ESCA Guideline No.15

Power and Renewable Energy Cable Repair Guidelines

Document Revision Procedure:

Any party wishing to propose a change to this document should address the proposed change to the Chair of the RPSG of the EUROPEAN SUBSEA CABLES ASSOCIATION. The RPSG will then review the proposed change and consider re-convening a Technical Working Group ("TWG") to discuss the proposal. Once the RPSG (and TWG, if appropriate) are satisfied, their findings and the revised document will be presented to the EUROPEAN SUBSEA CABLES ASSOCIATION Executive Committee and Plenary for approval. Only when all parties have approved the changes will the document be re-issued.

Document History

Issue No.	Name	Comments	Date
1		Initial Issue	Nov 2015
2		Re-branding to ESCA	Mar 2016
3	TZ / RPSG	Various text corrections and reference to Critical Cable Handling Parameters incorporated	Oct 2018
4	RPSG TWG	Additional wording to make the guideline more comprehensive regarding cable repairs preparedness plans	July 2023

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1 DEFINITIONS AND ABBREVIATIONS

CLV – Cable Lay Vessel.

CRV – Cable Repair Vessel**.**

CCHP – Critical Cable Handling Parameters, which includes parameters such as minimum bent radius during storage, minimum bent radius during installation and operation, weight in air, weight in water, max pinch pressure (compression), cable stiffness (axial, torsional and bending stiffness), max pulling tension, handling/laying speed controls, coiling/uncoiling drop height, and max unsupported horizontal span.

DIVING ACOPs – Britain Diving Approved Codes of Practice.

DOW – Depth of Water.

DTS – Desktop Study.

EEZ – Exclusive Economic Zone.

HAZOP - Hazard and Operability Study.

ISM Code - International Safety Management Code or ISM Code for Ships.

MOP – Method of Procedure.

MBR – Minimum Bent Radius.

MWS – Marine Warranty Surveyor.

Offshore Power Asset – Offshore wind farms, interconnectors, inter island distribution.

OP – Operational Permit. This is defined to mean any permit, operational notification (Notice to Mariners etc), or other administration for vessel activities to take place.

OTDR – Optical Time Domain Reflectometry Test.

OWF – Offshore Wind Farm or Floating Offshore Wind Farms including associated structures such as foundations, Met Masts, mooring systems and its seabed anchors, submarine cables, substations etc.

ROV – Remote Operated Vehicle.

RPL – Route Position List.

SIMOP – Simultaneous Operations Procedure.

TDM – Touch Down Monitoring.

TDR – Time Domain Reflectometry test.

VOO – Vessel of Opportunity.

WROV – Work ROV.

2 EXECUTIVE SUMMARY

With the introduction of varied owners and ownership structures in the developing renewable energy and interconnector sectors, this guideline aims to provide high level guidance on power cable repairs.

Any offshore power asset whether it be a generation or transmission asset relies on submarine power cables for power transmission and thus for their revenues. Hence any owner, operator or insurer must consider the submerged cable monitoring, maintenance, and repair when exogeneous or endogenous caused faults occur in the cable. This may be considered as part of Business Continuity Planning or as part of the asset Operation and Maintenance plan by its own right.

3 INTRODUCTION

Submarine power cable repairs have become more common over the recent years with an increasing number of cables being installed on the seabed due to the expansion of offshore wind farms and interconnectors.

This guideline aims to provide cable owners with a high-level overview of the issues to consider in the pre-fault planning stage and in the repair operations stage. The guideline aims to provide consultees and other interested parties who need information on the processes involved in carrying out a subsea cable repair with an overview of the processes and associated issues.

Repair scenarios can fall into several industry categories:

- Inter array cables in Offshore Wind Farms
- Offshore Wind Farms Export cables
- Interconnectors
- Inter-Island distribution cables

Within these categories, a repair could be required at various distinct areas which require a different approach in methodology, technology, and equipment to facilitate the repair:

- Shallow water (typically areas where DOW is lower than 15 metres)
- Deep Water (typically areas where DOW is greater than 250 metres)
- Shore end replacements
- End to end replacements (e.g. OWF inter array cables).

Cables within this range of repair scenarios can also vary in several parameters which are typically bounded by its electrical, optical, and mechanical parameters – including Cable Handling specifications (that include CCHP) -, and Lay configuration that are described by the cable technical specification produced by the manufacturer.

With so many variables in power cable repairs, for example: economic importance, loss of revenue, liabilities and criticality, the repair contingency preparedness planning needs to be specific to each individual case considering these points, and to be clearly defined, and in place, well in advance of the cable entering in service.

4 REPAIR SCENARIOS

Repair scenarios are very often dictated and limited by the availability of reliable submarine cable data in terms of route and burial, cable testing and survey services for pinpointing the fault location, cable repair vessels, de-burial and burial vessels, de-burial and burial equipment, cable handling and jointing equipment, qualified and experienced seafarers, and engineers - including jointers -, spare accessories, and the length of spare cable. A repair strategy together with sufficient spare cable and accessories, along suitable storage facilities should be considered from the outset when developing a power cable project, covering all potential cable repair scenarios. Development and manufacturing risk should also be taken into consideration at procurement stage as lead times, especially for cable manufacture, can be significant.

In all cases, cable (and joint if applicable) handling at all times, particularly during cable de-trenching and recovery, should be in accordance with cable manufacturers Cable Handling specifications (that include CCHP).

This cable repair guideline, which includes cable replacement , is comprised of various scenarios which would relate to Offshore Power Assets:

- Beach Landing: a repair / replacement strategy to be utilised when the fault occurs within these areas. Two scenarios should be assessed for the beach landing repair / replacement:
    - A spare cable is inserted offshore using two joints, to replace the damaged cable section;
    - A shore end replacement utilising spare cable, one subsea joint and a land / sea transition joint.
- Offshore: a repair on a cable beyond intertidal areas or substation platforms, involving two joints plus an inserted length of spare cable, without disconnection of the cable from the substation;
- Offshore substation: a repair at the offshore substation, involving the disconnection of the cable at the substation, replacement with a spare cable length with one subsea joint and a re-feed into the substation;
- Inter-Array: a repair / replacement on an inter-array cable. Various scenarios should be assessed for an inter-array cable repair e.g.;

- A single in-line cable joint with a replacement spare cable length hauled into the foundation structure.
- A repair scenario including two joints with a length of spare cable spliced in.
- Replacement of the entire inter-array cable and recovery of the old / damaged cable.

The repair / replacement process can be split into distinct steps which will be expanded upon throughout the document, see Figure 1 Repair / Replacement Process.

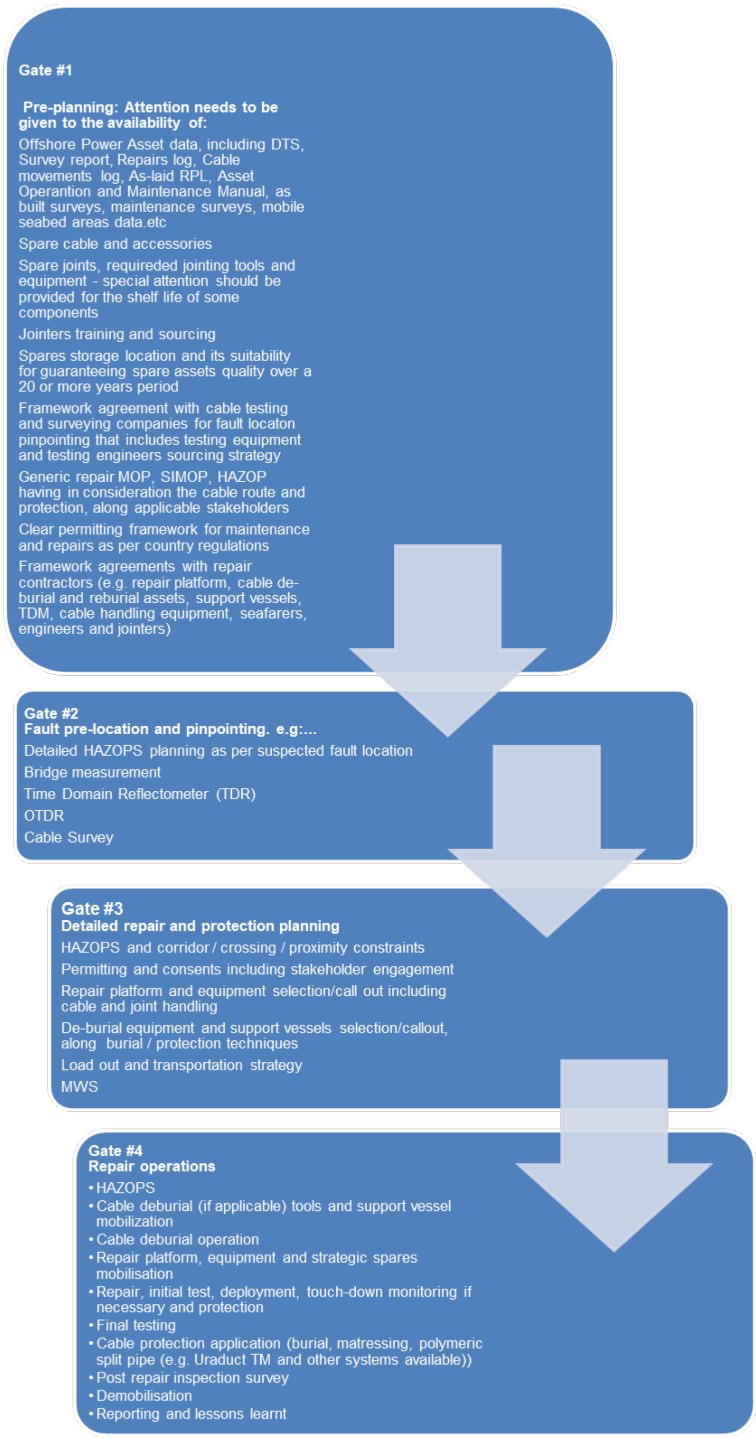

Figure 1 Repair / Replacement Process

5 PLANNING

Planning for cable repairs is essential in ensuring that a fault can be repaired as safely and quickly as possible. Financial losses can be reduced by employing an appropriate pre-planned repair strategy including critical equipment, repair timescales and repair costs.

Considering all the range of scenarios outlined in section 4 and the gating activities identified in Figure 1, individual repair timescales are predicated by the individual's state of repair readiness. However, industry experience suggests a typical timescale of 3 to 9 months might be expected due to the industry still relying on a VOO, equipment, and staff availability. However, this timescale can be reduced if framework agreements that pay a retainer for the VOO assets, equipment and staff availability are in place.

5.1 Health, Safety and Environment (HS&E) (Gates #1 - #4)

This is a predominant feature and must be considered throughout all stages of the repair process

Some areas that should be incorporated include:

- Legislative boundaries
- Environmental considerations
- Marine standards e.g., ISM code for vessel, Diving ACOPs
- HAZOP and electrical safety
- Onshore HSE and security requirements
- Offshore repair platform requirements
- Personnel training / certification requirements

5.2 Fault Location and Pinpointing (Gate #1 and #2)

Accurate fault location is a crucial factor in most repair situations (unless the repair strategy is by cable replacement e.g. inter array cable) for the cost-effective repair. (Gate #2)

There are several different test methods available including Bridge Measurements, TDR, OTDR to name just a few. Tests of power cables can be complex and time consuming, in general these tests are delegated by the responsible party to cable manufacturers or independent contractors specialising in this field.

If the visibility on the seabed allows, a ROV or mini ROV survey along the cable route can be considered to assist in pinpointing a fault. A detailed consideration of fault location techniques is beyond the scope of this guideline.

The Key message is that the more accurate the Fault Location is, the less the repair costs will be in time, resources, and materials.

5.3 Consenting, Licensing and Permitting (Gate #3)

A repair scenario can be classed as an "Emergency" or a "Non – Emergency".

Depending on the type and location of repair work being undertaken, the Offshore Power Asset construction permit (sometimes called Permit in Principle) will often cover its maintenance during its operation duration. However, an Operational Permit or other type of notification will be required to include identification of the vessel(s) that will be involved in a repair when such occurs, notify other sea users, and provide other details that may be required by the applicable authorities. Consideration should also be given to any shore based licenses and permits that might be required.

Note: Depending upon where the repair is taking place, consideration should be given to the flag under which the repair platform is operating and if there are country specific cabotage restrictions or other regulations in place that could impact vessel entry requirements.

As an example, in the UK if the cable repair is classed as an "EMERGENCY" repair, then the responsible party is exempt from requiring a license to undertake this repair activity.

For pre-emptive, planned maintenance, remedial improvement, or similar non-emergency "repair" work, you will almost certainly require some form of permit or marine license to carry out the activity which is a long-term planned execution type or work than immediate response intervention.

Emergency repair = a repair that is caused due to unexpected events, particularly where it poses a hazard on the seabed, risk to property, disruption impacting the community or the economy by interruption of power transmission or the risk of power transmission being interrupted, and impact to human health or the environment and requires rapid restoration.

The relevant authority in a particular jurisdiction needs to understand that there is an imperative to respond quickly to an incident or problem that has occurred.

If the emergency aspect of a query is questioned by the authorities, then details of the disruption, the existence of power outages in the region and potentially hazardous conditions for sea users (displaced cable or cable suspensions etc), can assist to demonstrate the case.

Subsea cables have certain freedoms under UNCLOS subject to certain provisions, meaning that they do not require consent to be laid or repaired outside of Territorial Waters (12NM). In some regions this can be dependent on whether that state has ratified UNCLOS and adopted it into domestic legislation.

Linear submarine power cables have these freedoms on the basis that they do not exploit natural resources or connect artificial islands or structures (See UNCLOS for further details). Cables connecting renewables are subject to licensing out to the extent of the EEZ (200NM).

In certain jurisdictions it is possible to apply for permits that cover maintenance for the duration of the life of the system. This is more typically seen for power cables that may have scenarios for planned repairs within the project lifecycle.

Generally telecommunications cables are assumed that they will not require repair unless they are damaged through third party external aggression (e.g. fishing and ships anchors) which are emergency repairs that risk disruption and cannot be planned for. Certain types of power cables are often considered in the same way – generally smaller domestic and inter island links.

5.4 Cable Repair Facility (Gate #3)

When a particular fault location and associated repair scenario is clearly defined, a repair asset will need to be identified based on the preparedness points presented in Gate#1 and #2. NB: Operational specific requirements are determined by the fault location water depth, seabed type, permits, cable burial status, weather, particular cable handling parameters (as per cable CCHP), and the repair environmental envelope.

For further background examples of cable installation platforms and cable repair platforms, refer to appendix 1

5.5 Repair Planning (Gates #3 - #4)

From the outset a project commissioning and repair preparedness plan should be prepared for use as an operational guide. This will act as an aide memoir as to how the repair process should proceed, detailing the outline repair requirements including specialist equipment. This plan may either be generic to the whole asset or could be expanded to detail specific requirements in different areas of the asset. The plan will also contain a risk management process to ensure that any repairs are managed correctly.

Owner/Operators are advised to maintain the repair plan as the plan is developed to ensure that the Marine Contractors MoP aligns with the Owners requirements. Any material differences need to be addressed during contract agreement or pre–operational meetings depending on the repair. This requirement may be reduced if a framework is in place for repair services.

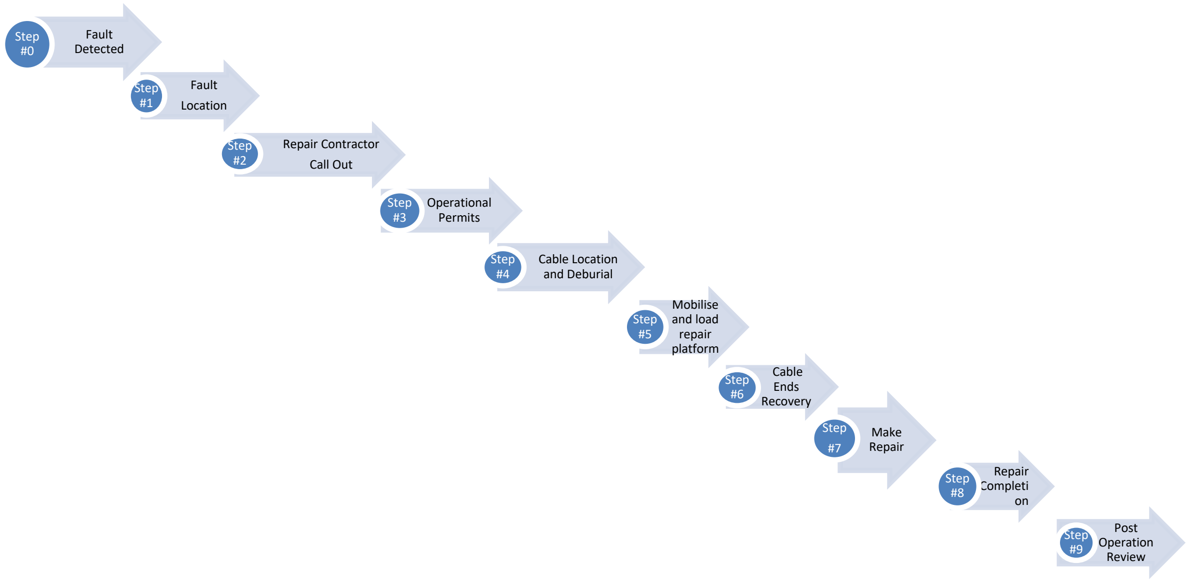

Figure 2 Generic Repair Plan Example considering cable recovery and replacement by jointed spare cable

Comparisons between a generic repair format and particular details will identify the specific requirements for a cable repair or replacement. Such as the scope of the repair spreads, cable repair vessel, support vessels, de-burial equipment, post repair protection, ships manning, jointing equipment, tools, and jointers, etc.

The following points show high level generic steps to undertake a cable repair operation using spare cable and two joints, where the affected cable section is in 15 metres or greater DOW.

Step 0: Fault identified in the Offshore Power Asset Cable

- Activate repair preparedness plan and send a notification to all applicable stakeholders in accordance with the plan;
- Start fault pinpointing process with applicable stakeholders, supplying the Offshore Power Asset Cable document package, which shall include, as-laid RPL, Survey data, DTS (if applicable), repair log, Cable Operation and Maintenance Manual.

Step 1: Fault Location

- Time spent isolating the location of the fault accurately reduces repair duration and cost;
- Make sure that the fault is "Offshore!";
- Draft a report pinpointing the fault along with any uncertainties;

Step 2: Repair Contractor Call Out

- Agree a contract or call out against an existing framework with a repair contractor, providing them with all required data regarding fault location.

Step 3: Operational Permits

- Obtain the necessary operational permits to undertake the cable repair operation as per fault location.

Step 4: Cable location and deburial

- If applicable mobilize cable survey/de-burial vessel along with applicable tools and ROV's as per asset preparedness plan;
- Physical cable location and cable de-burial.

Step 5: Mobilise and load repair platform

- Load spares & Mobilise cable repair platform along with appropriate repair equipment;
- The repair platform transits to site.

Step 6: Cable ends recovery

- Expose and cut the cable at a suitable location;
- Cut the cable with a suitable ROV tool if the cable is not cut already as a result of the fault;
- Attach recovery line(s) with ROV to one end of the cut cable;
- Recover the cable(s) whilst maintaining all cable handling parameters (particularly MBR and cable tension within the cable CCHP) at all stages of the operation, particularly if the cable is planned to be re-used / jointed onto good cable;
- First cable end recovery, clear fault, test to shore, seal the cable and deploy to the seabed on cable buoy;
- Second cable end recovery and test to shore.

Step 7: Make repair

- Undertake the first joint to the spare cable, deploy joint to the seabed and lay cable up to second cable end location - TDM monitoring might be necessary;
- Recover second end, undertake second joint, and return repair bight to the seabed – TDM monitoring is recommended.

Step 8: Repair Completion

- Repair Confirmation Tests;
- Cable protection application (burial, mattressing etc);
- Cable burial inspection survey;
- Demobilisation;
- Post Operation Documentation.

Step 9: Post Operation Review

- Lessons learnt meeting;
- Review and revision of Repair preparedness plan;
- Fault cause analysis;
- Potential maintenance work to prevent repetition of fault in a different location.

5.6 De-burial, Post Repair Burial, Remedial Protection, and Inspection

In water depths up to 1500 metres it is good engineering practice to provide a cable with the best available protection from external aggression by burial during installation. This being the case, it is almost certain that de-burial and subsequent re–burial will form part of most repair operations. Where burial is not achieved to the degree desired, other remedial protection operations may be undertaken, e.g. mattressing or rock placement. From an operational economic standpoint the minimum amount of cable should be de-buried to affect a repair. It can be appreciated that the accuracy of fault localisation has a direct bearing on this.

It is also important to check with the cable manufacturer a max cable burial depth in a specific seabed geology to maintain cable operating temperatures below their maximums.

This point identifies common solutions used to de-bury, bury, and provide additional protection.

5.6.1 Jetting

Jetting relies on a high-pressure water flow from nozzles, which fluidises the seabed. As the jetting tool is moved along and around the cable, the seabed is fluidised moving sediments and exposing the cable. Thus making it possible to hook and recover the cable.

Jetting may be performed in several different ways most common of these, for maintenance, are ROVs or Divers.

Specific cable de-trenchers are being developed that will maintain the cables Cable Handling parameters (as per cable CCHP) during de-burial and recovery. These tools will also make the de-burial and recovery operation potentially faster thus reducing costs and weather window exposure.

5.6.2 Mass flow excavation

Another means of de-burial is the use of a Mass Flow Excavation device, which generally consists of a high-flow turbine in a cylinder which can be deployed from a crane on board a small vessel. It “blows” large quantities of water towards or “sucks” seabed material away from the area which needs deburial reburial. However they tend to only work in sandy / non-cohesive seabed. Mass Flow Excavators are not the preferred tool of choice by the consent and permitting authorities, therefore, they might prove problematical when gaining approval for extended use.

5.6.3 Post-Repair Burial

Specially adapted ploughs and water jetting equipment can be used for simultaneous cable laying and burial, or for post lay burial.

A post lay burial operation may be performed at a convenient time after the cable has been laid, usually from a smaller vessel. However, the cable is at risk during the time window between laying and burial.

5.6.4 Post Repair Additional Protection

In the event of remedial cable protection being required on the cables, the following solutions could be applied:

- Split pipe protection
- Plastic protectors
- Mattressing
- Rock placement.

5.6.4.1 Split Pipe Protection

Articulated split pipe protection consists of interlocking cast iron (impact resistant) pipe halves, which lock together to protect the cable from abrasion or other external damage. Split pipe protection can be self-locking therefore no bolts may be required. Articulated split pipe protection is manufactured in approximately 0.5m lengths and can be installed onto the cable onboard ship during the lay out or by divers following cable installation.

5.6.4.2 Plastic Protectors

Plastic protectors can be a form of split pipe cable protection, which comprise of cylindrical half shells moulded from high performance polyurethane. Each half shell overlaps and interlocks to form close fitting protection around the cable. Each shell is secured in place using corrosion resistant banding, negating the need for bolts. Plastic protectors are manufactured in lengths of approximately 2.0m with various internal diameters and flexing characteristics to suit the required minimum bending radius. Plastic protectors can be fitted on deck as the cable is being installed or fitted post lay by divers.

5.6.4.3 Mattresses

Mattresses are often concrete and are designed to work as a highly resistant stabilisation and protection system for pipelines, cables, and umbilicals. Mattress designs often consist of high strength concrete segments linked together with a network of polypropylene ropes to form a continuous but flexible barrier. Most mattresses can be installed with a quick release installation frame and come in various sizes appropriate to the application.

5.6.4.4 Rock-Placement

Specialised rock (such as granite of certain cross-sections) is placed on the area using a fall-pipe or off the side of specialist vessels. This serves to act as a stabilisation and protection system. However, caution should be exercised regarding the potential side effects of rock placement in causing secondary scouring around the cable.

6 REPORTING

One of the most important aspects, often overlooked, during repair work is post operational documentation. Such documentation is important for several reasons:

Maintenance records are required for the operational life of the system, in support of ongoing operational decisions as well as to complete post repair notifications to permitting authorities and databases such as KIS-ORCA.

It is normal to keep a detailed account of the evolution of the system parameters over its life such as losses, measurement, splice lists, route position lists, depth of burial, spares, and equipment inventories etc.

It is also important to keep records of each cable transfer operation during the cable lifetime before installation, including cable transfer procedures, and transfer logs with photographic or video evidence of events (e.g. damaged serving) detected on the cable whilst being transferred. This will allow for better management of spares as each piece of cable has a specific handling budget and methodology defined by the manufacturer.

It is recommended that the Owners / The Responsible Party define their documentation requirements and drawing standards as part of their installation and maintenance policy and invest reasonable time in assuring the appointed maintenance contractors adhere to policy.

Offshore Power Assets records keeping over the asset lifetime (over 50+ years in the case of an interconnector) might sometimes be a challenging task to manage to have the documentation available when needed in a repair. This may be due to the eventual staff turnover and owners that an asset might have during such period. Therefore, it may be a good option to rely on specialized companies to manage these records, keep them up to date, and make them available when needed.

7 APPENDIX 1

7.1 REPAIR FACILITY EXPECTATIONS

As has been previously mentioned, subsea cable repair facilities come in many shapes and forms. The optimum selection depends very much on operational water depth, expected prevailing weather conditions and tidal/sea states. For shallow waters, barges or special shallow water vessels may be used. If the repair is in an intertidal area jack up platform/barges might be required, or even vessels with grounding capabilities. The compromises with these types of vessels however are reduced weather windows and operating conditions due to their relatively flat underwater hull profile. For deeper waters, more conventional vessels can be used.

The use of DP for station keeping is now very common and can assist in ensuring that the cable is properly placed within only a few metres of the planned route.

The selected vessel should be able to continue to provide a stable platform to repair cable in agreed sea states. Preferably, the vessel should also be able to launch and recover any ROVs if required in these sea states and undertake surface lay of cable in worse sea states. Note, however, that cable touchdown point refreshing is considered to be essential for any scenario, particularly considering the extended timescales anticipated for a power cable repair, to minimise the potential for cable serving damage and fatigue stress.

Cable vessels should provide good, sheltered working conditions on deck for the crew in all weather conditions. The ability to provide covered cable tanks / carousels and cable pathways is considered to be desirable in extending the working window and enhance safety on deck.

One of the often-overlooked features of a cable repair vessel facility is the need to accommodate relatively high numbers of crew. There is also a typical requirement for several discreet office spaces with internet communication and general communication facilities for the quality assurance personnel and other supernumeraries.

The generation of broad methodologies leading to comprehensive onboard procedures for use during all anticipated stages of a cable repair, should be undertaken well ahead of the project. This also includes shore end landings and hauls onto platforms. Emphasis should be attached to hauling the cable onto platforms to ensure that the Cable Handling parameters (as per cable CCHP) are not compromised and that there is adequate room at the head of any “J” tube for the cable end rigging and turning.

The deployment of the repair joint should ideally be in the straight leg, not the head of the repair bight, the head of the repair bight being subsequently deployed using a quadrant. Thus, minimising the risk of flipping on the seabed when deployed and promoting subsequent cable protection measures. It is however appreciated that some repair joints might need to be deployed at the head of the bight. In this instance, extreme care should be exercised to balance the outboard cable tensions in each leg before carefully deploying the joint. Care should also be taken to ensure that no rigging is attached outboard of the repair joint, and it’s bend restrictors that might subsequently lead to compromising the MBR and integrity of the cable.

7.2 Repair vessel typical deck / bight layout

Generic deck layout

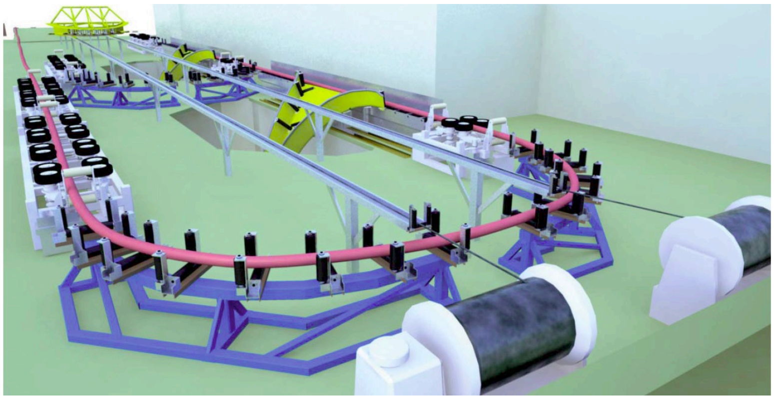

Figure 3 Illustrative Cable Repair Set Up

7.3 Cable Repair Support Vessels

Depending upon the repair strategy and the selection of CRV, a variety of support vessels may be required to perform support task such as anchor handling and dive support operations.

Multi-cats are extremely flexible multipurpose work vessels with the ability to undertake almost every task. They are ideally suited to:

- Towing and pushing operations
- Buoy and anchor handling
- Dive support
- Pollution response
- Dredging / deburial support
- Survey support.

Multi-cats can also provide other support equipment such as:

- Deck cranes
- Winches
- Good working deck space.

A dedicated Cable Lay Vessel (CLV) is designed for the task of cable installation but, by careful design from the outset, can also often be utilised as a Cable Repair Vessel (CRV). A dedicated CRV might have a lower deck load requirement for shorter repair lengths, ample deck space for jointing enclosures and remedial burial tools on deck, as well as appropriate accommodation.

Vessels vary in their suitability depending on the combination of many criteria:

- Station keeping ability
- Load capacity
- Deck arrangements
- Water depth
- Local conditions
- Manoeuvrability
- Crane/A frame capabilities.

A repair vessel would ideally have a large working deck with sufficient space to mobilise for repair including:

- Cable engines
- Cable trackways
- Cable quadrant
- Winches
- Cranes and/or "A" frame launch system for relatively long length rigid repair joints typically used in power cable systems
- Cable chute(s)
- Dive equipment
- Jointing enclosure (climate controlled)
- Burial equipment
- Spare cables storage and accessories.

Depending upon the cable repair location and port facilities, a significant level of accommodation may also still be required on board a CRV. Depending upon the scope (i.e. de-burial, WROV/Divers) it could be the case that the required accommodation is more than that of a CLV.

There are several main differences in the vessel that could be selected for undertaking a power cable repair:

- Propulsion: propelled or non-propelled. Non propelled vessels have a requirement for additional support vessels to tow and handle anchors;

- Spud legs / Jack up legs: use of spud legs or jack up legs can remove the need for anchors. However, on a barge without propulsion, movements may be best controlled within a mooring spread;
- Dynamic Positioning (DP): DP systems can allow a vessel to remain on station without the need for anchors. (Note that shallow water may however preclude the use of DP systems);
- Grounding out: in shallow water the ability of the CRV to ground out could be important when trying to remain on station against tidal swings during prolonged jointing operations;
- Support vessel might also be required to undertake TDM (Touch Down Monitoring) during the cable repair operation.

Repair requirements for cables.

7.4 Main Equipment requirements to consider include:

- Cable spread descriptions
- Cable exposure device
- Cable cutting device
- Cable de-trenching device
- Cable protection system
- End caps (cable seals)
- Hermetically controlled jointing area
- On-board cable storage – Carousel/Reel/Tank
- Lifting crane / A Frame
- Any special joint handling requirements
- Cable bight deployment and set-down quadrant
- Recovery and deployment winches
- Lifting accessories and rigging
- Linear or drum cable engine
- Cable rollers / double highway
- Diving / WROV spread
- Survey and positioning
- Support frame for recovery and launch of cable(s)
- Facilities to store damaged cable section(s) for post operation investigation (insurance).

7.5 Site Specific Considerations

- Mooring analysis and station keeping capabilities at joint location
- Dynamic and static cable analysis
- Weather conditions on site
- Seabed conditions
- Proximity of offshore assets (e.g. other submarine cables, OWF, pipelines etc)
- Operations at shipping lanes / Marine traffic
- Tidal range / currents.

Optimum power cable repair scenarios can be very broad ranging. The engagement of skilled personnel and contractors at an early stage is highly desirable. Generation of generic methodologies and procedures well in advance of any actual repair scenario would be beneficial, to enable the rapid commissioning of a repair solution with minimum delay and potential lost revenue.