PROBLEMS OF USING COAXIAL WIRES FOR CROSS-BONDING OF CABLE LINE SCREENS

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In the construction of modern cable lines (CL), cables with insulation made of cross-linked polyethylene (XLPE) are widely used, and single-core cables have become the most widespread. As is known, to combat parasitic losses of active power in the screens of single-core cables caused by the passage of induced currents, various schemes for connecting screens are used: one-side grounding or cross-bonding. In practice, to perform these schemes, grounding boxes (GB) or cross-bonding boxes (CBB) are used, connected to the CL screens using single-core connecting wires. Unfortunately, recently cases of connecting boxes with coaxial connecting wires have become more frequent, which have a number of significant disadvantages compared to single-core wires.

Keywords: cable line, single-core cable, cross-linked polyethylene (XLPE), screens grounding, screens cross-bonding, grounding box, link-box, connecting wire, coaxial wire.

1. GROUNDING SCHEMES WITHOUT POWER LOSSES IN SCREENS

For single-core power cables, three grounding schemes of CL screens are known:

- two-side grounding;
- one-side grounding
- screens cross-bonding.

The first of the schemes, as a rule, is dangerous by the occurrence of induced currents in the screens, which lead to losses of active power in the screens, heating of the screens and the cable XLPE insulation adjacent to them, and therefore to an increase in power losses throughout the CL and to a limitation of the CL long-term permissible current of the core. The main ways to deal with currents and losses in the screens of single-core cables are one-side grounding of the screens (Fig.1,a) or their cross-bonding (Fig.1,b).

Diagram Fig.1,a is usually used for short CL 6-500 kV up to 0.3-1.5 km long, since for longer CL there is induced voltage on the screens, which is dangerous for the outer sheath of power cables. The cross-bonding scheme (Fig.1,b) is used where it is not possible to make a one-side grounding. To protect the cable outer sheath from impulse overvoltages (lightning and switching) in the diagrams Fig.1,a,b, metal-oxide surge arresters (MOA) located in electrical boxes are connected between the screens and the ground.

Boxes with a housing made of polymer materials, unlike metal (steel, aluminum), are resistant to aggressive and chemically active media, are light in weight, and also ensure the safety of personnel in the event of electrical damage of the MOA. Such boxes are marked: GB – polymer grounding box; CBB – polymer transposition box.

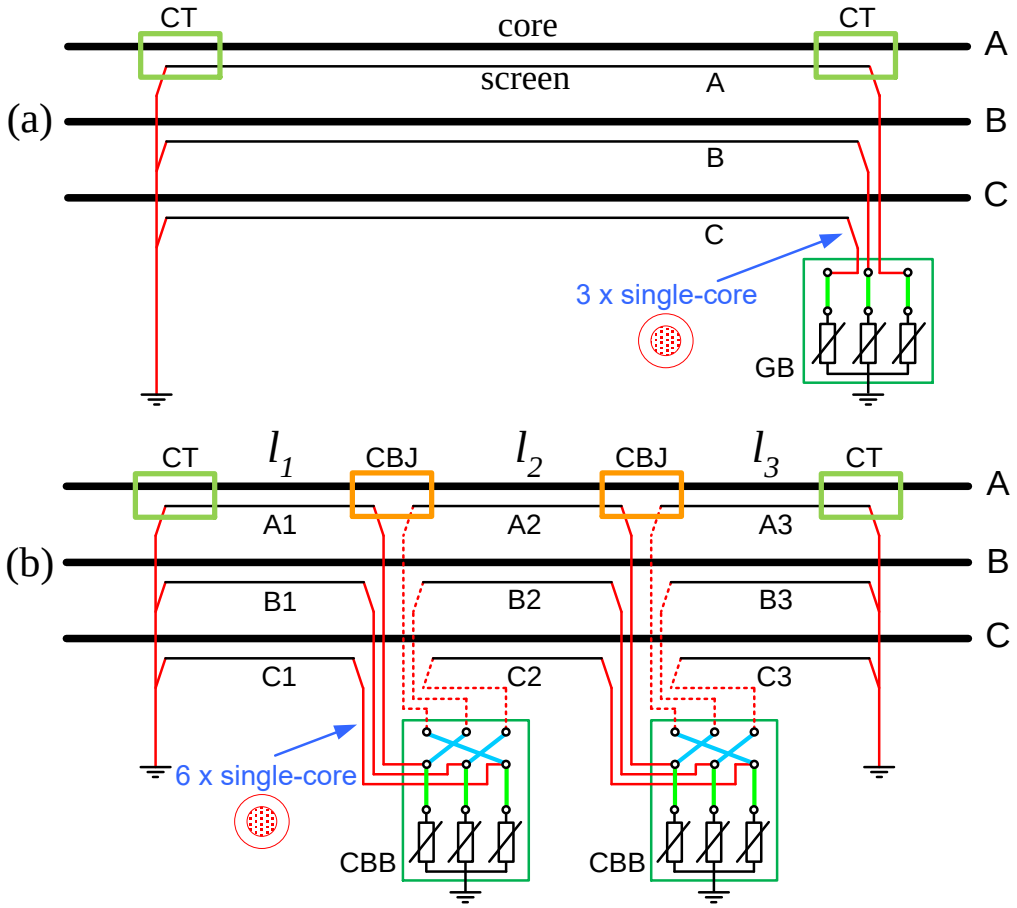

Fig.1. Connection diagrams of screens of single-core cables:
(a) – one-side grounding; (b) – screens cross-bonding.

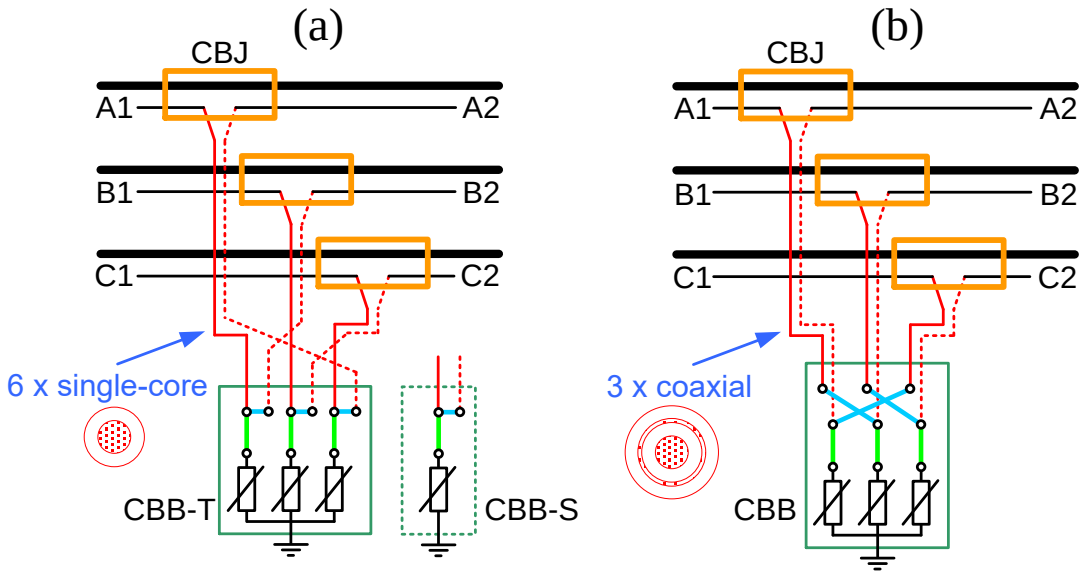

Fig.2. The design of the screens cross-bonding node depending on the type of connecting wires:
(a) – single-core wires; (b) – coaxial wires.

2. COMPARISON OF SINGLE-CORE AND COAXIAL WIRES

Connection of the GB and CBB boxes to the cable terminations (CT) and cable joints of cross-bonding type (CBJ) is performed by connecting wires with polyethylene insulation. These wires must have the following electrical characteristics:

- the active resistance of the current-carrying parts is no more than that of the screen of the power cable;
- the insulation strength of the current-carrying parts is not less than that of the power cable outer sheath.

Two types of connecting wires are known:

- single-core (only one core with insulation on it, see Fig.2,a);
- coaxial (core and screen of equal cross-section, isolated from each other and from the environment, see Fig.2,b).

Single-core wires are most often used – they are used both for one-side grounding of screens (Fig.1,a) and for screens cross-bonding (Fig.1,b). Coaxial wires are used less often, and only in the nodes of the cross-bonding (Fig.2,b).

The introduction of coaxial wires is explained by the fact that they have a "small inductance" and, therefore, a small longitudinal voltage drop in the area between the CBJ joint and the MOA in the box, which ensures more efficient operation of the MOA. It should be noted that, in fact, coaxial wires do not have advantages over single-core ones, since:

- the inductance of a coaxial wire is small only when the currents in its core and the screen are equal to each other and are directed in opposite directions, which is rare in practice;
- the inductance of the coaxial wire will not differ markedly from the inductance of the two corresponding single-core wires laid close to each other;
- the coaxial wire makes it difficult to install the cross-bonding node, since it has a large weight, diameter, bending radius, and it requires complex cutting at the connection points to the box;
- the coaxial wire makes it impossible to control screen currents of power cable line.

Single-core wires, in comparison with coaxial ones, have a small weight, diameter, bending radius – this makes it easier to install them. Also, single-core wires, unlike coaxial ones, make it possible to control currents in the screens of the power cable.

Monitoring of screen currents is important due to the fact that sometimes during the operation of the CL there is a need to check the correctness of the operation of the cross-bonding – for this, current measurements should be carried out in all the screens of the CL, on each of the sections of the CL route. The presence of screen currents of tens or hundreds of amperes will mean that the cross-bonding is designed or mounted incorrectly, i.e., it does not fulfill the tasks assigned to it to reduce currents and losses in the screens. To measure the currents in the cable screens without putting personnel at risk, current measuring pliers should be used, alternately putting them on the connecting wires coming out of the cable terminations or joints. If the CBB boxes are connected to the joints with coaxial wires, then the pliers will show the resulting current of the core and the screen of coaxial connecting wire, not allowing to determine the currents of the particular CL screens. Single-core wires, on the contrary, are devoid of such disadvantages and guarantee the ability to quickly safely control the current of each of the CL screens on any section of the CL route.

A significant advantage of single-core wires is the simplicity of their cutting, which allows connecting wires to pass-through insulators located on the outer side surface of a closed CBB box (these insulators are shown in Photo 1 and Photo 2), which eliminates the need to open the box and thereby violate its tightness.

Another advantage of single-core wires is to reduce the overall dimensions of the CBB boxes – it is achieved due to the fact that single-core wires, unlike coaxial ones, allow to make screens cross-bonding not inside the box, but outside, by cross-connecting 6 wires to pass-through insulators (Fig.2,a or Photo 1). When using coaxial wires, this can no longer be done, and the cross-bonding is organized inside the box due to cross metallic jumpers passing over each other (Fig.2,b), increasing the dimensions of the box, complicating its installation and maintenance.

The use of single-core wires simplifies the design of the CBB box so much that in the cross-bonding node, instead of one three-phase CBB-T box (Photo 1), three single-phase boxes CBB-O (Photo 2) can be installed – this contributes to a convenient arrangement of the node and minimizes the consequences in case of damage to one of the three MOA.

(a) (b)

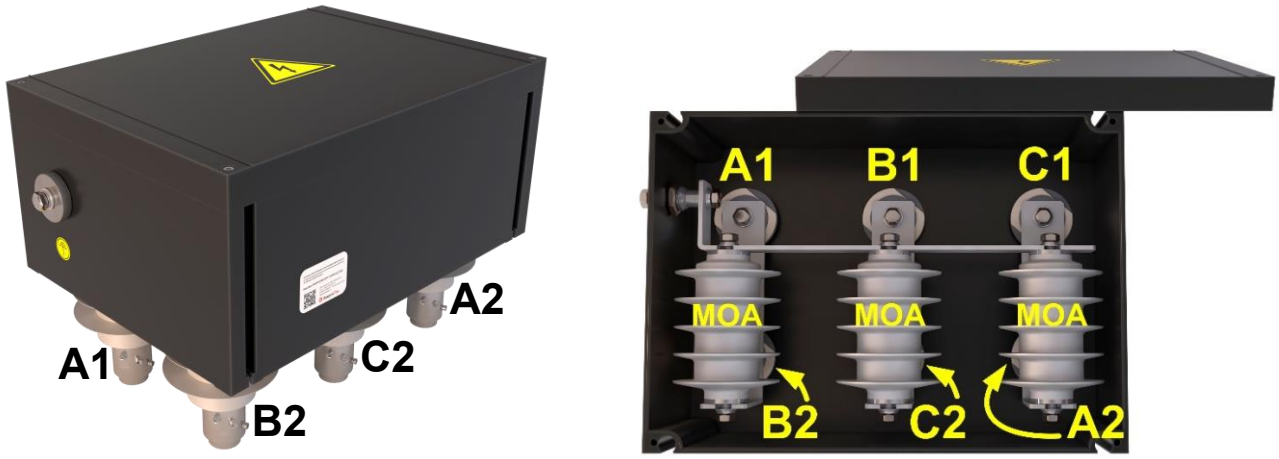

Photo 1. Three-phase screens cross-bonding box (CBB-T): (a) – from the outside; (b) – from the inside.

(a) (b)

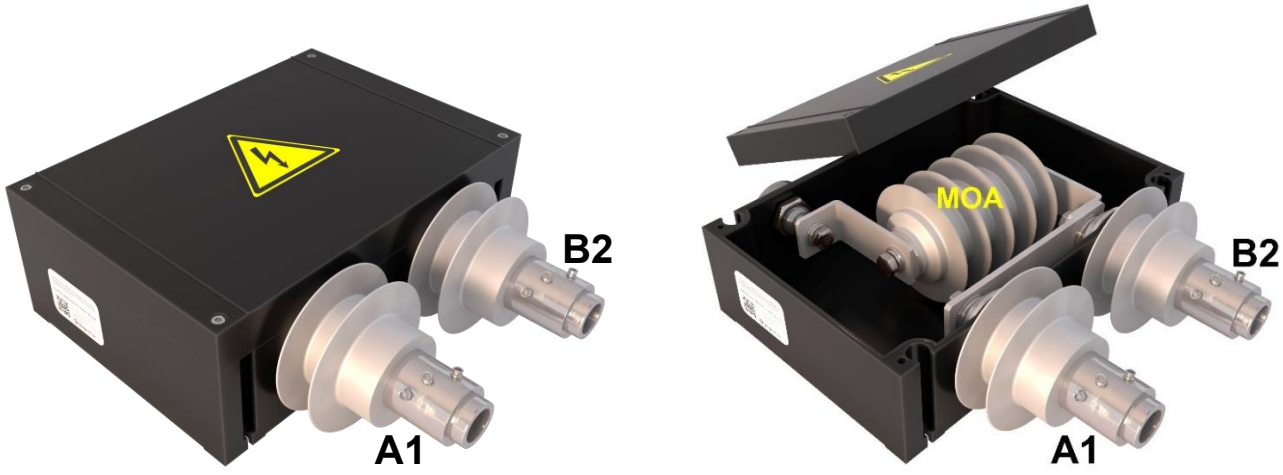

Photo 2. Single-phase screens cross-bonding box (CBB-O): (a) – from the outside; (b) – from the inside.

3. SURGE ARRESTERS FOR SCREEN BOXES

In addition to the absence of the need to open the CBB boxes during installation, they do not need to be opened when testing the outer sheath of power single-core cables with a DC voltage of 10 kV level. Usually, at the time of these tests, it is recommended to remove the MOA from the boxes so that the MOA does not pass the current from the screen of the tested cable to the ground and does not create a false impression of the presence of damage on the cable outer sheath. However, modern modifications of CBB boxes are equipped with such MOA that do not react to the effects of a DC voltage of 10 kV level – therefore, during the testing of the outer sheath of power cables, it is not necessary to open the CBB and remove the MOA from it, which preserves the factory tightness of the boxes.

4. CONCLUSIONS

The only advantage of coaxial connecting wires over single-core connecting wires – their low inductance – is leveled by paired laying of single-core wires close to each other. Thus, in order to reduce the cost of construction and operation of screens cross-bonding, it is recommended to use only single-core wires, since they are, in comparison with coaxial:

- have less weight and diameter, bend better and are easier to cut;
- allow you to control the currents in the CL screens on any section of the route;
- provide the possibility of connecting to the cross-bonding boxes from the outside of their housing through pass-through insulators, which eliminates the need to open the boxes during installation, thereby preserving their factory tightness;
- reduce the dimensions of the cross-bonding boxes, freeing up space for staff to work in the cross-bonding well;
- make possible the transition from three-phase to single-phase boxes, bringing variety to the layout options of cross-bonding nodes, as well as reducing the cost of repairs.