Cable Health Assessment Requirements

Recommendations for a standardised approach

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1 Document Purpose

This document sets out requirements for cable health assessment activities. At the time of writing there is little in the way of standards or public guidelines exist to support the industry.

Indeximate Ltd have published this document with a creative commons CC-BY licence to enable an independent body to establish to a more formal standard – however we welcome anyone taking and using this work.

The document is written from an agnostic perspective of equipment and process and is intended to outline outcomes rather than procedures.

1.1 Relevant Background

Current standards that make reference to cable health condition assessment:

DNVGL-ST-0359: Subsea power cables for wind power plants

CIGRE-WG B1.40: Offshore Generation Cable Connections

1.2 Document Scope

The document is intended to cover the needs of subsea power cables, both AC and DC, static and dynamic and is a response to the threats and conditions that a cable is expected to see over its working life.

The document considers the health of a deployed and operational cable on the seabed. Some outcomes and techniques may well be desirable earlier in the life of the cable – e.g. during Factory Acceptance or deployment but are beyond the scope of this document.

Establishing a procedure to create a report to meet these guidelines should result in a significant jump in knowledge of the condition of the cable, enabling:

- **Preventative Maintenance**: Performing remedial or stabilisation works at locations on the cable to return it to a prior state of performance.
- **Palliative Care**: In the case of a cable that is beyond remediation and has locations that are close to failure, proper use of these guidelines will enable a lifetime extension (with a likely concurrent derating of power) either sufficient to reach pre-emptive replacement or possibly on a longer term depending on cost-benefit analysis.
- **Pre-Emptive Replacement:** Using the output of such reports to inform on condition and degradation to help anticipate failure and plan a replacement before the worst case happens

The document is intended to support all asset owners and related stakeholders:

Asset classes

- **AC Export Cables**
- **AC Inter-Array Cables**
- **DC Export Cables**
- **DC Interconnects**
- **Dynamic (Floating) cables as well as Static (seabed) cables**
- **Buried & non-buried**

Stakeholders

- **Asset Owners**
- **O&M Partners**
- **Insurance Brokers**
- **Insurers**
- **Risk Advisors**

Additional

The document contents are also expected to offer appropriate advice to a similar set of stakeholders interested in subsea telecommunication cables although likely a subset of the advice contained.

The document is intended to focus solely on the subsea aspects of the cable and therefore the starting point for consideration is typically the Transition Joint Bay (TJB). The methods arising from following guidelines may also be suitable for inspecting the land element.

The document is written from the perspective of information likely to be required by either an asset owner or partner involved in the chain of insurance. As such it considers a statement of health of the cable from the perspective of “moment in time validity”. It does additionally recognise the benefits of permanent condition monitoring over sample condition monitoring and requires those stating health to present the details of their assessment and whether it includes permanent monitoring. However, the main objective is the outcomes in terms of improved knowledge of the cable condition. Permanent monitoring without specified health outcomes is less of a benefit than a consulting assessment taken in depth.

The document is expressed in terms of outcomes rather than inputs, although reporters on health are mandated to report on the extent of their chosen input to cover the required outcomes and the degree of granularity. The authors declaration of interest in this matter arises from the benefits of distributed fibre optic sensing however this is not explicitly expressed to maintain agnosticism. The document in no way recommends specific approaches (our own included) nor specific devices. Users of this document are left to represent their own approach in terms of the ability to respond to the desired to outcomes.

2 Outcomes

The outcome of a well implemented cable health assessment will be an enhanced knowledge of the condition of the cable at as many points along the cable as the chosen technologies can achieve with a granularity again appropriate to the technology.

The author of a report should be able to identify locations of the cable which are:

- Experiencing degradation of the integrity of one or more components of the cable
  - Ideally to identify which component is degrading – e.g. armour, conductor, fibre optic
  - Ideally inform on the nature of the degradation
- Experiencing degradation of their deployment environment over that which was originally specified:
  - Burial State
  - Burial Depth
  - Free Spanning
- Suffering intrusion of the environment into the good working of the cable:
  - Fatigue
  - Abrasion
- At risk of damage due to shipping / malignant activity

In addition to providing a definite positive identification of the conditions and locations above the report should also provide a positive identification of the absence of such conditions – i.e. the report should be complete in knowledge able to provide both a clean bill of health as well as identifying troubling locations.

3 Report Approach

3.1 Inputs for consideration

The following data should be collected by the report writer prior to analysis:

- Construction of the cable:
  - Type of cable, details of armour
  - Presence of factory joints
  - Presence of subsea joints
- Deployment of the cable
  - Nature of burial (if any)
  - How that varies along route
  - Presence of crossings (over or under other utilities)
- Deployment Environment
  - Bathymetry
  - Other subsea furniture
  - Other surface furniture
- History of the cable
  - Repairs if any – location, method, joint approach, distances, lay geometry
  - Known defects arising from manufacture, deployment or use
  - Prior cable health assessments
  - Purpose of assessment[1]

3.2 Data Collection

3.2.1 Data to be collected

Technology approach is the choice of the report writer, however approaches to achieve the following will be required (some or all of the following):

- Electrical behaviour of the cable whilst subject to a varying load
- Thermal behaviour of the cable whilst subject to a varying load
- Methods to identify and quantify with an appropriate granularity and resolution:
  - unburied sections
  - depth of burial
  - presence of free spans
  - fatigue
  - abrasion
  - vibration

[1] Is the assessment a routine activity noting the occurrence of issues, or is it a targeted activity to report on the health of a previously detected issue. Both have a separate benefit, there is no drawback to either.

    - arcing
    - presence of cetaceans
- Methods to identify and quantify the threat from shipping[2]
    - Illicit subsea activity such as bottom trawling in restricted area
    - Anchoring and anchor drag
- Methods to identify and quantify the threat from terrorist incidents / hostile state actions such as attaching remote destructive packages to the cable

3.2.2 Approach to collection

As the subsea environment is dynamic the nature of that environment needs recorded in parallel with the measurements to be collected.

In addition as the environment is expected to vary considerably, the data should be planned to be recorded for a sufficient length of time to experience a full range of environmental conditions:

- Multiple tidal cycles
- Range of weather conditions
- Power and current utilization up to 100% of rating
    - Or a specified limit
- Frequency of reporting in the presence of deteriorating conditions

3.2.3 Additional Data to be collected

Additional data that should be collected will be determined by the requirements of Section 3.2.1 but are likely to include the following and be captured throughout the exercise:

- Power and Current in the cable through the data
- Wind speed & direction at representative location(s)
- Wave speed & direction at representative location(s)
- Vessel movements
- Tidal records

3.3 Data Analysis

3.3.1 Methodology

Analysis approach should be specified and/or referenced in a resulting report to allow an understanding of the approach used by any of the key stakeholders – this is a key element in allowing different approaches to be evaluated and comparisons in data output to be made.

3.3.2 Analysis Products

Derived information content should be produced that will enable the outcomes (Section 2) to be achieved. Whether the reporter chooses to publish the analysis products in the final report is a choice for the reporter but it as context is a key component of any findings there should be sufficient use of analysis products to allow meaningful conclusions to be considered representatively.

3.4 Reporting & Health Certification

The report and summary of findings is the key element and should be succinct but also provide sufficient depth for deeper analysis and understanding of causes rather than purely a statement of

[2] Which in turn should be correlated with our risks profiled to raise concern over co-incident risk

issue. The following sections consider a provider issuing a report on the health of the cable together with a certificate detailing their assessment of the conditions – both positive and negative.

3.4.1 Basic Certificate Content

The certificate should detail the following:

- The Issuing Body
- Project Name (e.g. windfarm)
- Asset Owner
- Asset Identifier (i.e. cable designator)[3]
- Asset Type (e.g. Export or array)
- Report Traceability (unique reference from reporter of certificate and report)
- Purpose of Report (e.g. general health check / targeted health check / repeat of targeted)[4]

3.4.2 Conditions of Data Gathering[5]:

- Period over which permanent monitoring is considered; or
- Date range over which data was gathered for reporting
- Any data ranges or spatial ranges excluded from analysis

3.4.3 Methodology of report:

- Standard adopted (e.g. in response to this document)
- Standard procedure utilised (e.g. responder's internal documented approach)
- Any 3rd party verifications of standards utilised

3.4.4 Report Validity

- Note the maximum generated power / maximum cable current experienced during the reporting period

3.4.5 Report Responsibility

- Signed technical and commercial responsibility for the certificate details.

3.4.6 Limitations of report

The report should state clearly the limitations of the report - for example:

- Highlight the maximum power utilization & duration over the reporting period
- Highlight the ambient conditions during the reporting period
- Highlight the georeferencing accuracy and granularity of the techniques applied

These elements are critical to ensure that reports are considered in context.

3.4.7 Outcomes Included

Section 2 produces a list of outcomes desired – the report should clarify early which of these are addressed and which are not. As important it is to identify weak spots in the cable it is more important to assure the health of the wider cable. This section of the document confirms for the owner and insurer which outcomes are addressed and to what sensitivity.

The certificate should present a clear and unambiguous confirmation of what outcomes are addressed in the report and with what sensitivity. Typically, in order to address the outcomes in Section 2 and

[3] Additional information on water depth variation / cable coordinates, routing etc should be available from asset owner or in the report but if not should be stated.
[4] If the reporter is requested to assess health of a targeted location with known issues this information is of help to insurers and conveys a positive approach to condition monitoring and should not be considered a negative.
[5] Additional information on test conditions should be included in report – e.g. temperatures, power, weather etc.

Section 3.2.1 multiple technologies will be required. Reports may still be useful with a subset of approaches.

The following matrix is suggested:

Establish the Presence and location of:	Reporter Confirmation Yes/No	Sensitivity Limits / Exceptions
Degradation in the electrical integrity of the cable / anomalies		
Degradation in the thermal integrity of the cable / anomalies		
Free Spans (location, length)		
Unburied locations		
Persistent & Significant Abrasion		
Persistent & Significant Fatigue / VIV		
Persistent & Significant Strain		
Persistent & Significant Arcing		
Seabed routing anomalies / changes since last report		
Risk from vessel activity		
Terrorist or hostile activities		
Cetacean detection		
Marine Growth		

“Degradation” implies a change over time. For a first report this would represent a deviation from an expected factory fresh uniform, linear cable. For follow up reports this may be expressed as deltas over previous reports, however locations should only be removed from the report once evidence has accumulated that through maintenance activities for example a degradation factor has been removed.

New cables are not necessarily free from defect and techniques which are able to identify integrity may also be deployed prior to seabed handover – at the factory, during transport and during lay operations – that is beyond the scope of this document.

3.4.8 Summary Content

The summary content should be a clear statement of the health of the cable as follows:

- Precise Identification of points on the cable that meet the following criteria:
  - Areas requiring power capping
  - Areas requiring remediation
  - Area requiring monitoring
  - Area requiring investigation
- In addition the summary should state that all (or a defined subset) other points on the cable are free from conditions described in Section 2

- Any additional points not specified in either of those two bullets above should be clearly identified and explained.

The definition of the location criteria is as follows:

Areas requiring power capping.

If a location exhibits an indicator of degradation at a given current both the location and the minimum acceptable current should be identified together with the reasons for the location identification.

Areas requiring current remediation.

If a location indicates degradation in either internal structure or that the external supporting environment is observed to be degraded (e.g. free span, unburial, armour issues) then these should be identified together with the reasons for the assessment.

Areas requiring monitoring

If a location exhibits an early indication of degradation – e.g. electrical or thermal for which restitution / preventative maintenance is not possible then such locations should be identified for recommend repeat monitoring to allow degradation to be trended over time. In critical cases this may call for permanent monitoring – essentially as degradation heads towards a current limitation.

Areas requiring investigation

In some locations issues may be observed but the supporting analysis is not possible or inconclusive in terms of root cause. In such cases the location should be flagged for a follow-up investigation – e.g. by visual inspection.

3.4.9 Detail Content

The detail content should demonstrate how each of the identified locations in the Summary Content (including the background confirmation of positive negative outcomes) has been arrived at.

The support of graphical measures to illustrate the background positive negatives is strongly recommended.

Such content is likely to be more suitably expressed in the associated report.