ABSTRACT

Environmental concerns, improvement of the energy supply quality, increasing service safety levels and company image towards its Clients led EDP Distribuição to adopt, during the year of 2007, new solutions in medium voltage overhead lines.

Several different technologies were analysed and EDP Distribuição decided to implement a pilot, a small 15 kV network with a compact network system of covered conductors, known as “spacer cable system”, the first experience in Portugal, followed in a special way by the Portuguese Electrical Authorities, owing to the fact that national regulations only refer to bare and insulated overhead conductors. This case is supposed to contribute to the introduction of covered conductors and compact networks in national legislation.

INTRODUCTION

EDP Distribuição (EDP D.), a company of EDP – Energias de Portugal group, maintains about 168000 km of overhead distribution power lines, supplying 6 million customers in Portugal.

In the last times, Distribution System Operators (DSO) have felt an increasing pressure to give a better and better answer to health and environmental concerns and to improve the electricity supply quality and network reliability. This pressure has stimulated DSO to find new solutions, namely to networks with overhead lines, networks exposed to a large amount of quality and reliability inhibitors.

EDP D., following the innovation way, has been looking for better answer to these challenges, studying and analyzing several different technologies. In this context, EDP D. decided to implement a pilot, building a new and small 15 kV network with spacer cable system, a compact network system of covered conductors from Hendrix Wire & Cable.

Being this pilot the first experience in Portugal with spacer cable, and concerning the fact that national regulations only refer to bare and insulated overhead conductors, it was necessary a special agreement from the Portuguese Electrical Authorities (DGEG and DRCME).

Although not being conform with the national regulations, the standards relative to bare conductors in medium/high voltage overhead lines, namely in the project and installation stages, had been respected, as far as possible. Furthermore, it was necessary to adapt the spacer cable system to the Portuguese networks materials and techniques.

SPACER CABLE SYSTEM

In the spacer cable system, a high-strength grounded messenger supports a 3-phase distribution system using covered conductors in a close triangular configuration, from 5 kV to 46 kV. Hendrix has also a spacer cable solution to 69 kV.

The system has the mechanical strength to weather severe storms and the electrical strength to prevent faults due to phase to ground or phase to phase contact, tree contact or animal contact.

The messenger wire is the support member of the spacer cable system. It supports the mechanical strength, as well as wind and conductor’s weight loads. Two types of messenger wires are available – Alumoweld-Aluminum (AWA) or Alumoweld (AW). It ties to the poles through galvanized steel or aluminum alloy brackets.

The messenger may be used as system neutral and serves also as a shield wire against lightning strikes. Special messengers are available for long spans such as river or highway crossings.

Pole hardware elements, such as tangent, angle, dead end, tap and pole top extension brackets, are available for spacer cable system. This hardware is compatible with Hendrix Roll-by installation equipment.

Covered conductors are designed to be used in spacer cable systems. These conductors are suspended by high density polyethylene spacers from the messenger. Spacers have a diamond design and are placed at approximately 10 m intervals. These spacers separate, compact and maintain the phase conductors in a triangular configuration.

Covered conductors consist of stranded hard drawn aluminum conductors with one, two or three extruded layers depending on the voltage rating. The covering thickness of conductors is specific for each voltage. Covered conductors are available in black or gray depending on visual preference.
Conductors have a black, semiconducting conductor shield for 25 kV and above. It is recommended for 15 kV when tree contact is expected. They have also an inner layer of natural low density polyethylene for high dielectric strength and strippability and an outer layer of proprietary, high density polyethylene for resistance to tracking, abrasion and ultraviolet degradation. They are dielectrically compatible with insulators and spacers. Covered conductors do not have an outer insulation shield, so, they are included in the category of nonshielded cables and for safety reasons (e.g. public safety, during live works) they should always be considered as bare conductors.

High density polyethylene insulators are recommended for use on spacer cable construction at angles. These insulators avoid the problem of increased corona and the resulting erosion of covering that can occur with porcelain insulators. They are also recommended to areas with a history of vandalism and for contaminated environments due to their long leakage distance and washing characteristics. Polyethylene insulators are electrically compatible with covered conductors, in other words, no stripping is required. Covered tie wire must be used to secure covered conductors to the Tie-top insulators. Vise-top insulators have integral conductor clamp. They must be used with standard insulator pins.

Polymer dead-end insulators are used to electrically isolate the phase conductors from ground. The use of a shackle clevis is recommended when attaching dead-end insulators to dead-end brackets. These insulators consist of a fiberglass core with a polymeric sheath and weathersheds. End fittings are of galvanized steel.

FIELD INSTALLATION

Project

The EDP D. pilot experience consists in building two 15 kV overhead lines connecting two distinct substation feeders of Mangualde, in the center region of Portugal. The lines are along municipal roads and close to heavily treed areas.

During the engineering phase of the project, as well as the construction phase, it was necessary to fit the spacer cable system to the Portuguese networks materials, namely, pole hardware.

To go along with the Portuguese regulations and the standards for bare conductors in medium/high voltage overhead lines, it was necessary to define some initial conditions:
- The messenger wire supports the mechanical strength.
- The spacers are placed at approximately 10 m intervals.
- In the total weight it was considered the weight of the messenger, covered conductors and spacers.

The considered initial tension was:
- 10 kg/mm², to messenger;
- 1 kg/mm², to phase conductors.

The project and design of the line have been implemented under the national regulation. Taking into consideration that this is a new technology for the construction of medium voltage (MV) lines, where a large number of materials and equipment for the assembly were supplied by Hendrix and being this pilot the first experience in Portugal with spacer cable, it was necessary to study, analyze and adapt the materials to the Portuguese networks materials and techniques, namely to the concrete poles. Concluded the process of dimensioning of the mechanical stability of poles, isolation, covered conductors and messenger wire, the first experimental tests were made.

Installation

The installation of the spacer cable system is a simple process and easily learned by line crews. Hendrix provided technical assistance.

The installation develops these following basic steps:
1. Poles are framed with required materials and stringing equipment.
2. The messenger is installed and correctly tensioned.
3. The phase conductors are strung.
4. The phase conductors are tensioned.
5. Stringing equipment is removed and spacers are installed.

The actual stringing of the conductors is accomplished by one of these two following methods: the “pole-by-pole” method or the “roll-by” method. Since the nature of the line, EDP D. chose to use the roll-by method, this is rather unique and it is a very effective way of installing the spacer cable system. A brief overview of the roll-by method is presented.

Roll-by Method

Pulling sections are planned between dead-ends. During the framing of the poles, a messenger stringing guide is installed with a finger line for installing the pulling rope. At the same time, a slack bracket with a roller and a finger line is hung from the main support bracket to guide the pulling rope for the phase conductors. After the poles are framed with the required materials, the stringing process begins with the installation of the messenger. The pulling rope is installed along the length of the pull and the messenger is pulled in and tensioned to the required tension. The use of a dynamometer is recommended to assure on one hand the correct tension and on the other hand that the messenger is over tensioned by 90-140 kgf to account for anchor settling.

The next step is the installation of the conductors by pulling in the three phases simultaneously. No tensioning equipment is needed once conductors are pulled in under limited tension while being supported by three sheave roll-by stringing blocks. A reel trailer or stands of some type are needed to hold the three reels of conductor. The pulling rope is then installed by pulling it through the rollers in the slack brackets.
On the first pole from the reel end of the pull, a triple sheave stringing block or three individual stringing blocks are installed. Once the pulling rope is installed, the three conductors must be attached to it at the reel end of the pull.

The pulling rope is attached to messenger trolley as the starting point for the pull. The messenger trolley has a rope attached from itself to the next roll-by stringing block. A lineman is positioned at the first pole from the reel trailer to install the roll-by stringing blocks sequentially as the pull progresses. As the pull progresses, each roll-by stringing block is connected to the next roll-by stringing block supporting the conductor. The speed of the pull is determined by the lineman’s ability to keep up with the attachment of blocks and tag lines. The three-sheave stringing blocks are designed to “roll by” each pole bracket, one after the other. This method allows the three conductors at reduced tension while being supported from the messenger. This method minimizes the opportunity for conductors to sag down into other facilities.

Once the conductors have been strung, they can easily be sagged. Measurements can be taken between the conductors and the messenger at several locations throughout the pull. After the sagging is completed, the stringing blocks are removed and the spacers are installed.

Splices and Taps
The recommended way of stripping the conductors for splicing or installing connections is using one of the stripping tools. Splices should be made with a partial or full tension sleeve that is rated for the ampacity and breaking strength of the conductor. Automatic splices are not recommended for use with spacer cable system because of their reduced tension. After the splice is installed, it is covered with a cold shrink splice cover. Heat shrinkable tube coverings and hand tapped covers can be applied as alternatives. Connections could be left bare to allow easy access to the connectors for applying or removal.

One important aspect of the spacer cable system is that it is important to install surge arresters at all locations where the spacer cable system is connected to a bare conductor system. Experience has shown that lightning surges can concentrate at the junction of the insulated wire and bare wire, creating the potential for a conductor burn down.

Covered conductors are always treated as bare conductors from the standpoint of personnel or public safety.

Once this is the first experience in Portugal with spacer cable, it was useful to take full advantage of this technology. In one of the lines a low voltage circuit with public lighting was built, at the same concrete poles. The poles had already been designed to support this low voltage circuit.

The whole process had the technical support of Hendrix, both in the design, purchase of materials as well as in monitoring the construction.

PROJECT ANALYSIS
Several reasons led EDP D. to decide for Spacer Cable System: improve service quality (better SAIFI and TIEPI), network reliability (lower number of incidents, thus lower number of linemen involved), safety of personnel, environmental protection (reduction of tree trimming – just in a 80 cm radius around the conductors, collisions and electrocution of birds, electromagnetic fields (EMF) – due to the “compacted” disposition of the conductors, cost reduction (in the same pole several voltage levels and services can be supported – eventually from HV to telecommunications).

On highly polluted areas or on the seaside, the deposition of aggressive agents on conductor covering cause tracking; in consequence, lines with covered conductors are restricted to a distance of 300 m away from seaside.
OTHER SOLUTIONS

In Portugal an alternative solution for the classic binomial bare overhead lines/underground lines, is in use for more than 20 years by means of MV aerial bundled conductors (ABC), with good performance, although having a more relevant visual impact and cost towards bare cables, due to conductors, fittings and number of poles, owing to the fact that spans should not exceed 40 m.

During 2007 another pilot was realized with tree wire system from Hendrix in a wildlife protection zone with small trees. This system uses covered conductors (aluminum, aluminum alloy or ACSR) similar to spacer cable, but with no messenger wire and spacers. This system is designed for full span applications and is supported on polyethylene insulators.

This 30 kV pilot respected the Portuguese traditional project and installation techniques, as well the recommendations from national regulations to overhead lines with bare conductors. It was used EDP D. standard hardware, namely poles and crossarms, and the average span exceeded 100 m. With this system, span lengths are limited by the conductor breaking strength and the amount of sag that is permissible.

Another experience with covered conductors was made last year. In this 15 kV case, 50 mm$^2$ ACSR conductors with one layer of covering, using also standard EDP D. techniques and hardware, were installed in a zone with small differences in level (no sloping spans). Since 2004, this type of cable was just used as jumpers in wildlife protection zones.

CONCLUSIONS

The pilot experience performed by EDP D. with spacer cable system was very important to the system and its components’ knowledge, as well as to its applicability. Furthermore, it allowed to know in loco some of the system advantages.

This solution, with multiple layer covered conductors, compact design and high mechanical strength, seems to demonstrate to be an important contribution to minimize the impact of the root causes of outages on MV overhead distribution networks, in particular in hard jobs. The magnetic field reduction allowed by compact network may also be an important contribution to the actual discussion about health and electromagnetic fields due to overhead power lines.

Taking into account its costs and restrictions, MV ABC will have higher application in short transitions, alleys and other confined areas where bare or covered conductors cannot meet clearance requirements and underground construction is not practical.

For situations where the imposed conditions and the necessities do not justify the investment in spacer cable system, the “tree wire” solution can be an alternative. The single layer covered conductors solution, being less onerous, can be sufficient to “no tree” situations with some wildlife or straw and rubbish flying problems.

The various solutions have different design and operating characteristics. These differences must be carefully considered when choosing for different applications. Although more onerous than traditional networks, these solutions permit EDP D. to answer in a more adequate way to the quality and reliability challenges settled actually by several factors, mainly environmental, to overhead distribution networks, with the respective economies coming from its advantages.

However, it is necessary, and expectative, that the reported experiences strongly contribute for an inclusion of covered conductors, compact network and spacer cable system in the national, and maybe European, regulations, enabling its utilization in Portuguese networks.

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REFERENCES


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