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PRODUCING OVERHEAD LINES WITH INSULATED AlFe CONDUCTORS

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ABSTRACT

This paper presents aplication of insulated AlFe conductor (farther insulated conductor), it"s technical characteristics and kind of mounting. Description of mounting averhead lines with insulated conductors in distribution area of "Elektromorava ", Požarevac is presented as well as benefits and lacks of insulated conductor.

INTRODUCTION

Lines wich are used for transmission el. Power we can devide in two groups:

- overhead lines
- underground lines.

Fig. 1. shows the lines which are used for transmission of el. power.

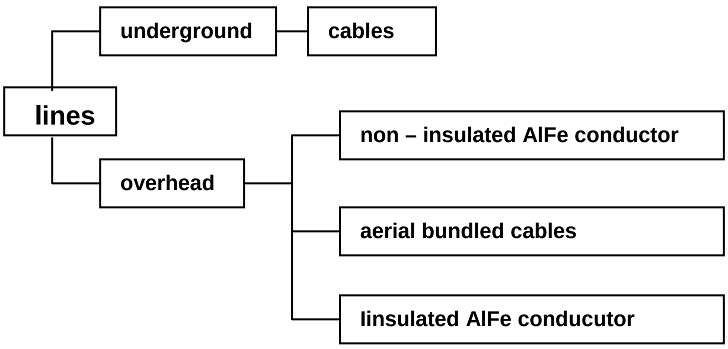

Fig. 1. Basic kinds of transmission lines

Every line that used for transmission of el. power posses benefits and lacks in compare with other, above mentioned.

In this paper compare between insulated and non-insulated conductors is made. Subject of this paper is aplication of insulated conductor for overhead lines up to 35 kV.Reason of production of insulated AlFe conductors lacks as:

- sensitivity on earth-fault (breakdown of insulator)
- sensitivity on phase-to-phase fault (“showering” of conductor)
- influence of tree limbs
- interruption of supplying due to fail of pillar twisted conductors
- influence of thunderlights
- other influences (intended disconection, birds,…..).

Common thing of above mentioned is interruption of supplying some groups, town and maybe whole area of consum, shorter or longer time, depending how fast failure will be eliminated and line will be under voltage again.
Period without voltage, produces seriously conseqvences for community and cause big expences and damages due to interruption in supplying.
Aim of each transmission and distribution line is continualy supplying of el. power with reduction and elimination non-planed interruptions.
If you want to eliminate non-planed interruption of transmission line you need to eliminate causes which lead to interruption of line.
Reliability of lines can be increased by:

- Rise educated staffs,because of higher quality of control (cleaning of line route, pillars and insulators) this means added expences for more works, added equipment, added expences for maintance, but at the same time it does not mean total elimination of causes of failures on lines.
- Application of other type of overhead lines: aerial bundled cable, type XHP48. Technically, it is possible but economic aspect says that price of aerial bundled cable is couple times higher than for insulated AlFe conductor.

This is main reason why aerial bundled cables have not found biger aplication on 10 kV, 20 kV and 35 kV aerial bundled cables is worth while for shorter sections of lines, especialy for urban areas, while for longer sections overhead lines with insulated conductors is beter solution.

PRODUCTION AND APPLICATION OF INSULATED CONDUCTOR IN EUROPE

The beginning of production and technology solution of insulated conductor started in Scandinawia (Sweden and Finland) and Great Britan, before 15 yearas.
Need for insulated conductor in Scandinawia was appeared because of great areas under forest, what caused many problems concern overhead lines throught rural systems (earth faults, interruptions of conductor or breaking of pillar).
All of theese problems were caused by contacts of tree limbs with non-insulated conductors.
Reason for production of overhead lines in Great Britain is closeness overhead lines and sae (big concentration of salt damaged non-insulated conductors and caused shurter service life of overhead lines).
At first, AlFe conductor was insulated only with PVC insulation and had many lacks. After long-life testing made by producer, as well as users,was found out solution which is used up to date.
Insulated conductors which are used today have iliminated all lacks of non-insulated AlFe conducter.
Today, you can find insulated conductors up to 145 kV. Purpose of insulated AlFe conductors is manyfold:

1. Enterprises for transmission of el. power in Portugal have had many problems with intertruptions in supplying caused by flok birds during migration. This problem was solved by means of insulated conductors.
2. In Israel, terrorists have found the way to destroyed non-insulated overhead lines by means of chains inded with weigts. In this way they made short-circuit (phase-to-phase) and caused interruption of suppllying of el. power. Change non-insulatet conductors by insulated concuctors that problem was solved.
3. In Norway, there is overhead line with insulated conductors for 145 kV in experimental service. They had need to change non-insulated conductors for 60 kV by one for 145 kV.

That problem could be solved in two ways:

- Change the pillars,change consols (because of bigger distance between conductors), increasing number of articles in insulator chains and change AlFe conductor by bigger cross-section one.
- Change presence non-insulated AlFe conductors by insulated conductors bigger cross-section for 52 kV, but all distances between conductors, pillars and insulator chains stay anchanged

By means of analyzing expences for production of that overhead line it is concluded that second solutin is more chiper. This solution ask for shorter time for production overhead line of 145 kV.
There are no standards in Norway for reconstruction this kind of overheas lines, and thus this overhead line has made as experimental. This overheas line is in experimental service more than two years, without any problem.
Fig.2. shows this overhead line with insulated AlFe conductors.

Fig. 2. Overhead line with insulated conductors (Norway, 145 kV)

Regulations for insulated AlFe conductors made by European Union strictly define failure time duration if conductor is in normal service (nominal voltage). Some producers of insulated AlFe conductors have their own stronger criteries for testing insulated conductors in wet condition.
Producers in Sweden have achieved quality level that insulated AlFe conductor passed 48 hours in water at 52 kV.

TECHNICAL CHARACTERISTICS OF INSULATED CONDUCTOR

Cross section area of new generation insulated conductor is given on Fig. 3.

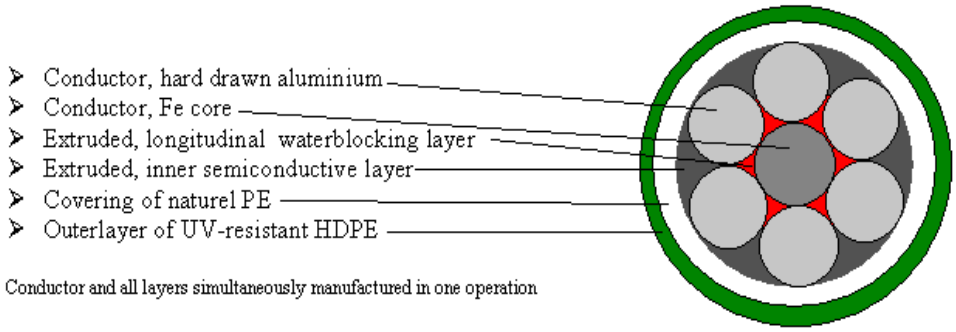

Fig. 3. Cross section of AlFe insulated conductor

Center is Fe core. Over Fe core laid aluminium conductors. Between Fe core and aluminium conductors there is watertigtness filler. Above Al conductors is extruded, inner semiconductive layer. It is covered with nature termoplastic PE. Outerlayer is UV-resistant hdpe with good mechanical charasteristics. Outer layer is green coloured becarse green has better time endurance than black. Insulation of conductor is recycling material.

Next table presents technical characteristics of AlFe insulater conductor for cross sections 62 mm^2 and 99 mm^2 .

Table 1. Characteristics of insulated conductor

Crossection, type	**62 AlFe**	**99 AlFe**	mm^2
Lay up of conductor, Fe+Al	(1+6)3,37	(1+6)4,25	
Conductor diameter, bare conductor, nom	10,1	12,8	mm
Inner semiconductive layer,thickness,nom	0,1	0,1	mm
Inner PE covering, thickness,nom	1,2	1,2	mm
Outer UV –resist.HDPE covering, thickness,nom	1,1	1,1	mm
Diameter over covering, min – max	14,6-16,1	17,3-18,8	mm
Weight,nom	309	449	kg/km
Rated operating voltage	24	24	kV
DC – resistance at 20^0 C, maximum	0,535	0,336	Ω/km
Resistance temp.coefficint	0,00403	0,00403	$/^0C$
Reactanse, estimated value	0,32	0,30	Ω/km
Per phase capacitance, estimated value	12	12	nF/km
Phase eart capacitance, estimated value	4	4	nF/km
Lightening impulse withstand strength od HDPE layer	100	100	kV
Operating temperature maximum, IEC 1597	70	70	^0C
Max load, cond.temp 60^0 C, air temp. 20^0C, IEC 1597, Wind sped, 1 m/s	259	348	A
Max short circuit current, 1 sec, + 50^0 C → + 200^0 C	5,2	8,2	kA
Breaking load of conductor, minimum	19	29,8	kN
Linear expansion coefficient	$19x10^{-6}$	$19x10^{-6}$	$/^0C$
Permissable elongation , creep	0,029	0,029	%
Module of elasticity before load (estimated values)	59	59	kN/mm^2
Module of elasticity after load (estimated values)	80	80	kN/mm^2

ACCESSORIES AND EQUIPMENT FOR MOUNTING OF INSULATED CONDUCTOR

Equipment, used for mounting insulated conductors is similar equipment for non-insulated conductors For wearin and straining of insulated conductors used insulators for the same voltage as for conductors. Fixing of insulated conductors on insulators perfored with so called “spiral”. Look of spiral and kind of fixing shown on fig. 4.

Fig. 4. Equipment for fixing and straining of insulated conductors

In Sweden distance phase-to-phase for 24 kV overhead line is 50 cm. That mean that console for insulated AlFe conductors is shorter than for non-insulated conductors what has good economical efecat. Fixing AlFe insulated conductors on supporting or straining pillar by means of “spiral” has benefit compare to non-insulated conductors. In case of falling tree limbs on overhead line there is no interruption of supplying or breaking of insulators as in case overhead line with non-insulated AlFe conductors. Reparation of this failure is very simple, and time of reparation is shorter than for non-insulated conductor.

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Fig. 5. Shows fixing of insulate AlFe conductor on supporting insulators. Voltage level is 24 kV.

Fig. 5. Fixing of insulated conductor to supporting insulator (24 kV, top of supporting pillar).

Fig.6. Shows straining of insulated conductors.

Fig.6. Straining of insulated conductor (24 kV, top of angle-strain pillar)

APPLICATION OF OVERHEAD LINE WITH INSULATED CONDUCTORS IN SERBIA & MONTENEGRO

First overhead line with insulated conductors in Serbia & Montenegro has installled in 2002.year in " Elektromorava" , Požarevac. It was donation. At the time of mounting this line, there is no regulations for insulated conductor. Regulations for non-insulated conductor were used. This is overhead line of 10 kV on section " Kravlji Do - Šljivovac ". Length of this overhead line with insulated conductors is about 3 km.

For mounting of this overhead line with insulated conductors domestic made equipment was ussed, as:

- Armoured concrete pillars with top triangle console type 12/400 and 12/1000
- Porters of supporting insulators type NPV 28A and NPV 28B
- Supporting insulators type Ps-17,5
- Straining insulators type J 100 DP (farther K – 3)
- Cu rope for earthing of pillar (cross-section 35 mm^2 .

Equipment for fixing and straining (as "spiral") was foreign origin.

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Insulated conductors of 62 mm^2, 24 kV has ussed. Look of this overhead line is given on Fig. 7.

Fig. 7. 10 kV – Overhead line " KRAVLJI DO -ŠLJIVOVAC " (J.P. "ELEKTROMORAVA ", Požarevac)

Fig. 8. Shows mounting of insulated conductors on supporting pillars.

Fig. 8. Top of supporting pillar (10 kV , " KRAVLJI DO - ŠLJIVOVAC ")

On the next Fig. angle-strain pillar is presented as well as fixing and straining of insulated conductors by means of domestic made equipment.

Fig. 9. Top of angle-straining pillar (10 kV overhead line, " KRAVLJI DO - ŠLJIVOVAC")

EXPIRIENCE IN SERVICE OVERHEAD LINE AFTER RECONSTRUCTION

Before reconstruction 10 kV overhead line " Kravlji Do – Šljivovac " had average number of interruption per year – 40. Every bad weather was enougth reason for interruption of this line. Vegetation had very big influence on interruption of overhead line. The most interruptions were in autumn or winter. In that time period reparation on overhead line is hard becouse of heavy mouvement of machinery, frozen soil, low temperature. All of that had influence of el. power supplying that consum.
Reconstruction has planed for distance of 5 km ; 2 km with non-insulated AlFe conductor and 3 km of bad circumstances (forest e.t.c.) performed with insulated conductor.
Reconstruction of 10 kV overhead line "Kravlji Do - Šljivovac" has been performed about 6 mounths. After reconstruction has been done, reliability of this overhead line is important increased and number of interruption is allmost zero. During two years in explotation this overhead line has not had interruptinons caused by aboumentined reason.
There were couple of interruptions due to protection of tranformer 35/10 kV caused by other components.
We can say that for certain period this overhead line showed high level of reliability and that there are not clasical lacks of overhed line with non-insulated AlFe conductor.
Maintance of this overhead line only asks for routine check periodically. Noone intervention has been on this overhead line.

POSSIBILITY OF APPLYING OF INSULATED CONDUCTOR, BENEFITS AND LACKS

Existing regulations for performing overhead lines from 1 kV to 400 kV in Serbia and Montenegro are not adequate for extended applying of insulated AlFe conductor. Existing regulations have the same tretman for insulated and non-insulated AlFe conductor. This obstructs reduction of spacing between phased, and obstructs installation reduces the clearances required between energized lines and tree limbs.
Benefits of applying of insulated conductor are the next:

1. Non-sensitivity on earth fault:
   Earth fault is allmost eliminated, exept in case of significant damage of insulation. Insulation protects from outher mechanical influence on conductor. Damaged supporting straining insulator has no consequence in supplaing as well as vegetation and tree limbs. Construction and equipment for fixing of insulated comductor prevent of mechanical damage of conductor. In Sweden has made experiment; tree was lean against insulater conductor – overhead line has worked in normal service more than 6 mounths.
2. Phase-to-phase short circuit is eliminated:
   In contact phase-to-phase there is no short circuit even in case of twisted conductors line servicing without problem. Also, overhead line works regullary if conductors are in water or mud without damage of insulation.
3. Console for carring of insulator is shorter (for example:for 24 kV length of console is 1 m)
4. Application of insulated conductor instead of non-insulated conductor up to 3 kV when the route cross the forest or in area where the wind and ice have big influence on overhead line.
5. Significant decreasing of maintaince expences.
6. Ease to make a route overhead line 10 kV, 20kV or 30 kV throught urban area.
7. It is possible to use pillars of low-volte lines for overhead lines with insulated conductor.
8. It is possible to use the same pillars for mounting two or more overhead lines the same or diferent voltage level.
9. Higher mechanical and electrical reliability of overhead lines (crossed railway, area with crowd of people and ease flamability surround).
10. Good for area with higher posibility of thunderlight.
11. There is possibility to increase voltage level of overhead line (for example:from 10 kV to 20 kV it is enought to change only conductors without insulators and other components).

Lacks of insulated conductor are:

1. Mounting of insulated conductor is harder than non-insulated AlFe conductor.
2. Due to higher specific gravity and strain force for the same cross-section of conductor, pillars must be stronger than clasical overhead line. In case of changing conductors of overhead line with wouden pillars, it is recommended that angle-strain pillar would be armoured-concrete.

CONCLUSION

On the base of above mentione, performing of overhead line with insulated conductors or only by means of changing conductors, reliability and stability or el. power supplying are significant increased.
It si good to noted that allmost the same equipment is used for line with insulated as well as non-insulated conductors.
At the end, we can say that investment in changing of non-insulated conductor with insulated conductor is good investment. Losses caused non-delivered el. power in case non-insulated conductors are to big.
Average price of insulated conductor is about 40 % higher than non-insulated conductor.