2022 Paris Session

10881
Study Committee B1: Insulated Cables
Preferential subject 1: LEARNING FROM EXPERIENCES

Decommissioning of a Self-Contained Fluid-Filled cable: operating method and risks mitigation

I. KAMAL
EDF
imane.kamal@edf.fr

M. LEFEBVRE
CTE PLUS
marc.lefebvre@cte-france.fr

SUMMARY

To fight against climate change, all coal-fired power plants in France shall be decommissioned by 2022. In this context, EDF, the main electricity producer in France, decided in 2015 to decommission several thermal power plants.

The decommissioning of such industrial sites requires the restoration of the concerned area to its original state to prepare it for the future projects. The industrial installation shall therefore be completely dismantled before considering the future use.

The dismantling of such installation requires the removal of the industrial building, and all the equipment which was used for the electrical energy output, in particular the high voltage links to the French electricity grid.

This paper will therefore present a project aiming at removing the high voltage connection to the grid which was composed of 225 kV Self Contained Fluid Filled (SCFF) land cables. It will describe the scope of the removal project, the issues and constraints faced during the different project stages.

KEYWORDS
225 kV SCFF cables; decommissioning; risk mitigation; high voltage cables recycling.

1. INTRODUCTION

After the decommissioning of the power plant, in order to restore the land to its initial state and prepare it for any type of future use, including non-industrial constructions, it is necessary to remove all the industrial constructions including the power plant building and all the other auxiliary installations.

The power plant taken as example for this paper was connected to the electrical grid by 4 underground cable links. So, 4 underground links of Self-Contained Fluid-Filled (SCFF) cables installed during the 1960s, their accessories, and the telecom cables which were used to operate these links shall also be removed in order to make the ground clean for future uses.

The concerned links were installed in shared structures belonging to different owners, which required a joint preparation phase to integrate the constraints and operating rules of each entity.

Moreover, the issues in terms of personal safety and environmental protection were considered during the early stage of the removal preparation to guarantee the safety of the operation.

Finally, the removal operation required the waste processing and enabled the financial recovery of the materials.

2. DESCRIPTION OF THE CABLE INSTALLATION

2.1 Technology

The removal project was about of 4 underground links of Self-Contained Fluid-Filled (SCFF) cables, with sections of 820mm² and 800mm² in copper, the weight is approximately 23 kg / m. The length of each link was approximately 800m, representing 9.6 km of cable.

SCFF cable cross section

The cable was supposed to be on good state, without neither damages nor oil leakage.

2.2 Laying Methods

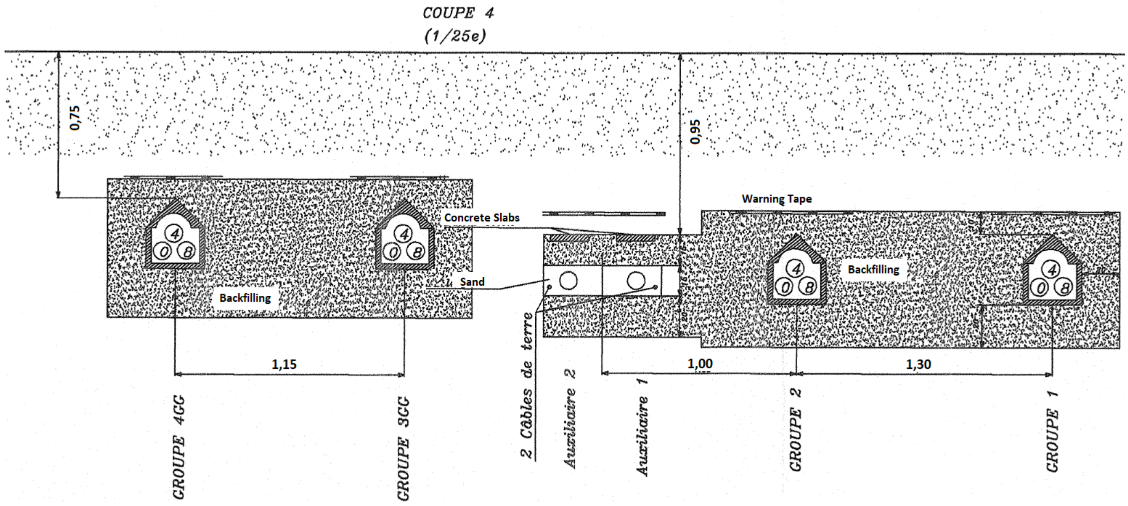
Along the route, cables were installed using different laying methods depending on the area.

Starting from the power plant, the cables were laid in buried and filled troughs over approximately 40% of the route.

For the road and railway crossings, the cables were laid in PVC ducts cast in concrete for about 10% of the route, then in a tunnel for 50% of the route.

Below are the sectional view of the main laying methods.

- **Buried and filled troughs**

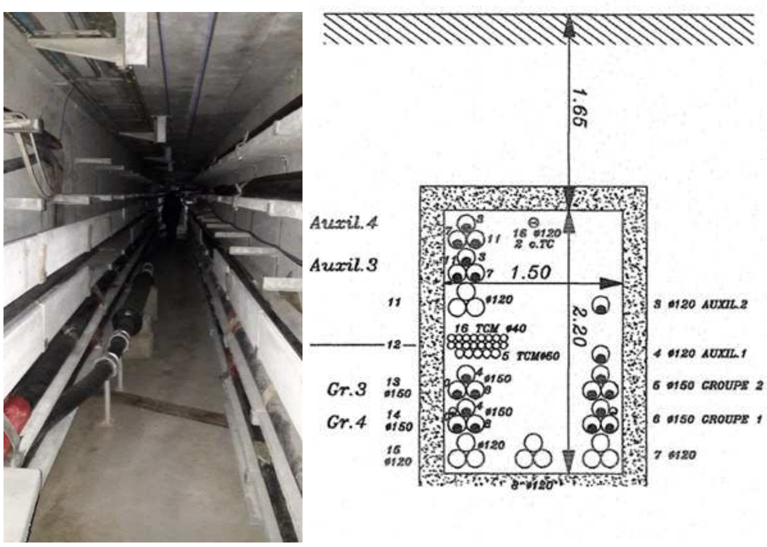


Sectional view of 225 kV cable trench

- **The Tunnel**

In the tunnel, other cables are still in operation and consequently electrically powered.

Moreover, as the cables were installed on support shelves, it was decided, given the period of construction of the tunnel, to take samples from the shelves to identify whether there was asbestos or not; this risk will be presented later.



Cables routed in tunnel

3 Studies before the decommissioning

3.1 About the installation to remove

When the removal request was received, the design phase began with the recovery of as much information as possible, as all the data on these facilities was not always available. While analysing the current state of the cable, we determined how the removal operation could be carried out safely for people and for environment.

It was necessary to check the cable technology to define the securing method and to launch the tender with the best information available.

There were doubts regarding the laying method on some parts of the route, a trench perpendicular to the route was achieved to get further-information.

3.2 About other surrounding installations

To remove the cables, excavations were needed, which represented a potential risk to other underground installations located nearby.

Indeed, the French regulations have evolved since the significant number of incidents on underground grids (17 incidents per day in 2008 over the 200,000 km of the gas distribution grid), with consequences on safety, the environment and then economy.

Since 2011, a digging authorization is mandatory before any earthwork. A centralized procedure using a website interface-shall be used by all companies to identify all the underground installation along the working area in the public space and sometimes also in the private field. The purpose of this procedure is to identify the utilities and to inform them about the company's wish to carry out work near their installations, and also to allow the company to locate other grids and have all the useful information to guarantee-safety during the excavations.

It was also necessary to figure out the changes that occurred to the industrial building and its impact on the removal project.

In addition, since this was a first-time operation, a detailed risk analysis had to be done to provide a specific operating mode for each laying method with a detailed description of the means of civil engineering works, and also to take into account the impact of this works over the long term.

4 The Project execution

4.1 General

The removal project was carried out by a consortium of two companies, one specialized in civil engineering work and the other one with a great experience in all types of work on SCFF cables and electrical risk mitigation.

After the engineering phase, the work consisted in:

- Recovery of oil present in cables and joints
- Access to cables in the tunnel or via excavations respect to buried parts
- Cable tapping and earthing
- Application of the removal procedure drawn up for each installation method

All the removal procedures required the installation of equipment for pulling, lifting, and cutting the cables in a watertight areas when needed. They are detailed in the following paragraph.

4.2 Inerting and draining the oil

4.2.1 Draining the liquid

Draining requires connecting the pipes to the bottom boxes of the cable heads and to the hydraulic plant. We then push with nitrogen or compressed air to recover the oil, depending on the altimetry profile of the cable links, in suitable containers.

In the present case, we recovered 1800 litres of oil from the central hole in the cables.

Connections in the fluid station of units 3 and 4 in the power plant

Connections in the RTE substation to the other side of the High voltage link

But a significant part of the oil is still contained in the impregnated papers. This will lead to 2 points to be considered:
- The central hole will be filled over time, by gravity, with the oil contained in the papers,
- Cutting the cable will immediately lead to oil dripping which-shall be controlled.

As the previous draining process couldn't be repeated when the cable is cut, for each cable cutting or handling operations, the ground below shall be protected against oil dripping. The protection shall be adapted to the quantity of oil and could be either a waterproof receiver or a cover with absorbent material.

4.2.2 Voltage testing

The first cut is to check that there is no voltage. On a 225 kV cable, it consists of positioning a hydraulic drifter that can be operated remotely, which is inserted into the core of the cable. On an oil filled cable, the operator shall also use a suitable container to collect the oil leaks.

Absence of voltage check under a cable sealing end

Absence of voltage check in excavation to safety cut the cables

4.2.3 Removing the outdoor sealing ends

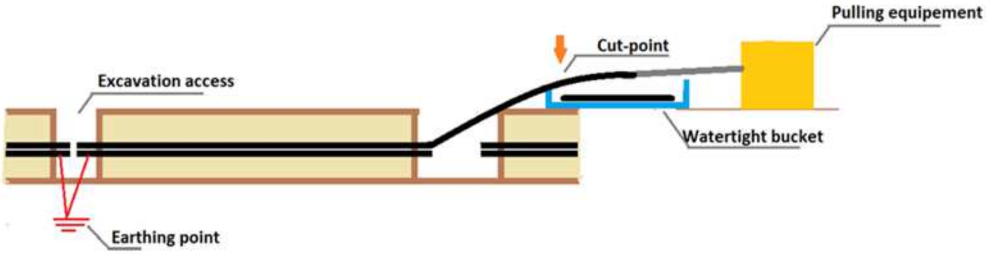
Most of the oil in the cable sealing ends was drained during the main drain, but a quantity of oil remains is still stuck in it. It is therefore necessary to remove the cable sealing ends carefully to avoid any leakage risk. The sealing ends were handled from above after cutting the cable.

4.2.4 Removing cable joints

The joints have a section which contains oil remaining hydraulically separated from the central hole of the cable. This equipment must therefore be removed separately to prevent oil leaks.

4.3 Buried and filled troughs

Regarding the buried and filled troughs, excavations perpendicular to the route were carried out. Once the grounding and the cutting of the cable-achieved, a winch positioned at ground level allowed the cable to be pulled to bring it above a sealed area where the cable could be cut in about 2-m length sections. For straight-line routed cables the possible draw length was of about 40 m, but in some portions with turns, openings had to be brought closer to reduce the draw length. The draw of the first phase was the most difficult each time because the friction factor was the highest, the following phases were easier to remove.



The removal method used for the cables in troughs and ducts

Watertight container with a roof to store cables

On a part of the route, during the power plant operation, an external structure with concrete foundations was built just above the cable route. This construction was a great modification and resulted in greater efforts on the cable as the friction force in the troughs was higher.

A survey excavation under the external structure

The removal of these cables would have required increasing the number of openings to cut shorter lengths. But this represented a risk on the structures above. This portion was therefore abandoned in situ and the choice was made to install a long-lasting and a hermetical sealing device. We therefore set up steel covers with the same diameter as the cable and lead-welded to the cable sheath. Below is a photo of this device:

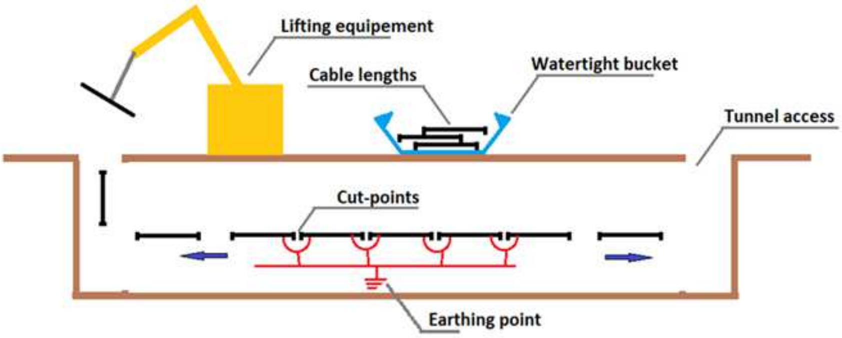

Cover in underground gallery

This solution is not a problem for the site restoration, as in the future it will be possible to remove this part of the link when the structure built above reaches its end of life.
It will still be necessary to keep a monitoring of the sealed ends at regular intervals to avoid accidental leaks.

4.4 Tunnel

In the tunnel, it was also necessary to consider the electrical risk due to induction, thus grounding at each cutting point was carried out.

Moreover, the access to the tunnel was so narrow that the previous method of pulling a long part of the cables could not be used. It was therefore necessary to cut the cable in the tunnel itself and then take out the small lengths. The cutting operation in the tunnel was carried out using a mechanical tool (a press) to avoid the projection of sparks which might cause a fire with the presence of oil.



The removal method for cables in the tunnel


Joint removal operation

4.5 Ducts

The same removing method as for the cables installed in buried troughs was used in ducts. The removing operation was easier as the friction effort was lower.

5 The risk mitigation

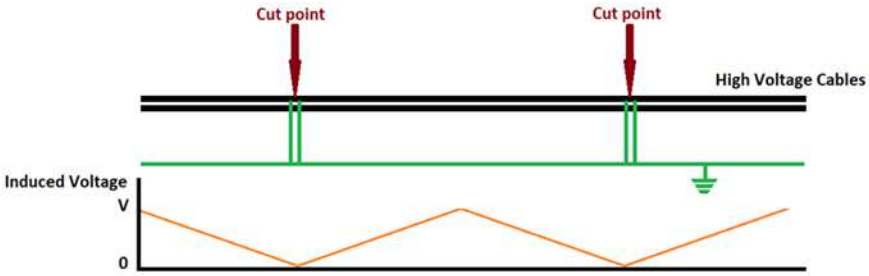
5.1 Electrical risk

The cables to be removed are de-energized but the cable route was close to other live cables, so it was therefore necessary to identify the cables to be removed with certainty, a discussion with other utilities with common surveys on the tunnel was carried out to be definitively sure the works are carried out on the right cable.

Moreover, the links were partially routed in an electrical substation into operation, so induction risks had to be considered in the operating procedure.

In an electrical substation, there is an electrical risk even on non-powered cables, due to the induction phenomenon. In such case, it is necessary to ground the screen and the core of cables, in several positions and at each cut point, to guarantee the operator's safety when cutting the cable.

Grounding device to connect the core and the screen of the cable



The cut points according to grounding points

5.2 Mechanical risks

The use of earth-moving equipment, cutting tools and lifting gears was necessary for the removal operation. This generates multiple risked operation.
To define the best way to manage and limit these risks, the latter were listed in the preparation phase.
For the risk related to earthworks and excavations, the regulatory procedure was applied and a survey trench was opened to clarify the removal method.
For the risk related to lifting, a reminder of the company's vital rules was delivered to the subcontractors, namely:

- not to stand under a load
- to use suitable and controlled lifting means
- to carefully supervise the lifting operation

Respect to the risks related to cutting operation, the use adequate safety equipment was necessary. And to eliminate the risk of fire due to the presence of oil, especially in the tunnel, the subcontractor was asked to use a non-electric cable-cutter.

5.3 Safety risk due to the presence of Asbestos

One of the most important safety issues was the presence of a fibre cement shelf protecting the cables in the tunnel (refer to photos).

Samples were taken a few months prior to the removal operation and it was confirmed that those vertical shelves contain asbestos. Then dust measurements of the atmosphere were carried out and did not reveal the presence of asbestos fibre in the atmosphere of the tunnel.
The removing operation of the cables was preceded by an "asbestos" operation to remove the side plates protecting the cable and to clean the tunnel to allow a safe intervention.
The main difficulty in this phase was the limited access to the tunnel and the lack of space inside.
At the end of the removal of the materials containing asbestos, the asbestos removal company carries out atmosphere measurements, then the removing operation of the 225 kV cables and of the auxiliary LV cables could begin.
Asbestos was also found in the joints of the high voltage cable; therefore, a cut was made on each side of each joint and the entire one was considered as waste containing asbestos.

5.4 Environmental risk due to the presence of fluid in the cables

Self-Contained Fluid-Filled cables are oil filled and we now know that 1 litre of oil is enough to cover 1000 m² of water and these oil filled cables contain up to 0.5 litre per m. So, each oil filled link contain hundreds of litres of oil is a significant threat to environment.

So, the risk of environmental pollution is significant and shall be taken into account from the study phase. Especially when it comes to removing cables or leaving them in the ground.

The oil cables have a lead sheath which allocates them a very good resistance over time. But after half a century of use, if the unpowered cable has to remain in the ground for a few more decades, the lead can crystallize and in the event of mechanical stress, a rupture of the lead screen will lead to an oil leak.

In the present case, the operator chose to remove the cables, which enabled him to make sure there is no risk of future pollution due to an underground oil leak.

6 The project feedback

6.1 The preparation stage:

The accuracy of the collected information is essential for the project because it has an impact on both the feasibility and project cost. An industrial site evolves, new structures can be built and it is therefore important to identify the route of underground connections not only on maps but also physically on the site. Maintaining an up-to-date history also allows decision-making consistent with safety rules and reduces uncertainties during the work preparation stage.

The main input data shall at least include:

- The technologies of the cables and of the accessories and their condition
- The laying method used at each point of the cable route which has a high impact on the feasibility of the project. The installation of the cables in ducts seems to be the best choice to facilitate the removal operation of cables as the damage risk to the cables during removal is lower.
- The list of the ownerships of cable routing areas to identify interfaces with other utilities and to get in touch as soon as possible with them because decision-making times have an impact on the project schedule.

- The description of other underground installations located nearby
- The feedback of other similar projects

Respect to this stage, chapter 9 of the Technical Brochure 652 "Guide for the operation of self-contained fluid filled cable systems" will be useful to assess the technical and environmental risks of a removal project, it also gives an idea of the practical options to deal with those risks during the preparation and the execution stages, specifically when removing some parts of the cables seems impossible.

Once the input data is available and confirmed, it is necessary to:

- Clearly communicate respect to the expected works to allow the stakeholders' opinion to be taken into account in the definition of the operating mode and in the risk analysis.
- Formalise in writing the exchanges to engage the stakeholders' responsibility.

6.2 The execution stage:

During the exclusion stage, a particular attention shall be payed to:

- The transmission of all useful information to the contractor
- The contractor skills and awareness of the electrical, environmental, and civil engineering risks
- Achieve regular monitoring of the site to check that risk management is efficiently carried out throughout the site and despite the change of teams involved
- The required adaptation of the operating mode according to what is discovered during the works

6.3 The share of the material recycling in the project financing

At the end of this removal project, it was possible to recover a large part of the buried cables, these cables could be recycled and some materials, in particular copper, could be financially valued.
The cost of this removal was half covered by the cable trading. This data depends of course on the nature of the core, copper or aluminium and also on the removal cost which can increase if the removal process is complex.
The price of metal varies over time, so depending on the project and the copper index at the time of the project, some cable removal projects can nearly be covered by the metal valorisation.

Beyond the financial aspect, the removal operation of industrial installations is in line with the upcycling and the reuse of resources.

7 Conclusion

To conclude, the removal operation of a cable system is a project which can be as much complex as a project for the construction of new underground cable links connections, and requires specific feasibility studies and risk mitigation in order to guarantee the safety of the people, the environment and of the other installations around. Moreover, it seems interesting to take the removal into account from the design phase of a new underground link and during the several steps of the cable life, it is important to consider the cable route and its different laying sections when modifying the environment to let a replacement phase or a full deposit possible.

Several reasons can be the justification of the removal operation, to replace the cable by a new technology, to guarantee the absence of environmental pollution and related legal risks or to restore the concerned area. But in a cable decommissioning case, it will always be interesting for the cable owner to study the financial aspects which can motivate the deposit of an abandoned cable.