Asset management of submarine cables and lessons learned from a repair

06/03/2018

Authors: Jean Charvet

Development of a three-terminal ready HVDC interconnector between France and Great Britain via Alderney
La SEE (Société de l'Electricité, de l'Electronique et des Technologies de l'Information et de la Communication – Association reconnue d’utilité publique, régie par la loi du 1er juillet 1901) met à la disposition de ses adhérents et des abonnés à ses publications, un ensemble de documents numériques accessibles à partir de son portail des publications. Ces documents incluent notamment les articles des revues REE, 3 EI et e-STA disponibles sous forme numérique ainsi que des publications additionnelles regroupées dans l’espace eREE. Les présentes conditions précisent les conditions de diffusion et d’utilisation de ces documents et des informations qu’ils contiennent. L’accès à ces documents, qu’il se fasse de façon gratuite ou dans le cadre d’abonnements ou d’achats faits à titre onéreux, implique l’acceptation sans restriction de ces dispositions.

Droits de propriété et de diffusion des contenus téléchargés sur le portail des publications

Les contenus rendus accessibles sur le portail des publications sont, en règle générale, protégés par le droit d'auteur. En tant que producteur, et le cas échéant d’auteur, des informations rassemblées dans les contenus accessibles par ce portail, SEE se réserve l’exclusivité des droits de copie et de diffusion de tout ou partie de ces contenus.

Les contenus sont rendus accessibles à titre individuel, pour les besoins de la personne en détenant des droits d’accès en cours de validité. Aussi, la modification, la reproduction et/ou la diffusion via Internet ou le Web, intranet, extranet ou toute autre forme numérique ou imprimée, de tout ou partie des contenus téléchargés sont interdites. Une tolérance est consentie quant à la reproduction d’extraits limités de ces contenus, dans le cadre de travaux ou d’activités auxquels ils sont utiles, à la condition que l’origine de ces reproductions partielles soit mentionnée de façon lisible et sans ambigüité. Figureront en particulier : la REE (ou toute autre revue accessible sur le portail) en tant que la source, la référence de la publication et le nom de l’auteur (s’il figure dans la revue).

Ces dispositions s’appliquent également aux figures, illustrations, logos ou images.

Publication externe des contenus du portail des publications

Tout extrait des contenus du portail destiné à être utilisé dans des publicités, des communiqués de presse ou du matériel de promotion nécessite un accord préalable écrit de la SEE. Une version préliminaire du document proposé contenant ces extraits doit accompagner chacune de ces demandes. SEE se réserve le droit de refuser un tel usage externe pour quelque raison que ce soit.

Responsabilités

La SEE apporte tout le soin possible à la préparation des informations délivrées dans les contenus
produits. Cependant elle ne peut être tenue pour responsable d'aucune perte ou frais qui pourrait découler d'imprécisions, d'inexactitudes, d'erreurs ou de possibles omissions portant sur des informations publiées, ni des résultats obtenus par l'utilisation et la pratique des informations délivrées.

**Utilisation des informations recueillies lors du téléchargement de contenu**

Le portail des publications est susceptible d'utiliser des « cookies » afin notamment de permettre l'utilisation de paniers d'achat et de personnaliser les parcours sur le site. SEE se réserve la possibilité d'utiliser les informations recueillies lors des téléchargements pour ses besoins internes et notamment pour l'amélioration de ses services, sans qu'elles puissent être cédées à des partenaires commerciaux. Conformément à la loi "informatique et libertés" du 6 janvier 1978, chaque utilisateur du portail dispose d'un droit d'accès et de rectification aux informations qui le concernent. Pour exercer ce droit, les utilisateurs doivent s'adresser à SEE – 17 rue de l'amiral Hamelin – 75783 Paris Cedex 16, par simple lettre ou en utilisant le formulaire de contact disponible sur son site.

Paris, le 28 avril 2013

---

**Metadata Datacite XML candidate:**

```xml
<resource xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns="http://datacite.org/schema/kernel-4"
  <identifier identifierType="DOI">10.23723/1301:2018-1/22500</identifier>
  <creators>
    <creator>
      <creatorName>Jean Charvet</creatorName>
    </creator>
  </creators>
  <titles>
    <title>Asset management of submarine cables and lessons learned from a repair</title>
  </titles>
  <publisher>SEE</publisher>
  <publicationYear>2018</publicationYear>
  <resourceType resourceTypeGeneral="Text">Text</resourceType>
  <dates>
    <date dateType="Created">Tue 6 Mar 2018</date>
    <date dateType="Updated">Sun 15 Jul 2018</date>
    <date dateType="Submitted">Fri 2 Aug 2019</date>
  </dates>
  <alternateIdentifiers>
    <alternateIdentifier alternateIdentifierType="bitstream">8277f6149d5eced75cd54f2e290a65d4ce91f9f</alternateIdentifier>
  </alternateIdentifiers>
  <formats>
    <format>application/pdf</format>
  </formats>
  <version>37537</version>
  <descriptions>
    <description descriptionType="Abstract"/>
  </descriptions>
</resource>
```

REE N°1/2018 ZICABLE HVDC’17 DOSSIER 2 REE N°1/2018 Z 109 Asset management of submarine cables and lessons learned from a repair Jean Charvet, RTE (France), jean.charvet@rte-france.com. Context Service experience of HVDC submarine cables CIGRE brochure TB379 – Update of service experience of HV underground and submarine cable systems, December 2009 – presents a failure rate for HVDC cables of approximately one failure per year per 1000 km of circuit, mostly caused from external damage. However, this figure is to be taken with great care because it is based on rather old service experience between 1990 and 2005, while in the past ten years, a lot of improvements has been achieved in marine engineering and routing, cable design, installation, protection and preventive maintenance. TB379 is currently being updated by CIGRE Working Group B1.57 with more recent data but results will not be published before end of 2018. In the meantime, RTE carried out a similar survey on the following sample: s6$#SUBMARINELINKSIN%UROPERANGINGFROMK6TOK6 s3SERVICEEXPERIENCEFROMTOMO s
failures known from public sources counted per circuit tone: failure may affect one or two cables) and after commissioning. Results of this survey is that for MI insulation technology, there is an average of less than one failure per year per 3000 km of circuit, while no failure has been reported for 8.0% technology of far away limited sample. % even if those figures seems reassuring a trend of decreasing failure rates, it is worth mentioning that HVDC submarine links are being built on increasingly long lengths, and thus can be more vulnerable to faults. Unavailability and cost of repair submarine cables generally don't need any planned unavailability, but can suffer from unplanned availabilities due to faults or the need for remedial protection works. Even with low failure rates, the fact that HVDC submarine cable failures take a long time to repair can lead to significant impact on interconnector business models and security of electricity supply. 

Lessons learned: 

- Emergency anchoring is probably more likely to affect multiple cables simultaneously.
- External faults in the vicinity of the submarine parts may cause damage to other cables in the vicinity.
- Cable awareness is crucial, and precise cable position should be reported on every relevant marine chart.

Design measures to prevent faults include:

- Preventive maintenance: The purpose of preventive maintenance is to de-crease the probability of failure. Cable awareness is crucial, and precise cable position should be reported on every relevant marine chart.
- Emergency anchoring: Emergency anchoring is probably more likely to affect multiple cables simultaneously.
- Cable awareness: Cable awareness is crucial, and precise cable position should be reported on every relevant marine chart.
- Preventive protection measures: Preventive protection measures against external threats and should be carefully designed.

For remedial protection works, even if those figures seems reassuring a trend of decreasing failure rates, it is a matter of concern that HVDC submarine links are being built on increasingly long lengths, and thus can be more vulnerable to faults. Unavailability and cost of repair submarine cables generally don't need any planned unavailability, but can suffer from unplanned availabilities due to faults or the need for remedial protection works. Even with low failure rates, the fact that HVDC submarine cable failures take a long time to repair can lead to significant impact on interconnector business models and security of electricity supply.

Lessons learned:

- Emergency anchoring is probably more likely to affect multiple cables simultaneously.
- External faults in the vicinity of the submarine parts may cause damage to other cables in the vicinity.
- Cable awareness is crucial, and precise cable position should be reported on every relevant marine chart.
- Preventive maintenance: The purpose of preventive maintenance is to de-crease the probability of failure. Cable awareness is crucial, and precise cable position should be reported on every relevant marine chart.
- Emergency anchoring: Emergency anchoring is probably more likely to affect multiple cables simultaneously.
- Cable awareness: Cable awareness is crucial, and precise cable position should be reported on every relevant marine chart.
- Preventive protection measures: Preventive protection measures against external threats and should be carefully designed.
Regarding operations, neither warranty period, which means that controls during all steps from cable design to cable installation are crucial. REE N°1/2018 Z 111

Asset management of submarine cables and lessons learned from a repair is also recommended to work with fishermen to define good practices when they work in the vicinity of the cables. Moreover, it is also possible to monitor vessels positions and movements in the vicinity of cable routes using real time AIS. DATA DETECTED RISK SITUATION CAN THEN LEAD TO CONTACT the vessel captain or marine authorities in order to prevent unauthorized activities in the vicinity of the cable. Cable monitoring 3 STANDARD PRACTICES FOR NEWLY BUILT (6$#) LINKS TO MONITOR TEMPERATURE ALONG THE LINK BY IMPLEMENTING $4$ SYSTEMS Development of local hotspots could indicate an internal defect or an unfavourable thermal environment, while local “cold spots” could reveal deburial. IT IS ALSO RECOMMENDED TO INSTALL $4$ SYSTEMS THAT COULD help locating deburials or external aggressions but experience is still very limited and signals are not easy to interpret. Partial discharge measurement are also sometimes considered but its interpretation can also be tricky. Those systems have a limited range and only a part of the submarine link may be monitored for long interconnectors, although technology is constantly improving. IN ORDER TO ENSURE THE EFFICIENCY OF & BASED SYSTEMS BEST PRACTICE IS THAT & UNIT S ARE EITHER BUNDLED OR DIRECTLY integrated to each power cable. This sometimes lead to install ANEXTRA& UNIT WHEN A PAIR OF POWER CABLES IS UNBUNDLED WHICH IS OFTENTHE CASE AT LAND FALLS. The way of interpreting data from those monitoring systems can vary from regular checks with analysis reports to CONTINUOUS CHECK WITH PRE DEIGNED LEVEL OF ALARM. LEARNING phase in the first month or years of operation may be necessary to fine tune the interpretation of monitoring data. In case an anomaly occurs and depending on its severity, it may be decided to launch surveys and/or remedial works. 1 AIS: Automatic Identification System, système d’échanges automatisés de messages entre navires par radio VHF qui permet aux navires et aux systèmes de surveillance de trafic de connaître l’identité, le statut, la position et la route des navires se situant dans la zone de navigation (NDLR). Geophysical marine surveys - INIMUM FREQUENCY AND EXTENT OF SURVEYS ARE OFTEN part of regulatory or insurance obligations, which can vary depending on the asset. The data to collect which are project specific generally INCLUDE MULTI- BEAM BATHYMETRY AND SOMETIMES SIDE SCAN sonar, measurement of cable position and burial depth, environmental monitoring, etc... Because marine survey operations on long links are very COSTLY, ACTIVITIES THE BEST PRACTICE IS TO ADAPT THE FREQUENCY and the extent of planned surveys depending on risks, notably SEABED MOBILITY AND EXTERNAL THREATS ANCHOR SISHING. Moreover, unplanned surveys may be decided upon occurrence of extreme meteorological event or anomaly detected on monitoring systems. ‘REACARE SHALL BE TAKEN ON FORMAT OF ’3 DATA ORDER to be able to compare each survey data from the previous surveys, and make the data usable for potential future works on or next to the link. Repair preparedness The purpose of repair preparedness is to reduce the time for a repair, and thus the induced losses. Organisation and emergency contingency plans % LABORATING AND MAINTAINING AN UP TO DATE EMERGENCY contingency plan for each submarine link is a key point for a QUICK RESPONSE AFTER A FAULT Figure 2: AIS monitoring on IFA2000. IFA2000 experience Immediately after fault happened in November AND BASED ON ITS EXPERIENCE OF EMERGENCY situation, RTE put in place an operational project team involving local personnel from project management and maintenance departments, relying on the support from internal cable expertise and offshore project departments, procurement and legal departments and outsourced marine and legal experts. Lessons learned: > AVING$2% QUALIEED PERSONNEL ON BOARD OF REPAIR Vessels allowed to handle interfaces between different contractors on board, which were sometimes critical and it surely has saved time and PARTICIPATED TO QUALITY AND SAFETY > Experience from repairs is valuable to improve contingency plans. JCABLE HVDC”17 DOSSIER 2 112 ZREE N°1/2018 3UCHAPLAN WOULD TYPICALLY INCLUDE s DESCRIPTIOF INTERNAL ORGANISATION OUTPUT INPLACE INCLUDING HUMAN RESOURCES ROLES AND RESPONSIBILITIES DECISION MAKING s$2 EPAIR PROCEDURES FOR DIFFERENT PLAUSIBLE FAULT SCENARIOS s$3 OF RELEVANT CONTACTS AND PROVIDERS s$4 INTERFACE MANAGEMENT s3AFETY% NVIRONMENT AND 2 EGU LATORY REQUIREMENTS Periodic revision of contingency plans shall be performed AND IT IS RECOMMENDED TO PERFORM REGULAR CRISIS EX EDER. Cises. Fault location & ULT LOCATION IS ON THE CRITICAL PATH OF A REPAIR IT IS GENERALLY performed in two steps: s$ 0RE LOCATION FROM LAND USING $4$ 2 BASED METHODS ON THE power cables, s$ 0 I N POINTING USING MAGNETIC-field AND DORACOUSTIC MEASUREMENTS at sea, and/or with fibre optic when available. Reliability and reactivity of those operations is of paramount importance and thus it is recommended either to have an internal expertise or frame agreement with a specialised provider. Marine operations Mobilization of an adapted marine spread to allow the repair needs to be done as soon as possible after fault location is confirmed. In addition to vessels that are necessary for fault location and surveys, type of marine vessels to mobilize depends mainly on water depth, and are generally: s$ACK UP BARGES AND TUGS FOR REPAIRS AT LAND FALLS s$ INCHORED BARGES AND TUGS FOR REPAIRS IN SHALLOW WATER s$15 m WD s$36 OR$0 VESSELS FOR REPAIRS IN DEEP WATER. Because it is very costly to keep in standby all those type of potentially necessary vessels for repairs, It is general practice, upon a failure, to hire vessels that are available on the market, through a specialized broker for example. O ROVER REPAIR OPERATIONS NEED SPECIFIC EQUIPMENT TO BE installed onboard which can vary depending on the holder.
Some of the critical equipment which can be project specific are listed below.

- Tools for deburial and burial, mainly depending on the type of soil and cable diameter.
- Able chute and quadrant mainly depending on cable coilability.
- Repair table or basket, mainly depending on cable coilability.
- Mainly depending on cable length and weight of spare and cable.
- Able chute and quadrant, mainly depending on cable coilability.

Localization and pin-pointing of faults on the four cables with 50 m accuracy were completed within 9 days after faults occurrence and later double confirmed by surveys showing anchor scars on the seabed. 24% has an internal expertise in fault localization and pin-pointing of faults on submarine cables with 50 m accuracy, and this was completed within 9 days after faults occurrence. This was confirmed by surveys showing anchor scars on the seabed.

Local expertise in pin-pointing and fault location was developed internally and patented. This was very efficient. Figure 3: Offshore pin-pointing equipment. Figure 4: Pin-pointing based on magnetic field measurements. Figure 5: One of the vessels hired for IFA2000 cable repairs, at mobilization site.

Having internally the equipment ready for mobilization together with regularly trained maintenance teams proved to be very efficient. Lessons learned: Having internally the equipment ready for mobilization together with regularly trained maintenance teams proved to be very efficient.

Contractual arrangements or a frame agreement for mobilization of marine spread personnel and equipment with a specialized contractor is a common practice in order to save time for negotiations and engineering after occurrence of a fault. Jointing operations are now how of specialized jointing teams is a key point for a successful and reliable repair, especially in very high voltage ranges. Spare parts storage is necessary to make sure that reliable spare materials of the cable system is immediately available in case a repair is needed without waiting for remanufacturing. Quantity of spares is project specific and mainly depends on: risks and failure scenarios to cover, water depth, researc areas where jointing will have to be conducted, possibility of rock berms, and times and minimum quantities to refill the stock after it is used. Lessons learned: Keeping a regular inventory and maintenance on the spare parts is valuable.

Conclusion Lessons learned from submarine cable repair experience makes possible to improve asset management policies. Sharing of service experience and collaboration for more standardization of repair solutions must be encouraged.

Glossary:
- AIS: Automatic Identification System
- DAS: Distributed Temperature Sensing
- DTS: Distributed Temperature Sensing
- DP: Dynamic Positioning
- DSV: Living Support Vessel
- FPR: Fibre Photonic GIS: Geographical Information Systems
- MBR: Minimum Bending Radius
- MI: Mass Impregnated
- TDR: Time Domain Reflectometry
- XLPE: Cross-linked Polyethylene
- LINKED OLYETHYLENE-ROSSED

The two repair vessels and one support vessel were hired within one month and ready before the jointing teams. The support vessel was dedicated to prepare cable cuts and cable deburial checks and tests on cables, sealing ends) while the two others were dedicated to jointing operations. Lessons learned: Having a frame agreement made possible to hire jointing teams contracted those operations to two different suppliers who were both competent to perform the cable jointing operations. Those operations appeared to be on the critical path of the repair, as marine spread was ready before jointing teams. Lessons learned: Having the possibility to install compatible joint from a different supplier than the original cable was beneficial and saved time.

Tests confirmed that the spare cable that was stored for more than thirty years in cable tanks were still in good condition. Two cable joints from the spare parts have been used for training of jointers, prior to perform the offshore repairs. Lessons learned: Regular inventory and maintenance on the spare parts is valuable.