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Protection of underground electrical cables

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ABSTRACT : The new protective covering for underground 20kv electrical cables, certified by EDF, is made of a material with an appropriate thermal conductivity (quartz sand) confined in a 300dtex cut fibre non-woven geo-textile that gives a high resistance to penetration. The advantages of this product, which has been installed on approximately 100km, are technical (protection on the whole surface of the cable and conductibility: very good thermal performance (k=0.92)), environmental (cutting out of most sand excavation) and economical (easier organisation of work).This application of textile fibres plus granular material outlines the efficiency of such an association for protection against penetration and shocks, which may be of interest to solve many other problems. The equipment developed for laying the cover and tightening is now available for any cable or pipe protection system including a flexible cover to be wrapped around the cable or pipe.

1 PURPOSE AND SCOPE

Lines for distribution of electrical energy (20kv) have been traditionally built as aerial lines (cables on poles) because it is the most simple and cheap solution. However aerial lines have two main draw-backs: aesthetics and sensitivity to weather conditions.

As far as appearance is concerned, in towns and villages, lines are often put in underground ducts (plastic pipes or concrete culverts). Ducts have the advantage of allowing an easy replacement of the cable if necessary, but have a poor performance as far as heat evacuation is concerned. This is a problem for electrical lines because current creates heat in the line ; such heat has to be removed to avoid an excessive temperature raise ; as temperature must not exceed a certain value (such as 60°C), the maximum intensity a line can carry (called ampacity of the line) is directly related to its heat production and evacuation performance. For short distances, this question can be solved by using cables with a larger conductor cross section producing less heat for a given intensity; however, for long distances, economy requires to optimizing cable cost and therefore, heat transfer performance of the cable environment becomes quite important and the use of ducts is inappropriate.

Meanwhile, it is often useful to bury lines in the countryside, on relatively long distances (individual stretches a few kilometres long), away from towns and villages. This does not result so much from aesthetic requirements but, as said above, to avoid destructive effects of weather conditions. Such conditions are icing and windstorms. The weight of ice can break poles or cable fastenings; there have been examples of devastating icing conditions in many regions of France, as well as in many other countries, even in areas where frost is not so frequent. Windstorms can damage lines either directly or as a consequence of tree falls, as it has been observed in France, for example, at the end of 1999, where thousands of homes have been without electricity for more than a week, and a number of them for two or three weeks.

The normal way for burying cables is to dig a trench and to lay down sand around the cable while it is laid in the trench, before backfilling. Sand has two functions: one is to avoid mechanical damage on the cable surface which could be due to sharp stones during backfilling, compaction and settlement of the fill; the other is to provide a fairly good contact between the cable and the surrounding soil in view of enhancing thermal exchange with the ground and, thus, allowing the cable to cool down when high intensity goes through the cable.

However, such use of sand has a number of draw-backs:

- environmental: several hundreds of thousands of tons are required for this use each year in France ; as presently river sand excavation is almost prohibited and quarries closures more and more frequent, avoiding excavation of such quantities becomes more and more advisable ; in addition, road trucking of such amounts from quarry to site is not environmentally desirable.
- operational: sand trucking is often prohibited or impossible in the vicinity of the trenching site ; available quarries may be at large distances ; logistics associated with sand handling result in slowing down the trenching and filling operations, leading to a cost increase of the burying process.
- technical: proper placement of the sand all around the cable is difficult to guarantee and in situations such as sloping rock (burying of lines in mountainous areas) sand is likely to be washed out during the rainy season.

In view of these conditions, a system has been developed to protect electrical cables to be buried, aiming at the following objectives:

- low environmental impact
- good operational efficiency
- high technical performance in all site conditions, both for mechanical protection and thermal efficiency

2 DESCRIPTION

The system includes two elements:

- The protective cover itself. (Figure1.)

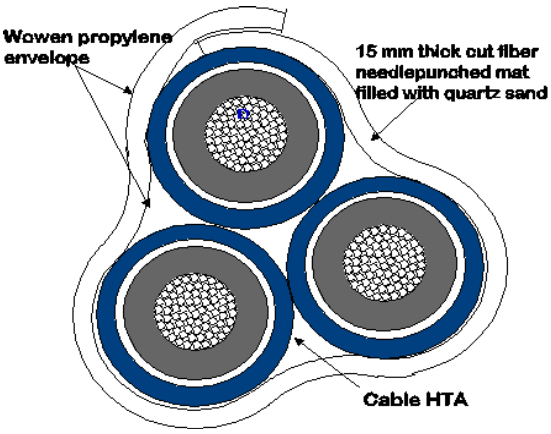

Figure1. Cross section of the protective cover

– The device to wrap it around the cable before burying. (Figure 3)

The cover is made of a 15 mm thick cut fibber needle punched mat filled with quartz sand, enclosed in a woven polypropylene envelope; the width is 370 mm, fitted to encircle a three 35 to 40 mm conductors cable

Production is a continuous process; the cover is then deposited in specially designed textile bags (Figure2) containing 120 m long sections.

Figure 2. Textile bag

The sand filling the 15mm thick mat has a very uniform grain size distribution, around 400 microns. The mat is designed to be easily filled by the sand poured in the mat in the dry condition, but being at the same time tight enough for the sand to stay enclosed in the mat when the sand becomes wet, even at very low water contents. Quartz sand is used because thermal conductivity of that mineral is much larger than that of other minerals, which is important, as said above, for the thermal performance of the system. The required amount of sand is approximately 7 kg per meter as compared to 100kg (or more, including handling and site losses) in the traditional system.

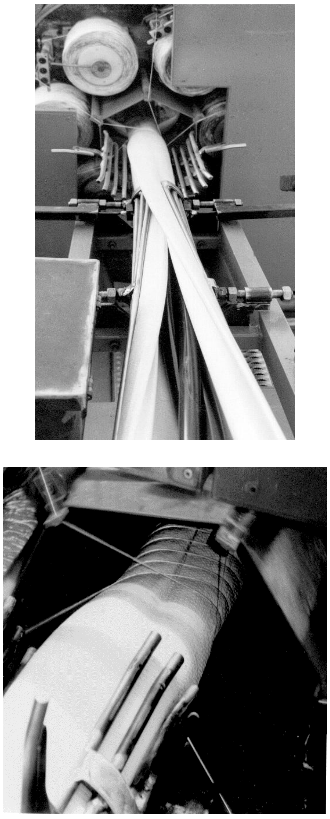

Figure 3. Laying of the covering around the cable.

The operation to wrap the cover around the cable is normally performed on site. The principle is to place the cover and the cable longitudinally one over each other, to fold the cover around the cable and to tight the cover around the cable by winding tensioned polyester threads.

There are two types of equipment for that purpose. One is a fairly heavy tractor on tracks carrying the cable reel, the cover bag and the folding and winding machine (Figure4); the tractor moves along the route along which the cable is to be buried and delivers the cable with its protective cover wrapped around it. The tractor must be a fairly heavy one since the cable reel and the cover bag have a total weight of several tons.

Figure 4.Winding machine carrying cable and Siltex.

The other system to wrap the cover around the cable uses lighter equipment (Figure 5).

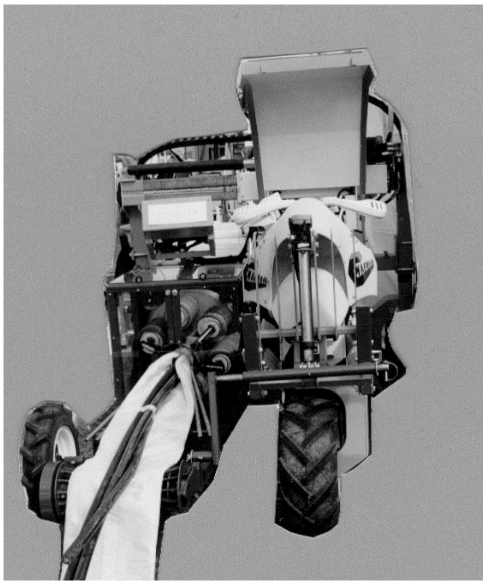

Figure 5. Lightweight winding machine.

The cover is first deposited on the ground by towing a trailer carrying the cover bag while one end of the cover is anchored in the ground.

Then the cable is deposited on the cover, again by towing a trailer holding, this time, the cable reel.

Then a special machine moves along, picks up the cover and the cable, folds the cover around the cable, winds the tightening threads and finally leaves the protected cable behind on the ground.

The protected cable may then be buried in a trench by any type of equipment.

The cover and the laying equipment are patented.

3 PERFORMANCE

As said above, the technical performance of the cable protection is twofold: mechanical, against stone puncture, scratch or abrasion, and thermal, to keep cable temperature at an acceptable level (1).

For mechanical protection official specifications refer to impact testing, to simulate the laying operations with falling rocks on the wrapped cable, and static penetration testing performed at 60° C, to simulate the resistance to sharp stones or gravel during lifetime in the ground. For both tests the protective cover presented in this paper gives excellent results, due to the combination of sand, fibers and tensioned winding threads, these combined elements leading to a high energy absorbing system with continuous deformations (no concentrated cracks) distributing very efficiently the residual stresses on the cable surface.

Thermal performance is measured in a full size test pit, in which the protected cable is buried, with thermocouples placed in the conductor cores and at different places in the protection. A steady current is applied so that the cable conductors reach a 90°C temperature. The overall thermal resistivity of the system cable plus protection can then be calculated and the ampacity (maximum acceptable intensity) may be determined in different conventional conditions. Test results are presented as the ratio of the ampacity of the system to the ampacity of a cable placed in conventional ideal conditions. For the protection system presented in this paper the figure is 92%. This compares favourably with the traditional procedure for which the usually accepted figure is 88% and with ducts showing a figure of 84% (2).

Figure 6. Protected cable before its laying down in the trench.

4 CONCLUSIONS OF GENERAL INTEREST FOR GEOTEXTILE TECHNOLOGY

In spite of the fact that the presented system deals with a quite specific problem, the authors feel that at least two conclusions can be outlined that are of interest for a number of other possible applications of geotextiles.

The first one is the performance of a fibre plus granular material association with respect to shock absorbing and penetration resistance. This effect had already been put to evidence with the Texsol system, used for protection of very large propane reservoirs. It is likely that a number of different problems can be answered using the fiber plus granular material association.

The second conclusion is the availability, through the equipment developed for this cable protection system, of a technology for wrapping a longitudinal envelope around a cable or a pipe. If, anywhere, a gas, water or any pipe or cable needs a geotextile wrapping for any purpose, the equipment to lay the geotextile over the pipe or cable is at hand.

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