DESIGN AND INSTALLATION OF CROSS-BONDING OF CABLE LINE SCREENS

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The concept of "screens cross-bonding" is well-known to those power engineers who use single-core cables with cross-linked polyethylene insulation (XLPE). This technical solution makes it possible to minimize the industrial frequency (50 Hz) currents induced in cable screens and losses of active power caused by them, which means to increase the efficiency of cable lines. Unfortunately, there is still an unsuccessful arrangement of cross-bonding nodes, which complicates installation and operation.

Keywords: cable line, single-core cable, cross-linked polyethylene (XLPE), cable screen, screen grounding, screen cross-bonding, link box, concrete manhole, plastic manhole.

1. CROSS-BONDING LINK BOX

Currently, single-core cables with XLPE insulation are laid in 110-500 kV networks. According to the Standard [1], almost every line with such cables requires the introduction of measures to combat parasitic losses in screens, among which are known:

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

Both measures give the same result – avoiding losses, but have a different scope of application: screens one-side grounding is used for cable lines up to 500-1000 m long, and in other cases screens cross-bonding is needed.

To organize cross-bonding (Fig.1), the cable line is divided into a multiple of three number of sections of approximately equal length. At the junctions of sections, special cable joints are installed with outputs of screens to the outside, called cross-bonding joints (CBJ). Cable screens are taken from CBJs using a connecting wire with polyethylene insulation (CW) and enter inside cross-bonding link boxes (CBLB), where metal-oxide surge arresters (MOA) are installed to protect the cable outer sheath from impulse overvoltages. At ends of the cable line, screens are taken from cable terminations (CT) and simply grounded.

The appearance of CBLB-MOA type boxes common in the country is shown in Fig.2, and the stages of its installation were described in detail in the article [2].

The most important requirement that is imposed on the cross-bonding link box is its maximum tightness, assuming in the worst case even operation under water. Of course, 100% tightness of the box can be guaranteed only when the number of openings and closures of its lid is minimized. That is why two most important patented solutions are implemented in the design of the CBLB-MOA:

– the connection of wires to the box is carried out only from the outside, through six pass-through insulators (bushings), i.e., when installing the box, it does not need to be opened;
– special MOAs with a low operating current are placed inside the box, i.e., during the operation of the cable line or during periodic tests of the cable sheath with a DC voltage of 10 kV, it is not necessary to open the box and disconnect MOAs placed in it.

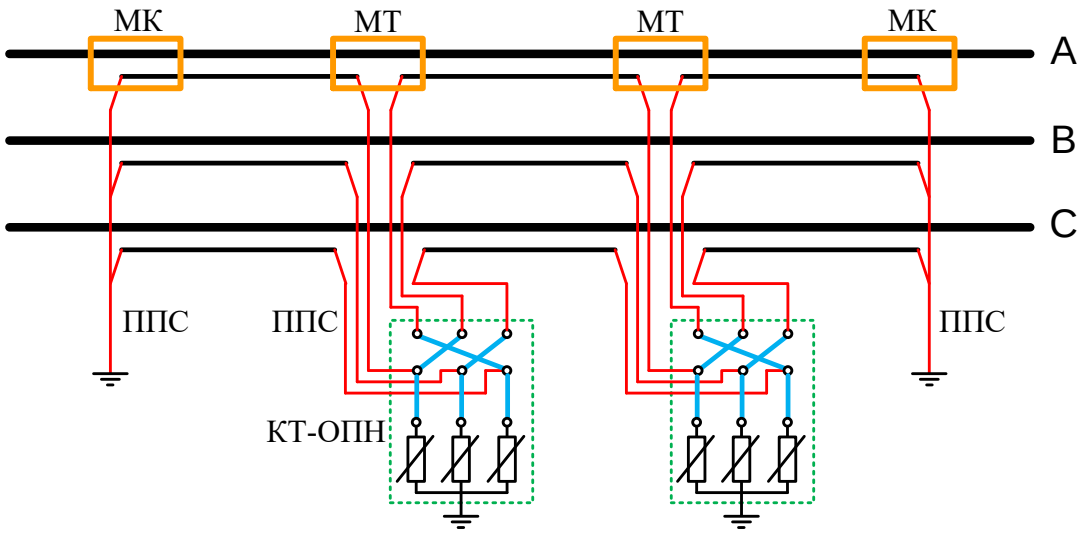


Fig.1. Screens cross-bonding scheme for single-core cables.



Fig.2. Screens cross-bonding link box.

The mentioned set of measures allows you to keep the tightness of the box checked in the factory laboratory for as long as possible.

Unfortunately, sometimes circumstances arise that require opening the cross-bonding box – this is the search for damage of the cable main XLPE insulation or cable outer sheath, when it is desirable to replace the cross connection of screens in the box with a direct one. Of course, after that there is no complete certainty whether the installers closed the lid of the box so carefully, whether the seal is not lost, whether more than a dozen bolts of the lid are tightened evenly and with the right effort.

In such cases, after opening/closing the lid of the box, it is recommended to perform a leak test using a mobile equipment similar to the one shown in Fig.3. The procedure is simple and based on creating an increased pressure inside the box (for example, with the involvement of a simple car compressor) and then measuring this pressure after 5 minutes.



Fig.3. Factory tests of the link box for tightness.

2. MANHOLE FOR CROSS-BONDING LINK BOX

Cross-bonding boxes are located along the cable line route in special places protected from the penetration of random persons and called cross-bonding manholes. As it turned out, the design of the manhole greatly affects the quality of installation of boxes placed in it, as well as the convenience of subsequent operation of the entire cable line.

In order for the installation and operation of screens cross-bonding scheme to be most successful, it is recommended to adhere to several simple but important rules.

1. The manhole should be of such a size that a convenient approach to the box is provided. The manhole should not be small and shallow, since it will not be possible to turn around in it, it will be easily flooded with water, and in winter it will freeze through. It is best to use reinforced concrete manholes of the KKS type, since they are spacious and allow you to place two boxes at once (in the case of a double-circuit cable line), are strong enough, massive (they will not be squeezed out by the ground).
2. The box should be placed in the upper part of the manhole, so that ground and rain water entering the manhole rarely reaches the box, and so that in winter time the box does not freeze into the ice.
3. The box should be placed so that pass-through insulators (bushings) look down into the floor of the manhole, because it is in the lower part of the manhole that six screens of the cable line departing from cross-bonding cable joints are brought into it with the help of wires.
4. The cross-section of the core of the connecting wire should be equal to the cross-section of the screen of the power cable (usually up to 240 mm^2). It is not recommended to use "universal" wires with a cross-section of 400 mm^2, since they are so rigid that it is impossible to bend them during installation and insert them into bushings of the box.
5. Installation and testing of the cable line do not require opening cross-bonding link boxes. It may be necessary to open/close the lid of the box only in case of damage of the XLPE insulation of the cable or its outer sheath.

Fig.4 schematically shows the first three of the five simple rules of arrangement of the manhole mentioned above.

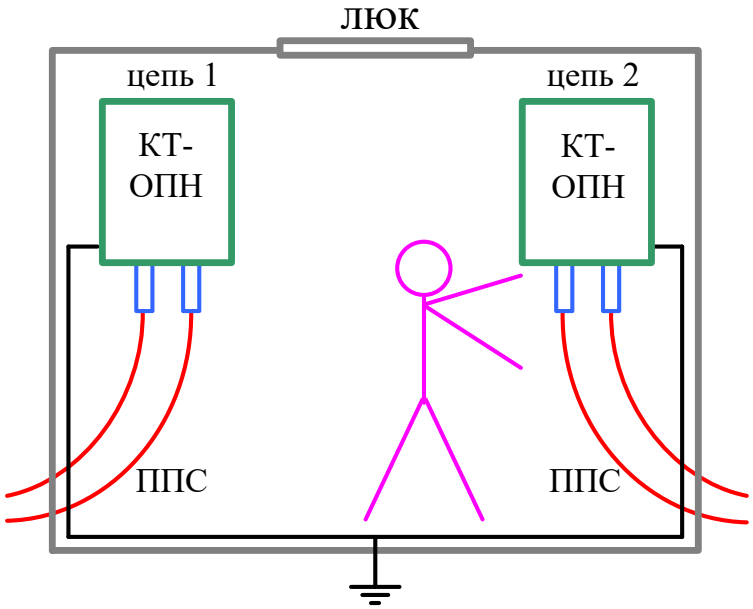


Fig.4. Installation of link boxes in the manhole for a double-circuit cable line.

3. BAD TECHNICAL SOLUTIONS AND THEIR CONSEQUENCES

Unfortunately, recently a number of power cable lines have appeared, where serious deviations from the rules mentioned above have been made during the arrangement of cross-bonding nodes. Let's analyze one of these cases identified in St. Petersburg.

Photos of the manhole with the box installed, taken on this cable line in the spring of 2015, are shown in Fig.5 and Fig.6. What were the mistakes?

Firstly, a small cross-bonding manhole (narrow and shallow) was used, which is easily flooded with water, and freezes through in winter (none of the world-famous companies makes link boxes for use in ice). The manhole's cover was made unsuccessfully, which is why in winter time it froze so much to its walls that it could not be opened. There is also a risk of the manhole being squeezed out of the ground.

Secondly, to connect cable screens to the link box, wires of a huge cross-section of 400 mm^2 were taken, which, given their rigidity and the small size of the manhole, did not allow normal connection to the pass-through insulators (bushings). To get out of the situation, the installers had to open the link box, remove the pass-through insulators from it, attach wires to the insulators and only after that with great effort install the insulators back into the box body, but sometimes without regular sealing rings. In other words, during installation, the instructions of the manufacturer of the CBLB-MOA were violated.

Thirdly, due to the small size of the manhole, when installing the box, it was not possible to place it with pass-through insulators (bushings) down, because then it would not be possible to reach them when mounting – therefore, the box was placed on its side so that the lid was on top. The box located in this way, taking into account the loss of the sealing rings, behaved like a kind of storage tank for water and was not able to drain it independently (even in those seasons when the water level in the manhole was falling).



Fig.5. A link box installed in a "compact" concrete manhole.



Fig.6. The process of opening the link box in the "compact" concrete manhole.

4. CONCLUSIONS

1. It is recommended to adhere to rules of arrangement of cross-bonding nodes noted in the article (in terms of choosing the dimensions of the manhole and the location of the link box in it).
2. The number of manipulations with the lid of the box should be minimized, since they are fraught with loss of box tightness if handled carelessly. During the installation of the box or during the testing of the cable line outer sheath with a DC voltage of 10 kV, it is not necessary to open the box (due to special type metal-oxide surge arresters inside the box).
3. If the opening of the box was still required, it would be useful to check the tightness of the box, which is easy to perform with a compact portable test equipment (car compressor and air pressure gauge).
4. It is advisable to involve manufacturers of link boxes more widely for the examination of design decisions, to monitor compliance with the rules of installation and operation of cross-bonding nodes, as well as to check the tightness of boxes in the field.

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