Asset management of submarine cables and lessons learned from a repair

06/03/2018

Authors: Jean Charvet

Abstract

Asset management of submarine cables and lessons learned from a repair

Development of a three-terminal ready HVDC interconnector between France and Great Britain via Alderney

Metrics

Downloaded: 3
Viewed: 0
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 échant 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 ambiguïté. Figurent 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 résulter 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">Sun 4 Aug 2019</date>
  </dates>
  <alternateIdentifiers>
    <alternateIdentifier alternateIdentifierType="bitstream">8277f6149d5ecad75cd54f2fe290a65d4ce91f9f</alternateIdentifier>
  </alternateIdentifiers>
  <formats>
    <format>application/pdf</format>
  </formats>
  <version>37537</version>
  <descriptions>
    <description descriptionType="Abstract"></description>
  </descriptions>
</resource>
```

**Résumé**

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: s 6$#SUBMARINELINKSIN%UROPERANGINGFROMK6TOK6 s3SERVICEEXPERIENCEFROMTO s
Design measures Fault causes and preventive design measures Risk mitigation regarding fault occurrence and induced losses starts from the design phase of submarine links. Type of faults and design measures to prevent them are described below. External faults may be caused either by human activities, natural phenomena or a combination of those: s 3EABED MOVEMENTS LINKED TO SEISMIC ACTIVITY OR CURRENTS AND WAVES s BUSHING GEARS s BURIED CABLES AND FREESPANS s IMPACTOR HOOK BY ANCHORS S HING GEARS s AGE CAUSED BY WORKS IN THE ABED DREDGING CABLE OR PIPE LAYERING EXTRICATION OF AGGREGATE s ALLING Objects SHIPWRECK s RIDANCE EXPLOSION IN THE VICINITY To prevent external faults, the cable route and the level of protection shall be carefully designed depending on the above mentioned risks. Internal faults may be caused by: s RROR OR DEFECT DURING MANUFACTURING OR ASSEMBLY OF JOINTS AND TERMINATION s ECHANICAL DESIGN PARAMETERS EXCEEDED DURING TRANSPORT STORAGE OR INSTALLATION s AD THERMAL ENVIRONMENT LEADING TO EXCEED TEMPERATURE DESIGN VALUES s VER VOLTAGE OVERLOADS ABOVE DESIGN VALUES 4 PREVENT INTERNAL FAULTS IT IS CONSEQUENTLY RECOMMENDED to select properly tested materials, have a robust inspection and test plan during every step from design, manufacturing and installation of submarine cables, have a robust thermal DESIGN BASED ON ON SITE MEASUREMENTS AND PUT IN PLACE proper protections against overvoltage and overloads. Maintenance friendly designs In order to allow an effective preventive maintenance and A QUICK REPAIR THE FOLLOWING KEY POINTS MUST BE CONSIDERED s INTEGRATION OF UNITS INSIDE POWER CABLES OR ALTERNATIVELY BUNDLED IS BENEFICIAL TO ALLOW s BASED CABLE MONITORING AND FAULT LOCATION s # ABLE MUST BE EASILY ACCESSIBLE IN CASE A REPAIR IS NEEDED this may be contradictory to preventive protection measures AGAINST EXTERNAL THREATS AND SHOULD BE CAREFULLY BALANCED sIMITING THE NUMBER OF DIFFERENT CABLE DESIGNS AND ACCESSORIES or making sure they are compatible between each other in order to rationalise spare parts storage. Preventive maintenance The purpose of preventive maintenance policies is to decrease the probability of failure. Cable awareness It is obvious that precise cable position shall be reported on every relevant marine charts. Figure 1: IFA 2000 experience 3 INCE IT HAS BEEN COMMISSIONED IN THE submarine part of the interconnector has experienced TWO SIMULTANEOUS EXTERNAL FAULTS AFFECTING four cables, presumably caused by anchors although cables were well buried at approx. 1.5 m in relatively stiff soil, 5 km away from English coast and relatively far from shipping lanes. Lessons learned: > Emergency anchoring is probably more likely to happen in nearshore areas and not inside a shipping lane. IFA2000 experience 3 INCE IT HAS BEEN COMMISSIONED IN THE submarine part of the interconnector has experienced one internal fault in 2003, affecting one cable, caused by mishandling during installation which created a weak point. Lesson learned: > NOT ALL DEFECTS CAN BE DETECTED DURING COMMISS
sioning tests, 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 it 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 PRACTICE FOR NEWLY BUILT 3 TASK 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 &/ UNITS 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 OFTEN THE 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 LEVELS 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 automatisé 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 - INIUM 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 IT IS BEST PRACTICE TO ADAPT THE FREQUENCY and the extent of planned surveys depending on risks, notably SEABED MOBILITY AND EXTERNAL THREATS ANCHORS RISING. Moreover, unplanned surveys may be decided upon occurrence of extreme meteorological event or anomaly detected on monitoring systems. 'REAL CARE SHALL BE TAKEN ON FORMAT OF' 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: > AVING24% QUALIFIED 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. JICABLE HVDC'17 DOSSIER 2 112 ZREE N°1/2018 SUCH A PLAN WOULD TYPICALLY INCLUDE s $ DESCRIPTION OF INTERNAL ORGANISATION OUTPUT IN PLACE INCLUDING HUMAN RESOURCES, ROLE AND RESPONSIBILITIES, DECISION MAKING s$ EARLY AIR PROTOCOLS FOR DIFFERENT PLASIBLE FAULT SCENARIOS s ISTRUMENTS s$ RELEVANT CONTACTS AND PROVIDERS s$ INTERFACE MANAGEMENT s$ SAFETY s$ ENVIRONMENT AND 2 EGUATORY REQUIREMENTS Periodic revision of contingency plans shall be performed AND IT IS SOREMENDED TO PERFORM REGULAR CRISIS EXERCISES. Fault location & AULT LOCATION IS ON THE CRITICAL PATH OF REPAIR) T IS GENERALLY performed in two steps: s 0RE LOCATION FROM LAND USING 4$ 2 BASED METHODS ON THE power cables, s 0IN POINTING USING MAGNETIC IELD OR ACOUSTIC 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 repairs to be completed 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: %ACK UP BARGES AND TUGS FOR REPAIRS AT LAND FALLS $ INCHORED BARGES AND TUGS FOR REPAIRS IN SHALLOW WATERS < 15 m WD s$360R$0VESSELS FOR REPAIRS IN DEEP WATERS 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. - OREOVER REPAIR OPERATIONS NEED SPECIFIC EQUIPMENT TO BE INSTALLED ONBOARD which can vary depending on the vessel.
Some of the critical equipment which can be project-specific are listed below. 

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 pointing.

Localisation 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.

Tenancé teams proved to be 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.

Ree N°1/2018 Z 113

Asset management of submarine cables and lessons learned from a repair 

Jointing operations + now how of specially jointing teams is a key point for a successful and reliable repair, especially in very high voltage ranges. Spare parts storage the purpose of spare part storage is 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:isks and failure scenarios to cover, water depth, area of areas where jointing will have to be avoided, for example: possibly rock berms, earthing times and minimum quantities stored after it is used. A storage site is usually close, early an a quay in a port with direct and permanent access to sea in a controlled and secure area aired and protected from UV and rain.

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.

Lessons learned: > Having a frame agreement made possible to hire and mobilize a consequent team within a short time because of the extent of the repairs to be done and limited availabilities of jointing teams, RTE contracted those operations to 2 different suppliers who were both competent to perform the cable jointing operations.

ANDMOBILIZEA CONSEQUENT MEET WITHIN A SHORT TIME 

IFA2000 experience Because of the extent of the repairs to be done and limited availabilities of jointing teams, RTE contracted those operations to 2 different suppliers who were both competent to perform the cable jointing operations. They operated 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. IFA2000 experience Tests confirmed that 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.

Lesson learned: > Regular inventory and maintenance on the spare parts is valuable.

https://www.see.asso.fr/en/node/22500/landing