaric doctor) ◆ Training of divers in real-life CPR position in the bell ◆ If there is an intermediate tending point and active tender (including extended umbilical) ◆ If there is an intermediate tending point and passive tender (including extended umbilical) ◆ Is there concurrent air diving operations with a potential that an air diver could assist? ◆ Are procedures posted/immediately available in dive control? ◆ Are procedures easy to follow (flow chart)? ◆ Are procedures (more or less) standardised across the fleet? ◆ Are all medical procedures approved by the company hyperbaric doctor? (CPR, suspended diver) ◆ Are procedures approved by offshore management, including the supervisor? ◆ Is assistance by ROV considered? ◆ Procedures should state that whenever there is a working diver in the bell (three man bell run) they are the rescue diver, not the bellman. Therefore their equipment should be ready to lockout. ◆ Diver recovery procedures should be removed from the diving contractor's company diving manual and placed into the vessel specific emergency procedures manual therefore specific to how the rescue is conducted on that vessel ◆ Procedures should state that if the supervisor believes that there is an incapacitated diver he should call an All Stop on any on-going lifting devices and vessel move ◆ Procedures should state where each incapacitated diver is placed in the bell and how they are secured. IMCA D24 Section 5 Items 6.58/9 no longer requires a seat for each diver, however does require restraints for each diver

13 FURTHER DIVER RESCUE CONSIDERATIONS

These considerations were included in the original issue of this report. Since then, an incident in the North Sea has provided evidence that some of these diver rescue considerations do work.

The Bibby Topaz lost a diver during a DP run-off. The diver was at approximately 100msw when the vessel lost DP, and subsequently, the diver's umbilical parted.

The diver was left on top of the subsea asset he was working on, which had a very limited bailout supply and no hot water. The gas supply in the bailout was quickly breathed down. The diver survived for over 30 minutes without breathing and without active heating. The diver survived by a combination of high oxygen within his body tissues and very low core temperature.

The above incident proves that the 'consideration' could have positive benefits during a diver's recovery.

By closing the diver's hot water, there are potentially several beneficial outcomes:

- If the diver has only a communication problem and his hot water has been diverted, he will immediately return to the bell. He will also realise that his communications are down. Hot water can be re-instated, and the bellman can stand down
- If the unresponsive diver does not start heading back, the supervisor knows an incident is occurring.
- The supervisor is registering the diver's level of consciousness (via the Glasgow coma scale)-AVPU.
- If there is a delay in locking out the rescue diver and the possibility that the IP will breathe down their bailout, lowering the core temperature may be beneficial.

Diving Response

Becoming cold very quickly may produce a body reflex called the 'diving response'. The diving response is more evident in the very young (infants and toddlers). It consists of a slowing of the heartbeat, a decrease or cessation of respiration, and a dramatic change in blood circulation, with circulation only to the inner core of the body—the heart, lungs, and brain. The casual observer sees this victim as cold, blue, and not breathing. These victims appear dead.

This response is attributed to victims who fall through ice and have been underwater for a long time. Some of these people have survived. Cold water immersion victims, in some cases, have been fully resuscitated. A saturation diver will have an abundance of O_2 in his circularity system, considerably more than any of those who fell through the ice. Remembering that a none breathing person (due to respiratory and cardiac arrest) requires O_2 and CPR within 6 minutes, or brain damage may occur

Haemorrhaging Injury

The cold makes the vascular system constrict and prevents further blood loss. This could apply to a diver with a large haemorrhaging injury. If the diver's hot water was closed, would the diver's vascular system constrict due to the cold and reduce blood loss?

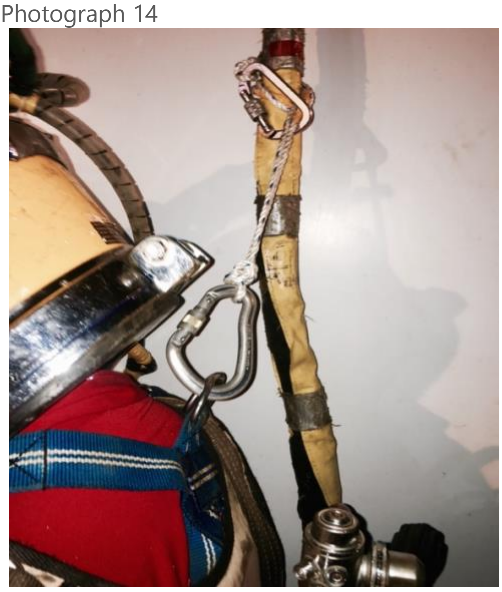
CPR

There is no point in recovering the incapacitated diver first, as any first aid / CPR will have to cease compressions to allow the second diver to be locked in. The fundamental point is that you must only start CPR if you can continue it. (stated in the USN manual and taught in the DMT course)

The actual events and injury may dictate events, but realistically, the bellman can only achieve something once the second diver is in.

If the diver is not breathing and anoxia is not suspected, his circulatory system should have an ample supply of O_2, especially if he has been breathing off his bailout. The second diver enters the bell, and the incapacitated diver only enters. The second diver can sort the bell for leaving the bottom, and the bellman can administer first aid.

Photograph 14



Rescue lanyard used to align IP to trunk

Aligning the IP in trunk for entry

The rescue lanyard can be utilised to align the IP with entry to the bell. If the lanyard is chocked on the IPs umbilical and secured to the dorsal D-ring it gives the bellman a horizontal pull (Photograph 14). This can be helpful in aligning the IP as the slack is taken out of the man-lift.

Photograph 15

Chest Spreader

Chest spreader

A diver recovery 'chest spreader beam' is used and attached to the thoral lifting points and should be part of the bell load out. Any chest spreader should be in the lifting register and PMS.

Extended Pneumo Hose.

This extension allows different length 'usable' hose ends for different applications, prevents damage to neck seal and injury to divers head/face , keeps the JIC end fitting intact for testing purpose and use with a buoyancy device (Photograph 16).

The red tape marks the safe distance the hose should be inserted under the neck seal to potential injury.

Photograph 16

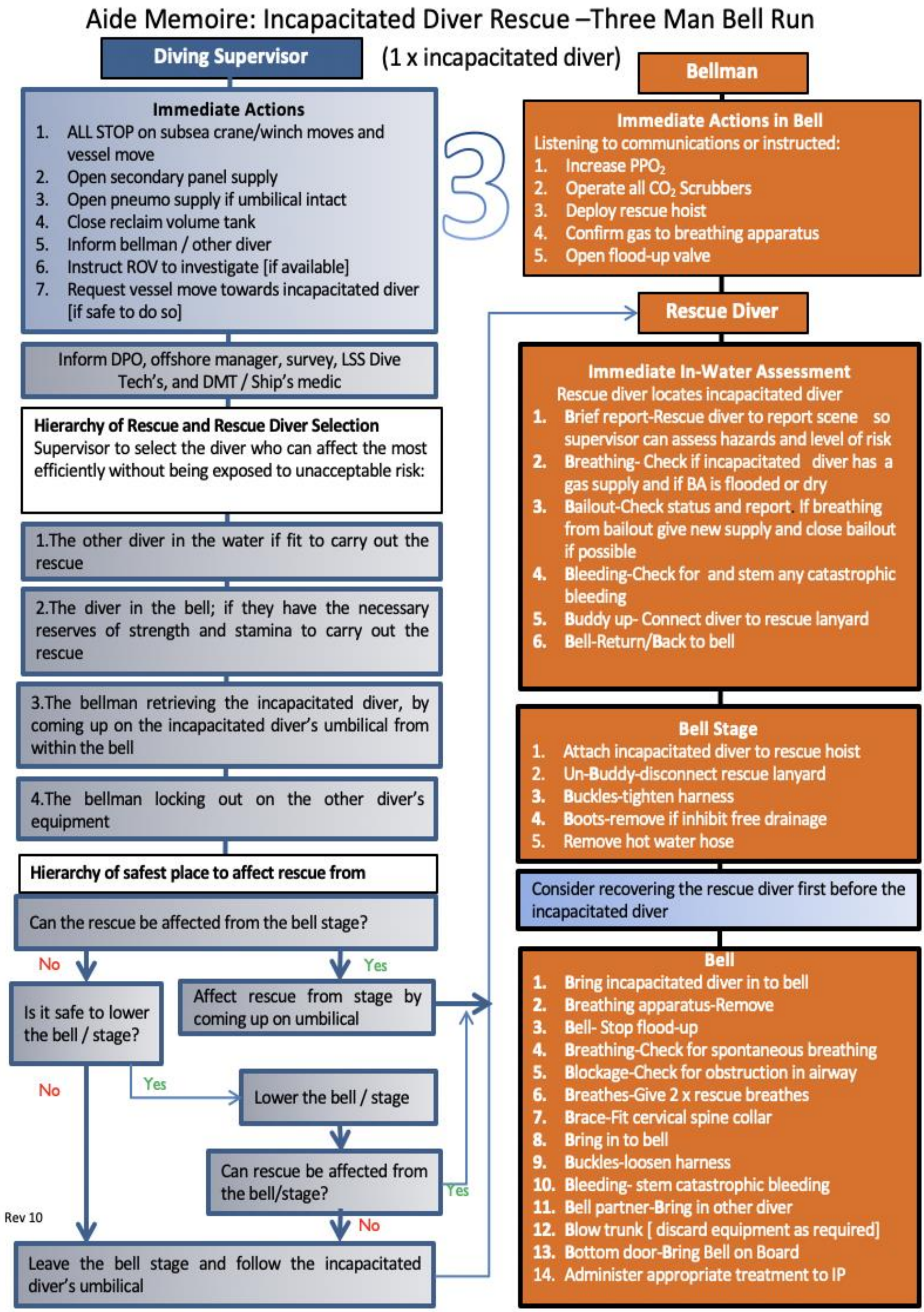
Pneumo extension for easy insetion

APPENDIX 1 EXAMPLE HIERARCHY OF RESCUE

Nearly all diving manuals limit procedures to a bellman lockout and rescue; this is the least preferred action. The hierarchy for a rescue of one incapacitated diver in the water should be as follows;

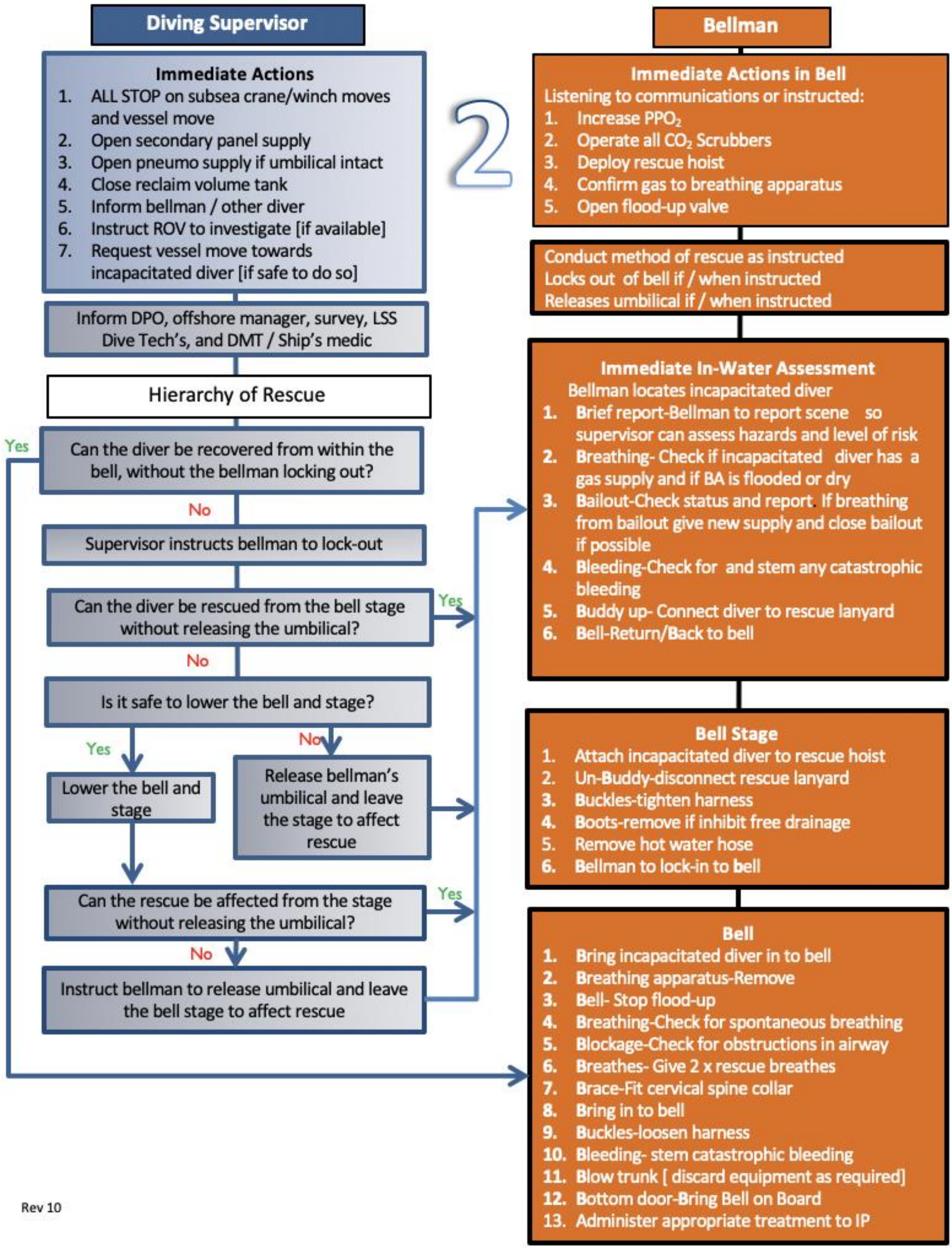
1. Any other diver in the water
2. Any other diver in the bell (could be waiting to lock out or sat in bell due to an 8-hour bell run)
3. Bellman locks out and recovers an incapacitated diver to guide weight by pulling him on the umbilical.
4. The least desirable –bellman locking out and releasing Diver 3's umbilical and recovering the incapacitated diver

APPENDIX 2 EXAMPLE NON-BELLMAN RESCUE FLOW CHART

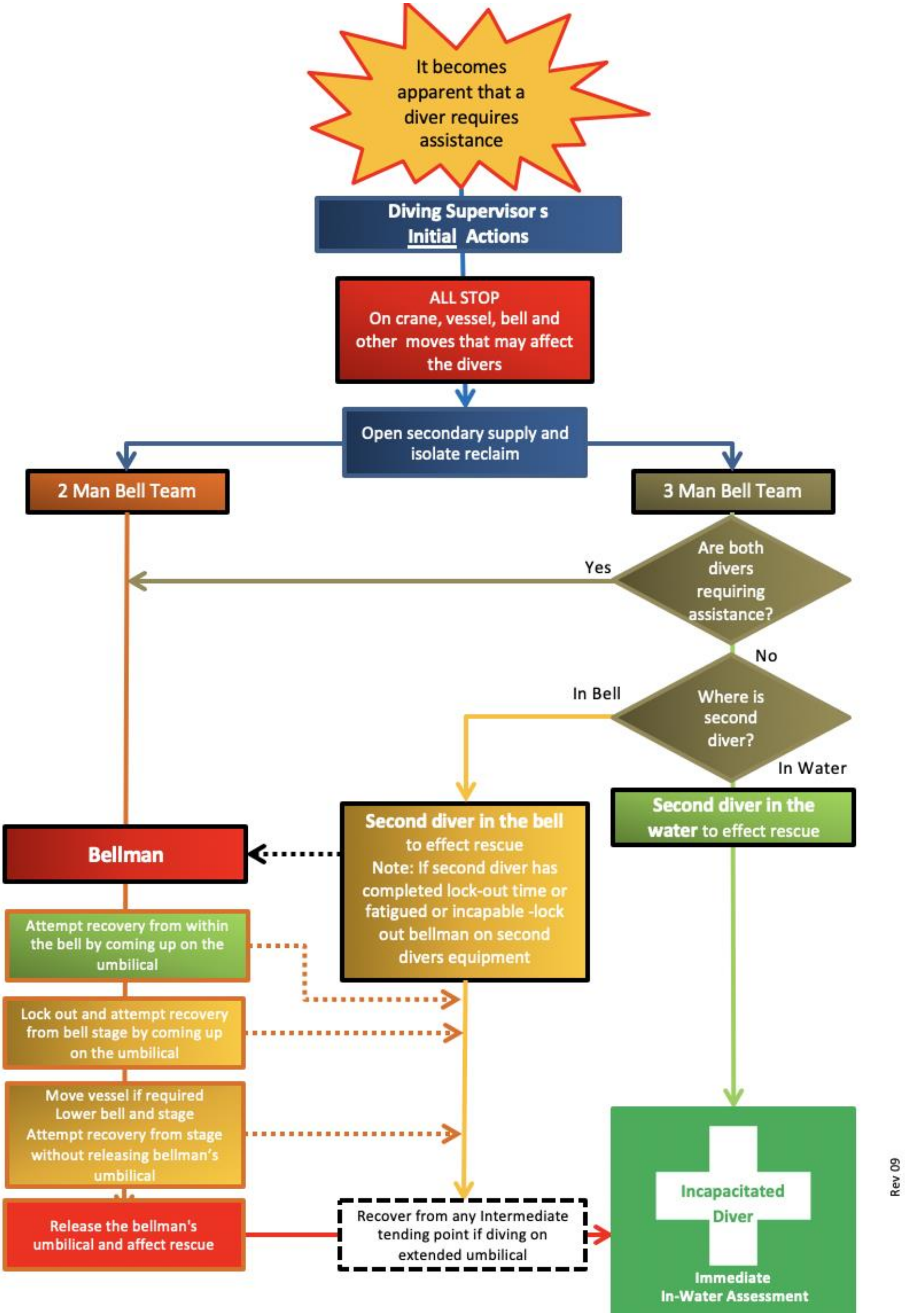


APPENDIX 3 EXAMPLE BELLMAN LOCKOUT AND RESCUE FLOW CHART

Aide Memoire – Incapacitated Diver Rescue –Two Man Bell Run



APPENDIX 4 EXAMPLE OF SUPERVISOR ACTIONS FLOW CHART



Note: The author has not attempted to procedurised a multi-casualty rescue

APPENDIX 5 REFERENCES

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Figures, Photos & Flow Charts

Photographs-Author
Figure1,8 & 9 IMCA
Figure 2, 3 & 4 The Principles of Safe diving Practice
Figure 5 NHS University Hospitals of Derby and Burton
Figure 6 TOTAL Energies
Flow Charts-Author