Safety Observation:

Commercial Divers Attachment Method to their Excursion Umbilical

4 Seas Safety Ltd

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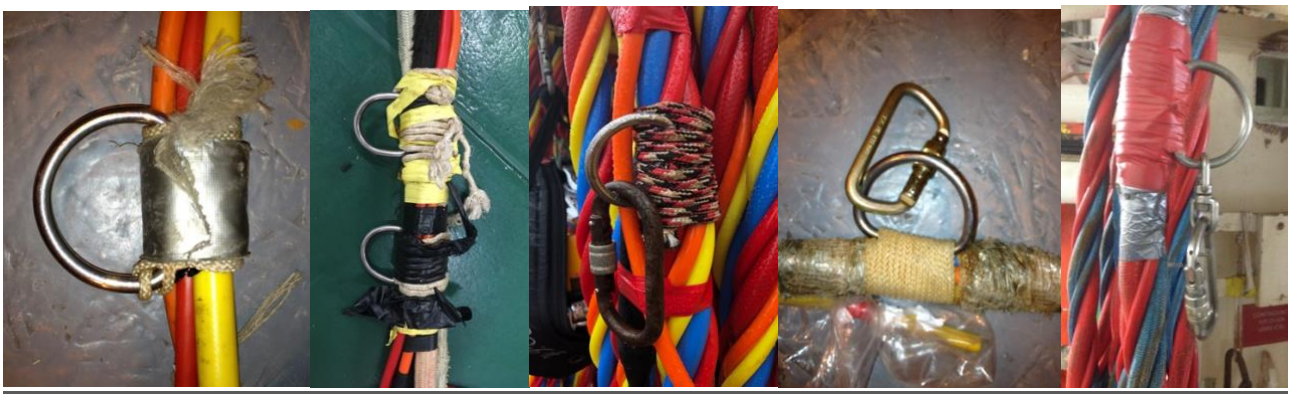

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Revision and Distribution History		
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06	July 2024	Annual Review. Added IMCA D78. Font change. Check with Grammarly

1.0 Introduction

A diver's umbilical arrangement comprises various components: umbilical, harness, D-ring with binding and a link connecter between the umbilical D-ring and harness securing point.

The diving industry seeks to minimise the effects of any potential equipment failure by setting testing criteria. This report identifies that diving industry leaders and influencers should consider including components, testing, and inspection in industry guidance material.

There are standards for diver harnesses, umbilical manufacture and testing; however, there are no standards or guidelines for umbilical security to the diver. There are also no in-service test criteria for D-ring security or the person's competency binding any D-ring to an umbilical.

The diver's attachment to their excursion umbilical is safety-critical; although the probability of failure is low, the impact would be high and possibly fatal for the diver.

1.1 Aim

This safety observation report aims to highlight to industry leaders and influencers that there are gaps in the procedural, equipment selection, testing and auditing of the connection assembly components between the diver's umbilical and harness.

1.2 Objectives

- Highlight inconsistencies in the diver's attachment to their umbilical, the equipment used, the testing, the auditing, and the competencies of those securing any D-ring to an umbilical.
- Suggest better working practices for commercial diving industry leaders and influencers for discussion and workgroups.
- Encourage industry workgroups to seek to implement uniformity throughout, conclude rational outcomes for changes to Codes of Practice and inspection guidance notes, and improve diver safety.
- Suggest an alternative method of attachment that is approved for lifting equipment.
- Update practice and thinking on how and where the diver and umbilical are connected.

2.0 Umbilical Tension Relief: Description of Assembly and Considerations

The diver is connected to their umbilical by the harness they are wearing, which is connected by a steel connector to a D-ring bound to the umbilical.

Standard industry references for the strength properties of the umbilical and tension relief assembly are:

- EN15333: '*The apparatus shall have a lifeline that can be used to help recover a diver in distress. It may be a separate line or can be the umbilical. The lifeline, including any connectors, shall be capable of withstanding a tensile load of 3500N* (approx.360kgf) *without damage'.*
- NORSOK implies that a diver may be recovered by their umbilical: '*The umbilical shall be of sufficient strength to ensure intact vital functions during emergency recovery'.*
- IMCA D22: '*The umbilical also acts as a lifeline and should be strong enough to lift a fully equipped diver from the water'.*
- IMCA D78: '*The umbilical also acts as a lifeline and should be strong enough to lift a fully equipped diver from the water.'*

The diving industry requires that a diver can be recovered by their umbilical, therefore necessitating the requirement for tested, certified lifting equipment.

2.1 Diver Harness

Standard industry references for divers personal harnesses are:

- IMCA D18 *Code of Practice for The Initial and Periodic Examination, Testing and Certification of Diving Plant and Equipment* requires; '*Manufactured to an appropriate national or international standard and fit for the purpose for which it will be used.*'

- EN 15333 requires, '*The body harness shall provide a method to securely attach the umbilical to the diver. Each securing point on the body harness shall withstand a tensile load of 3 500 N* (Approx. 360kgf) *for 5 minutes*'

- ADCI: Harness, '*Is equipped with at least one attachment point for the umbilical that is rated to at least the same breaking strength as the lifeline or strength member in the umbilical bundle. If the harness has multiple attachment points of different strengths, those suitable for umbilical attachments are to be clearly identified. Each securing point intended for attaching an umbilical or lifting a diver out of the water in an emergency shall withstand a tensile of at least 2,000 pounds*' (907kg)

Currently, IMCA does not clearly state that a personal harness or 'lift harness' is to be worn by a diver. IMCA D22 implies that a 'lift harness' should be worn for SRP diving operations: '*There should be two full sets of diving equipment, including appropriate harnesses to aid diver recovery.*'

- Note: EN15333 distinguishes between the 'Body Harness' and the 'Lift Harness'. The body harness carries the independent emergency supply; therefore, it is the bailout harness/jacket, stab jacket, or SLS system in commercial diving.

- The lift harness is worn closest to the diver's body and used to recover an incapacitated diver.

Note: No 'personally owned' harnesses should be on-site; all harnesses should be tracked through the company PMS and comply with IMCA D18 Detail sheet 35.

Further investigation should be carried out to see if the industry should advise where the umbilical should be connected to the diver or if contractors should risk assess and state in their diving operations manual.

Consider the advantages and disadvantages:

- Surface-supplied divers typically connect their umbilical to their body harness, which carries the emergency reserve. Connecting to the bail-out harness most likely is custom and practice in case the diver needs to ditch their equipment and carry out a free ascent; also, attaching to the harness saves time when undressing when carrying out Sur-D-O_2.

- EN15333 states, '*The body harness shall provide a method to securely attach the umbilical to the diver. Each securing point on the body harness shall withstand a tensile load of 3500 N for 5 minutes*'. Therefore, the bailout harness, SLS and Stab jacket should conform to EN15333. Typically, this is not the case; bailout harnesses comply with EN250:2000 respiratory equipment, such as open circuit, self-contained air diving apparatus. There is no lifting/D-ring pull requirement in EN250:2000; however, manufacturers may have tested the tensile load themselves.

Note EN250:2000 has been withdrawn and replaced by EN250:2014

- Closed bell divers typically attach their umbilical to their lift harness. This practice is so that, if required, they can remove the bailout before entering the bell trunk during standard and emergency operations. The bellman only wears a lift harness; therefore, the umbilical attaches to it.

2.2 Load-Bearing Connector

The universally accepted method of attaching the umbilical to the diver and providing tension relief to the individual hose ends on the diver's helmet is utilising a load-bearing connector between the diver's harness and a D-ring bound onto the umbilical with cordage.

Load-bearing, gated 'carabiners' connect the diver's harness to the diver's umbilical. The carabiners are commonly rated for a safe working load of 5kN or more (equivalent to approximately 500 kg).[Wiki]

Standard industry references for load-bearing connectors are:

- IMCA DESIGN: '*The diver's end of the umbilical should be fitted with a means which allows it to be securely fastened to the diver's safety harness without putting any strain on the individual whip ends.*'
- EN15333: *'The umbilical shall be attached to the diver such that it cannot inadvertently be released underwater by the diver, fouling or other incidents.'*
- The USN require a snap shackle (Gibbs Clip) assembly at the diver end.
- KMDSI: '*The umbilical must now be hooked to the diver's harness utilising a* suitable clip *that is bound to the umbilical. Some divers and companies prefer a quick-release clip, and others prefer a clip that is screwed together so the diver cannot easily remove it from his harness*.

Picture 1

Screw-gate, non-stainless oval carabiner. The screw gate will eventually fail due to dissimilar metals and exposure to seawater/air

Picture 2

Seized oval screw-gate carabiner with 'snap-shackle' The carabiner has suffered fretting and dissimilar metal corrosion. In this example, the diver had the connectors permanently attached to the harness.

Picture 3

Screw-gate stainless D shaped carabiner. This assembly has a swivel arrangement fitted. The D-ring would have been cut to allow the swivel to be fitted. It was not known if the D-ring was re-welded.

Picture 4

D type stainless carabiner with webbing lanyard and unmoused stainless two-part shackle.

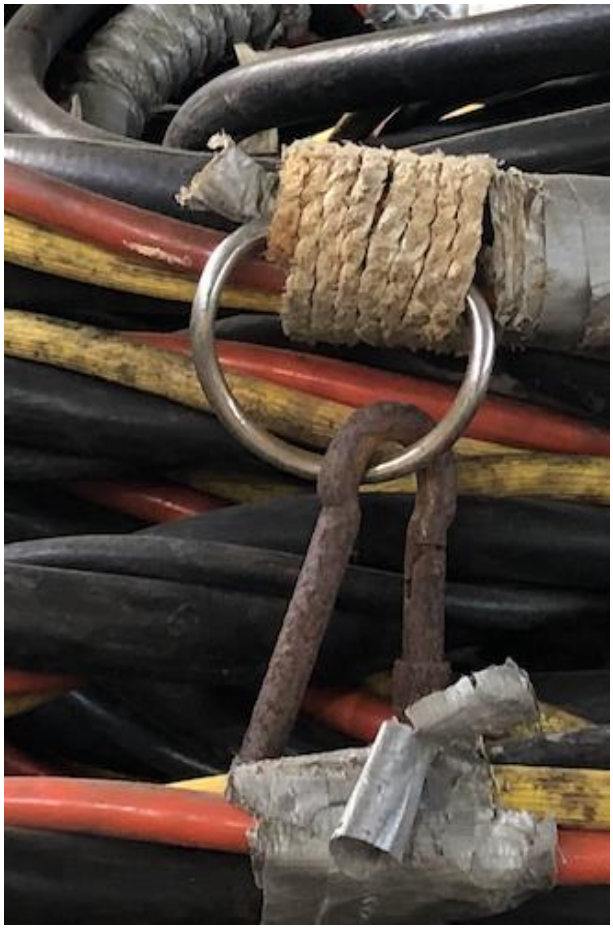
In this example, the diver had the connectors permanently attached to the harness.

IMCA is non-specific in DESIGN on how the following is achieved: "*The diver's end of the umbilical should be fitted with a means which allows it to be securely fastened to the diver's safety harness without putting any strain on the individual whip ends.* "

- Consider a study detailing the exact type of carabiner required. Some manufacturers offer options for carabiners with short chain lengths or carabiners/snap shackles fixed within the D-ring. Different-shaped carabiners are available and made from different materials.
- Consideration should be given to any locking mechanism. A non-locking carabiner has the potential to come unattached in a similar method as a 'latch' or 'snap' hook can become accidentally detached/reattached during subsea lifting (IMCA D60 Item A-1 8.1)
- IMCA D78 '*All carabiners used should be a lockable type'* (This is in reference to extended umbilical diving)
- Contractors should consider where the load-bearing connector is permanently attached. It could be permanently attached to the umbilical and inspected as part of the umbilical PMS or permanently attached to the diver's lift harness and included in the harness inspection. Both have advantages and disadvantages.

EN15333 states: "*The umbilical shall be attached to the diver such that it cannot inadvertently be released underwater by the diver, fouling or other incidents.*" This statement would indicate that any carabiner shall be screw-gate. Some diving equipment suppliers supply snap shackles with cord lanyards for easy release; this would contradict the EN15333 requirement as 'Gibbs clips' can be easily released.

Picture 6



- Mild steel screw-gate connector
- Connector not load-bearing
- This connector is seized
- Incorrect size of binding material
- The incorrect type of binding material
- Binding not protected by tape

This type of gated connector is commonly used to secure netting in food containers offshore.

Safety Flash 25-21 has an incident (non-diving) where an inappropriate spring snap-hook was used for lifting operations; unqualified loose gear should not be used for any lifting work.

2.3 D-Ring

The carabiner is clipped into the D-ring. D-rings are generally 2"-3" long by $^{3}/_{16}$" stainless steel, and some manufacturers state that the SWL is 500kg or more. (Picture 6)
The USN's Umbilical Manual requires:

- *If, during repair or assembly, the D-ring and shackle assembly have been welded or otherwise altered, or if not procured from the original manufacturer as a D-ring and shackle assembly, then the D-ring must be pull tested to 500 pounds(227kg) and support the weight for a minimum of 10 minutes without distortion, bending, or other damage*

- The USN Umbilical Manual requires the following criteria for a D-ring; *"If not procured as a D-ring and shackle combination, or if cut and welded during construction, the D-ring must be load tested."* Diving contractors should procure certified D-rings or tests before attaching them to the umbilical.

- The USN Umbilical Manual gives various sizes of D-rings: ¼" and $^{3}/_{8}$" diameter

Picture 6

Heavy-duty 2" x ¼" D-Rings
Manufacturer states;
SWL 500kg
Breaking load 1,350kg

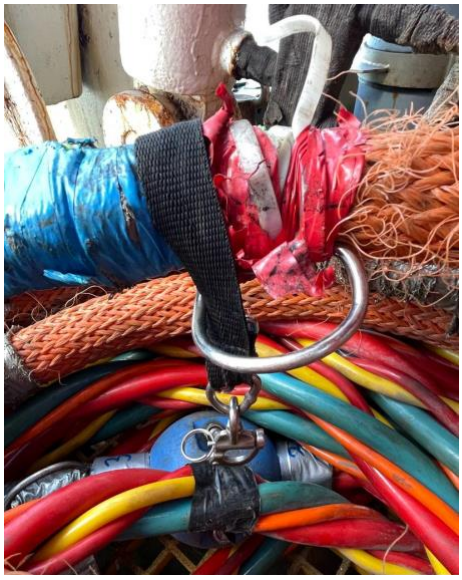
Picture 7

Two different sized D-Rings on the same umbilical

Picture 8

Nickle plated light-weight D-ring with 55^{O} bend, commonly used as a strap-down strong-point

Picture 8a



Picture 8a shows;

- Lightweight D-Ring, not suitable for weight bearing
- D-Ring secured with Tie-Wraps, contrary to best practice

It appears that the user realises that the binding is not appropriate and has attempted to secure the D-Ring with an IMCA D58 compliant 'Weak Link' used for securing the diver during DP operations

Note: All photographs show umbilical and D-rings from IMCA-approved Diving Contractors. All of these have 'passed' the appropriate DESIGN inspection.

2.4 Umbilical Strain Relief Methods

2.4.1 D-Ring Attachment Binding

The D-ring is typically attached to the diver's umbilical by a rope binding.

The only industry reference found for the installation of the D-ring is the USN Umbilical Manual (Summary):

- The USN Umbilical Manual gives the procedure for binding the D-ring to the umbilical using a $^{3}/_{16}$" nylon cord.
- On no occasion should tie wraps/cable ties be used to attach the D-ring to the umbilical.
- The USN Umbilical Manual requires the umbilical hoses to be pressurised to normal system pressure while seizing to account for the expansion needed during operation. USN hoses are rubber; this might not be required on a modern spiral wound high-performance polymer umbilical
- The USN Umbilical Manual recommends finishing the binding by wrapping the completed assembly with two layers of Polyken (preferred) or duct (alternate) tape.
- The USN Umbilical Manual does not require binding on top of duct tape.

Picture 9

D-ring attached by binding and cable-tie.
USN Umbilical Manual recommends Polyken or duct tape cover not electrical tape

Picture 10

Binding is exposed and damaged.
USN Umbilical Manual recommends Polyken or duct tape cover not electrical tape

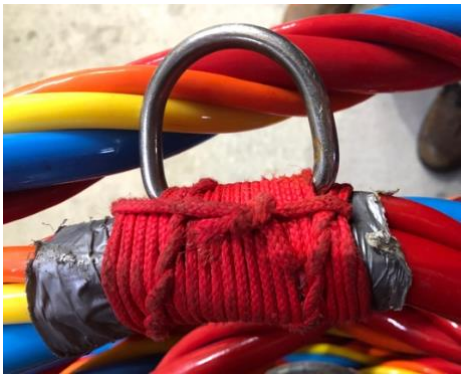
Picture 11

Inappropriate material for binding, the rope diameter is too large for effective binding.
Binding not protected by tape

Picture 12

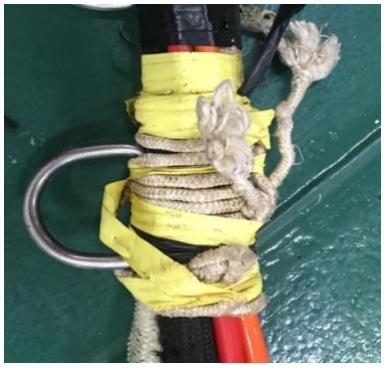
Damage to the binding.
Binding is on a layer of duct tape.
Binding not protected by tape.

Picture 13



Poor method of binding with an exposed reef knot.
Binding on a layer of duct tape.
Binding not protected by tape.

Picture 14



No Comment

2.4.2 Alternative Strain Relief Method

A nylon cord binding is not rated for lifting.

Proprietary lifting equipment is available for strain relief on flexible hoses/umbilicals (Pictures 15, 16, and 17). These should be considered, and the non-rated D-ring and binding should be removed as the primary attachment point.

Further consideration is required when attaching intermediate D-rings, utilising an extended umbilical, and securing the diver's umbilical to a LARS wire to prevent bellowing.

Picture 15

Pulling Fleeters (Chinese Fingers)certified load-bearing equipment;

- Plastic coated aramid fibre strands
- Kevlar versions
- Lighter than steel versions
- Stronger than steel versions

There are various types available with off-set eye or double eye connection points and mesh or lace-up versions.

Picture 16

Picture 17

2.5 Diver Umbilical

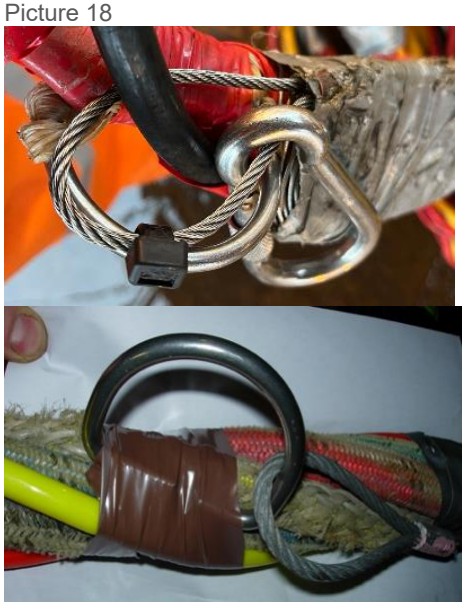
The diver's umbilical is the connection from the surface control system. It may consist of a single hose or multiple lines, a gas supply, voice communication and depth measuring system, and other services such as heating, power for lighting, and camera video signals. [EN15333]

The basic umbilical assembly consists of a $^{3}/_{8}$" breathing gas hose, a $^{1}/_{4}$" pneumofathometer hose, and a communication cable to a larger umbilical with an additional hot water hose, reclaim hose, tracking hose and video and lighting cables.

The umbilical assemblies presently used are of two basic constructions: spiral-wound and parallel.

- A spiral wound umbilical is generally the choice of diving contractors. These offer significant advantages, including greater flexibility and strength while resisting kinking and abrasion due to the inherently strong 'rope-like' structure. They do not generally have a strength member.
- The parallel umbilical comprises component hoses laid parallel and either taped or bound together. It may have a combination strength/communication member or a separate strength member and communication cable. If a separate strength member is incorporated, it must terminate at the diver's D-ring (Picture 18).
- EN15333 states: '*The apparatus shall have a lifeline that can be used to help recover a diver in distress. It may be a separate line or can be the umbilical. The lifeline, including any connectors, shall be capable of withstanding a tensile load of 3 500 N without damage'.*
- The distance between the gas hose fitting and the umbilical attachment point is undefined in the documentation and left to individual contractors to decide. Two D-rings are commonly attached to an umbilical to accommodate the height difference between dive team members (Pictures 19 and 20).

Picture 18



Unusual set-up. Wire rope strength member on a spiral wound umbilical.

Picture 19

Picture 20

3.0 Testing Criteria

3.1 Current Testing Requirements

IMCA D22 states, 'All diving plant and equipment, including all divers umbilical*,' ..require regular inspection, maintenance and testing to ensure every item is fit for purpose and safe to use, e.g., not damaged or suffering from deterioration. Regular maintenance is essential in ensuring diving equipment's safe operation. The diving contractor will need an effective system for planned maintenance and should have on-site an adequate supply of spares for all plant and equipment'*.

IMCA D 018 contains comprehensive guidance on the frequency and extent of examination, testing and certification required for all items of diving plant and equipment used in a diving project, together with the levels of competence required of those carrying out the work.

Specific guidance on the examination, testing and certification of divers' umbilical is set out in IMCA D 018 detail sheets 11 *Electrical Equipment* and 28 *Umbilical's – Hose Components only, including end terminations and fittings but excluding electrical components*.

Nothing within IMCA 18 requires binding or connectors to be inspected or examined.

IMCA DESIGN D23, D24, D37, and D40 have line items regarding umbilical strain relief. However, the requirement does not involve any testing or inspection.

3.2 Industry Testing Practices

There are no testing or certification criteria for a completed binding. When a spiral wound umbilical (or rope) comes under strain, the umbilical will stretch and the diameter/circumference will reduce. The reduced diameter/circumference may make the binding less effective, with the potential of the 'anchor point' becoming ineffective; the strain will go to the hose end fittings at the diver breathing apparatus. As recovery of a diver on their umbilical is an unplanned possibility, the attachment arrangement should be tested as if it were lifting equipment.

4.0 Recommended Corrective Actions

This Hazard Observation has highlighted several areas which merit further investigation or actions by others: There is no industry requirement to ensure that the linkage between the diver's harness and the umbilical is suitable. This link is safety-critical. The following suggestions may assist in diver safety.

4.1 Wearing of Lift Harness

IMCA should state that all divers shall wear a personal lift harness within appropriate documentation. The lifting harness shall be a separate system from the harness that carries the divers' bailout system. In any event, it shall be possible to easily remove the bailout system without removing the lifting harness.

4.2 State Umbilical to Harness Attachment Point

Contractors are to state, after risk assessment, where the umbilical is attached to the diver during each diving technique.

4.3 Use of Fleeter or Binding?

Industry leaders to investigate using approved lifting gear and a Fleeter/Chinese finger as a diver-umbilical attachment point.

4.4 D-Ring Specification

Industry should give guidance on the minimum size, strength and properties of D-rings attached to the divers umbilical; all D-rings have a safety-critical function such as:

- The primary D-ring that the diver attaches to
- D-rings used during extended umbilical diving
- D-rings connect the diver umbilical to a LARS wire to prevent 'bellowing' towards thrusters.

4.5 Carabiner Specification

IMCA to state that the load-bearing connector between the diver's harness and D-ring (or other assemblies) *shall* be a rated, stainless screw-gate carabiner with a minimum 5kN rating. (IMCA D18 or/and DESIGN)

4.6 Traceable Components

All components within the strain relief assembly should be traceable within the PMS.

- The assembly shall be individually identified.(treated as 'lifting gear')
- Include a six-month formal examination within IMCA D18 and appropriate DESIGN.
- Contractors should amend their predive checklists to include any binding and attachment accessories.

4.7 Include Components in DESIGN

IMCA should consider adding a line item within IMCA D18 to confirm that the D-ring and binding are secure. IMCA D23, D24, D37, and D40 confirm that any D-ring/attachment assembly and their binding (if any) has been confirmed suitable, safe and fit for purpose by a competent person. Each component is traceable within the PMS. (This would also cover a fleeter)

4.8 Industry leaders to develop a D-ring binding procedure for guidance. To include;

- Umbilical surface preparation. Should there be a layer of tape or heat shrink under the binding to protect the umbilical or/and increase friction between the binding and umbilical?
- When binding a D-ring to an umbilical, does the umbilical need to be under pressure for expansion as recommended in the USN Umbilical Manual?
- Type of cord (Kern-mantle, stranded, size, properties)
- Direction of lay (Binding to lay with or against the spiral direction)
- Length of binding (Only inside the D-ring or before and after?)
- Seizing/binding/whipping style (West Country or Common)
- Competencies of those carrying out the binding
- Type of protection over the binding on completion
- Testing criteria. Develop testing criteria for load-bearing attachment points. Testing should be for a minimum load of 150kg and should consider stretching the umbilical under tensile load, subsequent reduction in diameter, and slippage of binding.

Appendix 1 Draft Detail Sheet for IMCA D18

Detail Sheet 28.1

Diver Umbilical – Strain Relief Components

Strain relief: Diver umbilical including any bindings, D-rings, snap shackles, shackles, karabiners or pulling fleeter (Chinese Fingers) between an umbilical and the rated attachment point on the divers harness

Note: This includes subsea end divers surface supplied and closed bell excursion umbilical

When new

Examination/Test	Category of Competent Person
All individual components to be manufactured in accordance with a recognised code or standard or to manufacturer's standard specification and fit for the purpose it will be used for.	1, 2, 3 or 4
Any binding to be attached and certified to lift the intended man -riding SWL	2, 3 or 4
Function test at SWL	2, 3 or 4

When in Service

Examination/Test	Validity Period	Category of Competent Person
If binding or fleeter is replaced test as if new		1,2, 3 or 4
Thorough visual examination of bindings/fleeter check the integrity of shackles and components	6 months	1,2, 3 or 4
Load test to maximum safe working load	12 months	2, 3, or 4

Immediately Before Use

Visual check for damage and abrasion

1. When New, an umbilical may be bought from a supplier with an attachment point already fitted. The umbilical should be supplied with certification that the attachment point has undergone testing, and the certificate should state the SWL.
2. If an umbilical is supplied without an attachment point, an appropriately competent person can fit the attachment to the umbilical. Any cord bindings should be applied by a competent person following a company-approved procedure, with available data attesting that the binding will be fit for purpose.
3. All individual components such as D-rings, snap-shackles, shackles and karabiners shall have a manufacturer's certificate.
4. Any D-ring should have a manufacturer's Minimum Breaking Force (MBF). The MBF is the value below which the manufacturer guarantees that the D-ring will not break when new.
5. Suppose individual components, such as karabiners or shackles, have to be replaced. In that case, retesting does not require it, provided the change is made on a like-for-like basis, and the new component is supplied with its relevant examination and proof load test certificate.
6. The SWL of the umbilical strain relief is at the discretion of the competent person. It is suggested that a risk assessment is conducted to ascertain any potential weight loading during different diving techniques. For example, in extreme cases, a surface-supplied diver would be recovered by their umbilical, whereas a closed-bell diver is unlikely to be suspended by their umbilical. For calculations, a diver's weight is 150kg. Company-approved load/strain testing procedure to be in place
7. If a steel fleeter is used, consideration should be given to galvanic corrosion of any less noble crimping ferrules.
8. Any component cut or modified without a manufacturer's certificate should not be used.

Appendix 2 References and Source Material

References

US Navy	U.S. Navy Diving Umbilical manual
BS EN 15333-1:2008	Respiratory equipment. Open-circuit umbilical supplied compressed gas diving apparatus. Demand apparatus
EN 250:2014 EN 250:2000	Respiratory equipment - Open-circuit self-contained compressed air diving apparatus - Requirements, testing and marking
IMCA	DESIGN
IMCA D60	Guidelines for Lifting Operations
IMCA D22	Guidance for Diving Supervisors
KMDSI	Kirby Morgan 37 & 57 Operations manual Chapter 3.0 Operating Instructions
NORSOK	U100
ADCI	International Consensus Standards For Commercial Diving And Underwater Operations

Photographs and Pictures

1-6	Author
7	Wikipedia
8-15	Author
16-18	www. nova.sub.com
19-21	Author