INTRODUCTION

The 20 kV synthetic cable used on the French distribution network has an excellent experience feedback. Due to technical improvement on insulation materials achieved during the last 20 years, EDF has considered that its optimisation was possible. As a second step the descriptive specification as been replaced by a more functional one. The notion of the unique model of MV cable in France is now withdrawn.

At the same time, EDF undertakes actions in order to improve laying techniques of MV cable. In particular solutions for mechanical protection of cable leading to suppress the use of sand under and around the cable have been studied or are under consideration. Investigations carried out will allow completing the functional specification. Solutions could be rapidly used on site as a part of rebuilding of MV network.

Context of reconstruction of MV network

Improving quality and continuity of service had been a major concern for EDF for many years. Many studies and improvement has already been done. After the terrible storms that occurred in 1999 in France, it appeared that this effort had still to be increased. The main effort had to be undertaken on continuity and sensibility of customers with long electrical interruptions. These improvements are now a major objective for EDF Group.

It has been decide to have a work program with the following target: if a similar storm happen again in 15 years of later, 95% of the customers have to be re-energized within 5 days ; additionally, each village must be able to keep continuously at least one emergency electrical source in case of any storm. The objective of 95% / 5 days had to be reached from the year 2005.

Reaching these objectives requires decreasing the sensibility of MV network to climates events. It as been decided to replace main overhead lines situated in wooden zone by underground cables, or even to build another overhead line with another route situated in a non wooden zone. Line situated in zones exposed to direct severe climatic risks such as snow, ice, wind, storms, floods or even developing wooden plantations will be subjected to be re-enforced or rebuilt with underground lines.

Such installation condition have to be managed for economical and management reasons. As a result, MV cable, which represents a high part of the investments, has to be look carefully.

Evolution of cables

EDF started in 1998 a wide program of purchasing cost reduction. Analysis of the situation in Europe showed that existing MV cables currently used in Europe could not provide significant saves.

A collaborative project with manufacturers has been started. This project had two main steps. An adaptation of existing specification produced significant saves quickly. this first step was the so called « cable 2000 ». This step has been followed by a complete re-writing of the specification. The new specification is now more functional and has been published in France under the reference « C 33-226 ». This document has been introduced into the HD 620 § 5G.2. This last step permits a wider evolution of cable designs in the future and facilitates new suppliers for selling their cables in the French market.

Insulation optimisation of so called « Cable 2000 »

The 20 kV synthetic cable on the French distribution network has an excellent experience feedback; The very innovative design at the introduction of this cable on the network, has barely changed during 20 years of operation. Meanwhile, significant improvements of the synthetic insulation, on the material point of view as well as on the industrial process, have led to an extension of this technology to the highest voltage levels and to the development of more efficient accessories.

Due to these technical achievements, EDF and the manufacturers of this product have considered that its optimisation was possible.

The chosen way to directly draw benefit from progress of the synthetic insulation was to reduce the insulation thickness of the cables from 5,5 mm to 4,5 mm. These optimised cables were developed, and the corresponding connection accessories were also adapted.

Taking into account the reductions of the cable diameters,
and the increase in the electric field, the compatibility of these new cables with the accessories has been carefully studied. Accessories were validated according to the European document HD 629.1 as well as the French document C 33-001. Additional breakdown tests were undertaken. Field experimentation has been done and showed that some tools needed to be adapted. This project required also to remind to jointers the good practice of the cable preparation.

Since March 2000, Electricité de France, provisions exclusively the new cable with an insulation thickness of 4.5 mm without any particular problem. The insulation optimisation has only been done on 150 mm² and 240 mm² cable. The change to the new cable allowed a sensible reduction of the cost of 20 kV underground cable system.

Since this optimised cable is used, EDF did not notice any increasing number of faults rate on new cables or accessories.

**The more functional specification « C 33-226 »**

The past French specification, as number of European specification, was highly descriptive. Innovations could not be easily introduced as the cable design could not be changed.

Therefore, a more functional specification has been written with the contribution of European manufacturers. With this new specification, the concept of using only one single cable design in French network is withdrawn: numbers of different designs are now possible.

However, EDF has wished to preserve interoperability between the several new and old cables designs. This interoperability has to be applied to the accessories (joints and terminations) and tools used for preparation. A management of the interface of the system is now required to guaranty the global operability of the system.

Several designs were proposed by manufacturers and qualified. Accessories were tested and in some cases had to be partially modified. However, the major modification and improvements had already been done during the first step (cable 2000). Field experimentation showed that new preparation tools and to be used. Special instructions were also design to help the jointers doing the cable preparation.

The reduction in diameter shows in figure 1 shows the optimisation accomplished between 1999 and 2002.

![Figure 1](image)

This new cable has been progressively displayed from July 2002. In the beginning of year 2003, half of the French units will be using it. The other half is still using the so-called « cable 2000 ». This new cable required an investment in adaptable tools as well as a special training for all jointers. Despite this investment, this new cable specification will be able to achieve a cost reduction of underground MV cable.

The French document « C 33-226 » has been introduced in the European specification under the chapter 5G.2.

**DIRECT LAYING CABLE DESIGNS**

**Context**

MV cables are designed to be buried directly in the ground if sufficient fine backfill is available. However, in most practical cases, an additional backfill (sand) has to be bought and installed in the open trench around the cable. This additional sand is used to protect the cable from external aggressions and contributes to the thermal conductivity of the environment.

Providing an additional backfill requires a specific logistic such as lorries and temporary storage. This logistic is often expensive or complicated to be organized. It has to be pointed out that using sand is not always a very good solution. Phenomena such as draining, high thermal resistivity of dry sands can occur. As a result, EDF looked for alternative solutions and finally recommended some of them.

**Geosynthetic protections**

Geosynthetic materials are manufactured in a flat formation built with polymers currently used in geotechnique applications and civil work. Their main characteristic is to be fluid permeable.

In middle 90’s, EDF worked in cooperation with a mechanical laying machine manufacturer and a geosynthetic manufacturer. The aim of the project was to develop a protective solution for MV cables. This solution is now qualified by EDF. It consists in a mattress of sand...
compressed in a mechanically protective outer textile layer made with a long length band of polypropylene. The width of the protection band is adapted to the size of the cable conductors. The geosynthetic protection is then wrapped around the three phases of the cable and fixed with strings. Compared with traditional laying, this construction achieved a reduction of 90% of the sand consumption. The required logistic is significantly reduced too.

This solution is technically efficient and has many advantages:
- Installation of additional sand is not required
- a good thermal conductivity is ensured
- Protection can be wrapped in advance on the cable
- Compatible with mechanized laying technique
- Available with all type of cables
- Logistic costs are reduced
- Duration of the civil work is reduced (a triplex cable can be laid down at a speed up to 500 meters / hours).
- The risk of external aggression is reduced
- Environment is respected by preserving homogeneity of the soils
- Excavated ground can be sometimes reused
- Security is improved (less lorries are used)
- Cable can easily be laid down in sloping areas or narrow trails

General requirements for directly buried cable are very similar to other cables. In particular, this cable must be able to be prepared with tools and compatible with accessories used for other types of cables.

On the other hand, its particular functionality must enable this cable to be used directly buried in the ground even in aggressive soils containing gravel and rocks. It must sustain to be operated in an environment which generates severe thermomechanical constraints. Compared to “classical” cable this new cable has not to reduce excessively the ampacity of the link.

The mechanical protection given by the sheath of the cable has to be checked by tests:

- **Abrasion test**
  This test simulates the friction of a (sharp-pointed) stone on the external part of the cable during the installation. The level of the test constraint must be adapted in order to take into account soils must more aggressive (compared to calibrated sand) but also laying practices less careful.

- **Mechanical impact test**
  The purpose of this test is to check the ability of the cable design to withstand a mechanical impact that can occur during the installation of the cable. The cable must sustain the result of a falling stone.

- **High pressure test**
  The purpose of this test is to check the ability of the cable design to withstand a high pressure that occurs during the operation of the cable. High pressure is typically due to the contact of a stone with the sheath of the cable.

At the present time the test which is described the new functional specification is a material test. So, it has been decided to investigate on a full cable design the combination of the effects of mechanically aggressive soils, temperature variations due to current cycles and test duration through an adapted thermomechanical test (experimental test trench).

**Reinforced direct laying cables**

Another solution to avoid using sand consists in using a cable with a special design for such installation. Therefore, the new functional specification « C 33-226 » proposes a reinforced direct laying cable design. This cable is supposed to be able to be buried in any kind of environment.

Investigation tests are necessary to determine adapted tests methods and associated stress level to be applied. After these tests, it will be possible to introduce these new requirements into the specification « C 33-226 ».
The first part of these tests is now completed. Complementary investigations will be carried out in non-compacted soil in the next months.

- **field test trials**

In parallel with laboratory test investigations field experimentations are often necessary in order to precise the modalities of bringing these cables into operation.

The technical and economical analysis of data coming from laboratory tests and field experimentation driven on solutions alternative to the laying of cables in sand is now in progress. We expect that it will allow the merging of interesting technologies that could be rapidly used on site as a part of rebuilding of MV network.

**CONCLUSION**

The excellent experience feedback observed on synthetic cables and technological progress acquired during the last 20 years lead us to the optimisation of MV cable components and in particular insulation thickness. This approach produced significant savings. This step has been followed by the complete re-writing of the specification. It allows now a wider evolution of cable designs in the future and facilitates the coming of new suppliers on the French market.

In order to answer to particular constraints encountered in the field (mechanically aggressive soils, sloping areas), and with the aim of saving installation costs, other actions have been carried out concerning installation methods of MV cables. The action was focussed on the research of solutions alternative to the use of sand that presents many disadvantages. Some of these solutions are investigated. In a near future, the technical and economical analysis of laboratory tests results and field test trials will be carried out. It must allow the use some of these technologies as a part of rebuilding of MV network.

**BIBLIOGRAPHY**

