INVESTIGATION AND IMPLEMENTATION OF SILICONE CONDUCTOR COVER FOR MV & HV OVERHEAD LINES

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Abstract: *Demand for electrical power driven by technological growth and the subsequent improvement in living standards is constantly growing. Erection and operation of overhead lines is faced with increased public scrutiny due to their environmental, social and economic impact. The size and scale of overhead lines can dramatically change the surrounding landscape. Of particular concern has been the routing of overhead lines through or near areas of outstanding natural beauty, sites of nature conservation and archaeological sites. In addition to the Overhead Line impact to the environment is the visual impact. Residents living in close proximity to overhead lines are affected by noise pollution from crackling and humming noises caused mainly by corona discharges on overhead line conductors, especially during humid and rainy days. Landowners are hesitant to comply with developers who they may see as outsiders, without their interests in mind. Some people balk at the spectre of a transmission line cutting across their property, altering the perceived beauty of the landscape. Neighbors may fear that their property values will decrease. This resistance has a cost to developers, who must go through a great deal of work to procure the easements necessary for new transmission lines. As a result, transmission developers have found ways to decrease the right of way necessary for new projects. This is often done by reusing existing right of way, occupied by existing distribution lines. Developers often choose to uprate existing transmission lines to higher voltages.*

Key words: *Compact line design is the result of this space-saving strategy.*

ИЗСЛЕДВАНЕ И ВНЕДРЯВАНЕ НА СИЛИКОНОВО ПОКРИТИЕ ЗА ГОЛИ ПРОВОДНИЦИ ЗА ЕЛЕКТРОПРОВОДИ СРЕДНО И ВИСОКО НАПРЕЖЕНИЯ

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***Резюме**: Търсенето на електрическа енергия, задвижвано от технологичния растеж и последващото подобряване на жизнения стандарт непрекъснато нараства. Монтажът и експлоатацията на въздушните линии са изправени пред засилен обществен контрол поради тяхното екологично, социално и икономическо въздействие. Размерът и мащабът на въздушните линии могат драстично да променят околния пейзаж. От особена загриженост е преминаването на въздушни линии през или в близост до райони с изключителна природна красота, обекти за опазване на природата и археологически обекти. В допълнение към въздушната линия въздействието върху околната среда е и визуалното въздействие. Жителите, живеещи в непосредствена близост до въздушни линии, са засегнати от шумово замърсяване от пращене и брумчене, причинено главно от коронови разряди върху проводници на въздушни линии, особено през влажни и дъждовни дни. Собствениците на земя се колебаят да се съобразят с строителните компании, които те могат да възприемат като външни лица, без да имат предвид техните интереси. Някои хора се борят с призрака на преносната линия, пресичаща собствеността им, променяща възприеманата красота на пейзажа. Съседите могат да се страхуват, че стойността на имотите им ще намалее. Тази съпротива струва скъпо на компаниите, които трябва да преминат през много*

работа, за да набавят сервитутите, необходими за нови преносни линии. В резултат на това проектантите и строителите на електропроводи са намерили начини да намалят зоната на сигурност на линията, необходима за нови проекти. Това често се прави чрез повторно използване на зоната на сигурност на съществуващите електропроводни линии. Строителните компании често избират да надградят съществуващите далекопроводи до по-високи напрежения.

Ключови думи: *Компактният дизайн на линията е резултат от тази стратегия за спестяване на пространство.*

1. INTRODUCTION

1.1 Existing situation.

Demand for electrical power driven by technological growth and the subsequent improvement in living standards is constantly growing. At the same time distributed generation and renewable resources are changing the power flows across the transmission network. In the UK the 2020 target set by the Department of Energy and Climate Change (DECC) is for the percentage of electricity generated from renewable resources and nuclear power to reach 40 %. To satisfy the increased demand for electricity and connect the new methods of generation, the transmission network will have to expand by mainly building additional overhead lines when the upgrade of existing infrastructure is not possible [1].

1.2 Impact of overhead lines

However, the erection and operation of overhead lines is faced with increased public scrutiny due to their environmental, social and economic impact. The size and scale of overhead lines can dramatically change the surrounding landscape. Of particular concern has been the routing of overhead lines through or near areas of outstanding natural beauty, sites of nature conservation and archaeological sites. Another potential threat to the local environment has been the increasing bird mortality rates caused by collision with manmade structures such as overhead lines.

In addition to the visual impact, residents living in close proximity to overhead lines are affected by noise pollution from crackling and humming noises caused mainly by corona discharges on overhead line conductors, especially during humid and rainy days. Corona has also been found, to interfere with television and radio reception. More importantly, there have been concerns regarding potential health issues, such as childhood cancer, caused by the exposure to the electromagnetic field (EMF) emitted by overhead lines. Although

most of the studies conducted have failed to provide conclusive evidence that show a link between overhead lines and risks to health, the fear of exposure to EMF persists.

Furthermore, the visual presence and physical proximity to overhead lines have also been shown to negatively affect household property values because of the perceived environmental and social impacts. Hence, it is not uncommon for residents and local land owners to have developed strong, negative attitudes towards the construction of new overhead lines.

Because of the opposition of the public due to the aforementioned environmental, social and economic impact to the local communities, significant problems and delays can arise in obtaining planning permission for new overhead lines. As a result, the power industry has been seeking solutions to improve the power transfer capabilities of existing infrastructure [1].

1. Methods for upgrading overhead lines

Several methods are available for uprating overhead lines. Conductor re-tensioning or the re-purposing of suspension towers as tension towers is used to allow for additional conductor sag resulting from the increased thermal rating of an uprated line. However, the additional current and consequent higher temperatures can produce high temperature creep and annealing which alter the physical properties of the conductor resulting in plastic deformation and increased risk of fracture.

The replacement of existing conductors with novel conductors or conductors with bigger cross-sectional area can reduce the electrical resistance hence increasing the power transfer capability of the line. Still, the increased cost, increased weight and complex installation techniques which often include tower reinforcements make the decision for adoption of this solution all but straightforward.

Incremental voltage uprating of existing lines is another option for increasing system transmission capabilities since by increasing the line voltage the current value can be reduced for the same power rating. Yet, the difficulties and costs associated with its implementation often outweigh the benefits. Substation equipment needs to be able to operate at this higher voltage while the electrical isolation on the towers has to be increased which requires modifications and reinforcements of the towers and replacement of the insulators. Furthermore, in order to comply with radio interference and corona requirements the conductor would have to be replaced [3].

2. Conductor covers

To construct more reliable MV and HV Compact Over Head Lines it is necessary to have enough clearance between the energized and earthed parts of the line. It could be done if conductors are covered. Using the present XLPE for Coating conductors is not reliable, due to the weight of the coating which is almost 50% of the weight of the conductor per metre. It means that it could not be possible to be used on HV Overhead Lines. Utility Companies should seek another material for that.

During the research for the silicone cover we have found that there is a limited application of it only in Spain and in Canada for MV Overhead Lines, just for Bird's protection. In Spain Envertec company is using a similar silicone cover with thickness 2 mm, only as a Bird Protected Devise [2].

There is no any application of the product on the HV Power Lines. It could be used in construction of Compact Overhead Lines.

Traditional transmission lines were designed very conservatively - with wide spaces between phase conductors which made the risk of phase-to-phase flashovers very low, and left surface voltage gradients at very low levels. They had simple wooden frame designs which were cheap and easy to build. In recent

years, building new transmission lines has been difficult. Often, the biggest impediment to a transmission project is securing a right-of-way access. Landowners are hesitant to comply with developers who they may see as outsiders, without their interests in mind. Some people balk at the spectre of a transmission line cutting across their property, altering the perceived beauty of the landscape. Neighbors may fear that their property values will decrease. This resistance has a cost to developers, who must go through a great deal of work to procure the easements necessary for new transmission lines. As a result, transmission developers have found ways to decrease the right of way necessary for new projects. This is often done by reusing existing right of way, occupied by existing distribution lines. Developers often choose to uprate existing transmission lines to higher voltages.

Compact line design is the result of this space-saving strategy. New transmission lines are designed to take up far less lateral space by utilizing modern materials and altering tower geometries. These structure in these modern designs are simpler and require less space, reducing their visual impact. These designs reduce phase-to-phase and phase-to-structure distances, which in turn increase voltage gradients on conductors and reduced flashover voltage thresholds. Methods first used in EHV transmission design are utilized in order to guarantee that audible noise (AN), radio noise (RN), and EM fields are kept at acceptable levels. The horizontal cross-section of compact lines is decreased using several methods. Triangular and vertical arrangements of phases are used, rather than horizontal arrangements, in order to decrease the width of the lines. Steel pole structures and composite insulators are often used as well. These materials have increased strength, and can be used to support the lines with less material [1].

3. Advantages of implementing the cover onto OHL [3]:

Factors determining the appropriateness of the construction of Compact Overhead Transmission Lines (OTL)

- Narrowed conditions in big cities, resort areas, the presence of the forests of first group (stocks of forests with valuable species of trees, national, city parks and green areas), where, for one reason or another is a necessary passage for Overhead Lines.
- Reducing Right-of-way when passing through forest and mountain area is one of the biggest advantages of silicone covered conductors
- Economic impact: in a class of 20-220 kV voltage construction of compact Overhead Lines is cheaper than construction with normal dimensions. It means the economic component directs the client to the modern, and now more increasingly worldwide technical solution.
- Another advantage of the Compact ,Overhead Lines is its design, which allows to increase the reliability, safety and transiting ability of power line.
- Reducing phase-to-phase and phase-to-structure distances Transmitted power in ordinary power lines is limited, depending on the nominal voltage and current load. At the same time, Overhead T&D Lines generates inductance, which depends on the phase-to-phase distance. The greater is the distance between them, the greater is the inductance in the , Overhead T&D Lines and, accordingly, the smaller is the active transmitting power. This requires imstallation of additional costly equipment such as condenser batteries or STATCOM static compensators. Constructing of Compact , Overhead T&D Lines with minimum distances, optimal structures for the disposal of the phases in the single and double circuit , Overhead T&D Lines ensure improvement of parameters of the line at the expense of modifying the parameters of the electromagnetic field between the phases and the magnetic field around the loop.

Amplification of electromagnetic field inside the line in reducing the distance between phases allows to reduce the wave resistance of the , Overhead T&D Lines and hence increase the active ingredient of the transmitting power and improve the parameters of Overhead Lines. It's like we are connected capacitors between phases in every windspan.

- The silicone cover could be also widely used in Railway companies as insulating the messenger (the carrying rope), when the contact network is passing trough tunnels. Or it could be used to decrease the clearance and thus to light the poles.

4. Application [3].

It is an Innovative product easy to install over the existing Bare Conductors especially pertinent to isolate ACSR **on the MV and HV** overhead lines, with high dielectric strength - 22 kV/mm, fig. 1

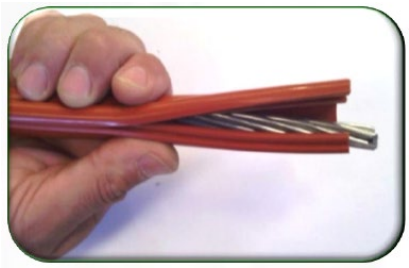

Fig. 1

Silicone coating for ACSR would solve some problems such as:

- Reducing clearances when passing overhead power lines in Urban areas, eliminating the possibility of electric shocks to people and animals at break of wire;
- Eliminates the need for large tracts when passing through wooded and mountainous areas – reducing the Right-of-way;

- Used as bird-protection in areas with intense movement of birds and causing short circuits bird feces.
- Put in tensioning poles and structures to cover the wire connecting tensioning chains of the same phase, to avoid contact with it to the earthed parts of the pole in the wind.
- Avoid icing of the conductor due to the hydrophobic features of silicone thereby preventing "playing" of the conductor.
- Protects wire from corrosion by salt spray, prevents ingress of water in the wire rain and prevents corrosion bearing steel;
- No "Corona" effect on power lines with a voltage above 35 kV.
- Can be used on high-temperature wires with operating temperatures up to 155 °C
- Once installed no maintenance is needed for the whole operating life of min 30 years.
- Better cooling performance than the bare conductor, due to the outstanding Thermal conductivity of the silicone material.
- Protects the power line working in harsh environments such as tunnels, culverts, bridges, etc. against oxidation and erosion damage caused by dust devils, moist air, acid rain, etc.
- Reliable protect against short circuits and power outages due to careless overlapping terminals.
- Easy assembly and disassembly, short-term repair and maintenance
- You do not need special skills, flexible, resistant to bending
- Protect electrical equipment from fire because they are non-combustible and do not support combustion.
- Isolation of bars (round and flat) in the switchyard and Switchgear substations, which in turn reduced:

- The possibility of electrical shock to personnel manipulations;
- Effective prevention of major accidents caused by reptiles or small animals entered the installations of the substation;
- Reduces risk during repair work near high voltage electrical equipment;
- Prevents accidents caused by forgotten tools repaired in Switchgear;

5. Thickness of the insulation

Thickness of cover	**10 kV**	**24 kV**	**110 kV**	**220 kV**	**400 kV**
Cross section 50 – 70 sq.mm (Ø 12 mm)	**2.0**	**3.0**	**-**	**-**	
Cross section 95 – 150 sq.mm (Ø 16 mm)	**2.0**	**3.0**	**-**	**-**	
Cross section 185 – 240 sq.mm (Ø 22 mm)	**-**	**-**	**4.0**	**6.0**	**8.0**
Cross section 400 sq.mm (Ø 38 mm)	**-**	**-**	**4.0**	**6.0**	**8.0**

Table 1

Dimensions

Dimensions (mm)	Ø 12	Ø 16	Ø 22	Ø 38
Weight (kg/m)	0.24	0.31	0.42	0.95

Table 2

6. Conclusions [3].

Silicone Conductor Cover could be widely used by Utility Companies for preventing Bare Conductors of MV & HV Overhead Lines from Icing and Corona effect. There is no icing due to the hydrophobicity of the silicone, thus avoiding effect of “playing conductors” and in the same time reducing or leaving “Corona” effect losses.

The cover could be used in the Infrastructure Railway Companies as an insulation of the messenger wire when lines are passing through tunnels and under bridges with decreased clearance.

7. Real application - Biovet Peshtera 110/6 kV substation fully equipped with Silicone Conductor Cover

Fig. 2 Open plan 110 kV system

Fig.3 Overhead Line conductor cover

Fig. 4 Silicone cover of transformer 110 kV busbars

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