SUBSTITUTION OF LEAD SHEATH BY COPPER LAMINATED COVERING IN HV CABLES

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SUMMARY

In this report attention is paid to the laminated covering, replacing the conventional lead sheath with corrugated aluminium or copper sheath in HV cables. Various designs and related pros and cons for both copper and aluminium laminated coverings will be discussed. Finally international experience and observed trends will be listed, resulting in the conclusion that a long term view, in which the beneficial properties of copper play a part, is recommendable.

1 INTRODUCTION

Lead is a common material used from the introduction of power cables to protect the cable insulation material against water ingress, to screen the cable electrically and to offer a conducting path for circulating, capacitive and short circuit currents.

Lead is heavy, expensive and last but not least increasingly becoming controversial for environmental reasons. For the last reason, lead is already a forbidden material in the USA.

CIGRE decided a number of years ago to initiate a WG to study more closely the alternative solutions for a proper lead sheath. These alternatives are:

- an aluminium laminated foil + copper screen
- a copper laminated foil.

In this report attention will be paid to this laminated covering as alternative for lead sheath and in some countries for corrugated copper or aluminium sheath for HV and EHV cables. What are the different design options, what are the pros and cons and what are the typical application options for copper or aluminium in such constructions?

2 DIFFERENT DESIGNS

A metal laminated covering consists of several layers of plain (not corrugated) metal and plastic materials bonded together to get a special set of properties: bending ability, water tightness and current carrying capacity. It can be used to carry capacitive, circulating and short circuit currents, according to the cable system design.

Three main designs can be identified:

1. Combined design (CD). The mechanical (water tightness) and electrical (short circuit currents) are combined in one thick metal foil (copper or aluminium) coated and bonded to the outer sheath:
   - XLPE insulation
   - Semi-conductive bedding
   - Thick metal foil either welded or glued, that carries the full short circuit current, coated and bonded to the outer sheath (usually HDPE)
   - Additional wires can eventually be added to match the short circuit requirement

Figure 1 Combined design 500 kV cable (from CIGRE TB 446)

2. Separate design (SD). The mechanical and electrical properties are separated in a coated thin metal (copper or aluminium) foil (0.2 mm)+ copper or aluminium wires
   - XLPE insulation
   - Copper or aluminium wires
   - Water swelling tapes to block the screen area
   - Coated laminated metal foil for example AL o.2 mm + 0.05 mm coating on one side
   - Over sheath (usually MDPE or HDPE

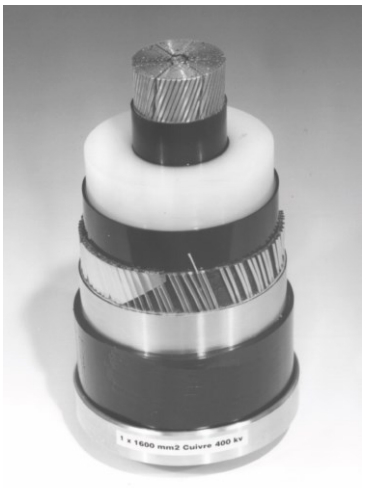

Figure 2 Separate design 400 kV cable (from CIGRE TB 446)

3. Separate semi –conductive design (SscD). The mechanical and electrical properties are separated using a thin metal foil (0.05mm) coated with semi conductive material and copper wires
   - XLPE insulation
   - Round copper wires screen, non-swelling semi-conductive tape below
   - Thin lead or Al foil (0.05 mm typical) with glue on one side, inner side (screen side) coated with typically 0.05 mm thick semi -conductive plastic
   - Over sheath (usually PVC).

Figure 3 Separate semi conductive design 275 kV cable (from CIGRE TB 446)

The metal layer is usually aluminium, as the wires are usually copper, although both copper and aluminium can be used for both applications.

3 INTERNATIONAL SITUATION

In CIGRE TB 446 a survey of experience with laminated aluminium coverings is given, being used since the eighties. There are three times more SD than CD circuit lengths, mainly due to the large experience of Germany of the SD design. In France the experience is based on the CD design since the nineties. The trend is to increase the number of circuits with laminated coverings as compared to other designs. The cables with laminated coverings are installed using the different installation methods: tunnels, ducts, surface trough and directly buried.

So far no corrosion problems have been reported with aluminium laminated coverings. Issues related to fatigue performance are not reported either.

Next to the information about the laminated coverings from CIGRE TB 446, we approached one manufacturer and two utilities with particular questions about the application of copper in laminated coverings.

Prysmian, NL

- Many Swiss customers ask for copper laminated coverings
- In the total price there is not much difference between cables with aluminium and with copper laminated coverings, because the copper laminate is thinner (0.25 mm is total thickness)
- A possible reason for selecting copper is fear for corrosion
- Good adhesion of laminate with outer covering is important to reduce risk of corrosion
- Another reason to select copper is probably tradition
- It does not make much difference from a production technology point of view what material is being selected
- Traditionally aluminium laminate is used in Europe.

AXPO Utility Switzerland

- AXPO is used to use copper laminated covering, but the company changed some time ago from copper to aluminium laminated covering
- The small difference in price is not the main reason, because it refers to a very thin layer of material (0.2 mm), but the company strategy is to buy standard components and copper is considered to be a specialty
- If the customer wants another material like copper, he is discouraged because of extra efforts in making new design, preparing production, testing which will be costly. So not the material price but the additional cost will keep him away from using copper
- Only those utilities that absolutely want copper will pursue.

BKW utility, Switzerland

- BKW uses copper laminated coverings, because of fear for corrosion for aluminium coverings
- for 110 kV 500 mm^2 copper the price difference was 1 Euro, however, they buy from local manufacturer (Brugg)
- BKW is a so called "all copper" utility, but they just decided to start a transition period to change to aluminium
- The considerations previous to the change are in particular focused on dimensions (ducts, bending radius) not on reliability issues.

4 PROS AND CONS OF LAMINATED COVERINGS

The application of laminated coverings compared to the conventional sheaths has the following pros and cons:

Pros:

- Less weight
- Lower in price
- More environmental friendly than lead, that is gradually becoming a forbidden material
- Reduced radial diameter, more length on a drum, less joints.

Cons:

- Aluminium laminated coverings need additional copper wires to match short circuit current rating
- Less robust than lead.

5 PROS AND CONS OF COPPER VERSUS ALUMINIUM LAMINATE

When considering copper versus aluminium to be used for laminated coverings the pros and cons of copper against aluminium are:

Pros:

- Resistance against corrosion
- Higher stress fatigue endurance limit
- Simpler design (no additional wires needed)
- Easier soldering and welding.

Cons:

- It is gradually becoming a non-standardized solution
- Additional costs discourage a non-standardized solution

6 ENVIRONMENTAL AND FINANCIAL ASPECTS

The replacement of lead is considered to be a positive action towards the environment. Lead is already called an environmental unfriendly material, and in some countries (USA) it is already a forbidden material. Consequently any appropriate replacement is most welcome.

The cost of laminated coverings is generally considered to be lower than for the traditional lead solution, although the manufacturer is reluctant to give any quantification. In spite of the higher material price, the application of copper laminated coverings does not result in a significant higher cable price, as only a very thin material layer is used. But as for some manufacturers the aluminium laminated covering is a standard design, an application of any other material is discouraged by additional costs (see chapter 4).

7 FUTURE DEVELOPMENTS

The general trend for laminated coverings, at least in Europe, will be aluminium. However, copper certainly has a good chance to compete with aluminium, because of the technical advantages, as indicated in chapter 4.

8 EVALUATION AND CONCLUSIONS

The laminated covering is replacing rapidly lead sheath or corrugated sheath. The laminated covering is mainly consisting of aluminium; however, according to the CIGRE TB 446 "Advanced Design of Metal laminated coverings", copper can be used as well. We got information that in Europe, particularly Swiss, utilities would prefer using copper laminated coverings. We approached two utilities: AXPO and BKW, but unfortunately AXPO does no longer use copper laminated covering and BKW is still using it, but decided recently to change to aluminium. The reason why BKW used copper laminate is the better resistance to corrosion, which is a valid argument. The reason why BKW is going to change is of strategic and not of economic nature, because the direct costs of copper laminate and aluminium laminate show hardly any difference as only a very thin metal layer is being used. However we understand that both utilities approached, want to buy standard components as those products are supposed to have the lowest costs.

The selection of copper compared to aluminium to be used as laminated covering in HV cables has more advantages than disadvantages. Nevertheless aluminium has the aura of being part of a standardized solution with the obvious financial profit and the related customer favour. However the TSO must act like he is acting in case of the selection of an insulating compound. The compound manufacturer supplies to the cable manufacturer but based on the information provided by the compound industry directly to the TSO, the TSO decides what compound he wants.

REFERENCE

CIGRE TB 446 Advanced Design of Metal Laminated Coverings, February 2011.