PLASTIC WELLS
FOR SCREENS CROSS-BONDING OF 6-500 kV CABLES

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Screens cross-bonding of single-core cables is a proven way of reducing power losses in a cable line and increasing its current carrying capacity. The arrangement of the screens cross-bonding, depending on specifics of the project, can reduce the cost of power losses in the cable line by even 10 thousand euro annually, as well as increase its current carrying capacity, sometimes up to two times! However, at present, unfortunately, there is no such arrangement of cross-bonding nodes that would fully meet the requirements of installation and operating organizations. Let's continue discussion started in [1].

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

1. INTRODUCTION

The composition of screens cross-bonding node includes three main elements:

– cross-bonding well;
– cross-bonding box (link box);
– grounding device.

The cross-bonding box is placed inside the well, and along its perimeter is arranged a grounding device with the necessary resistance. Each of three named above elements of the node is worthy of serious discussion, but in this article, we will mainly discuss only wells.

In the country, there is a standard [2] developed by PJSC "FSK EES", with the help of which the optimal scheme for cable screens bonding/grounding is selected, and often such a scheme is screens cross-bonding.

Formally, the standard applies to voltage classes from 110 to 500 kV, and therefore it may mistakenly seem that there is no problem of screens grounding in 6-35 kV networks. In fact, the excluding of 6-35 kV classes in [2] is only due to the fact that PJSC "FSK EES" is primarily engaged in 110 kV and higher networks. Examples of calculations according to [2] not only for 110 kV lines, but also for 10 kV are given in the article [3].

In practice, there are really few 6-35 kV cable lines with screens cross-bonding, and the main reason is not the absence of mention of these classes in the standard [2], but the absence of such cross-bonding nodes that would be acceptable for 6-35 kV networks laid in dense urban conditions.

For 6-35 kV cable lines, taking into account their significant number in the country, compact cross-bonding nodes are needed, and the technical solutions described in [1] and used for 110-500 kV classes are not quite suitable here.

Expected that with the appearance of various plastic structures on the market, it will be possible to find a successful way out of the situation not only for 6-35 kV networks, but even to revise the partially formed technical policy in 110-500 kV networks.

2. TIGHTNESS OF WELLS

It is considered that problems in the cross-bonding nodes are associated exclusively with link boxes, which should have 100% tightness, but in fact do not have such. It should be noted here that if the company can guarantee the tightness of the new link box, then its preservation during lifetime of cable line largely depends already not on the manufacturer, but on the quality of service of the cable line (after all, the box is repeatedly opened and then often carelessly closed). The article [1] offered a whole range of measures that increase the reliability of boxes:

– installation without opening the box (by passing connecting wires inside the box from outside using a system of bushings);
– equipping the box with special metal oxide surge arresters (MOA), which do not need to be removed from it during periodic tests of the cable sheath with a DC voltage of 10 kV;
– checking the tightness of the box after each opening and closing of its lid, carried out using a simple automobile air compressor.

Unfortunately, these measures do not affect the main reason for appearance of water in boxes – it lies in the weak tightness of the cross-bonding wells. If there was no water in the well (groundwater, rainwater, meltwater), then it would never have got into the link box. In other words, the tightness of the well is a very important, almost the main requirement for the cross-bonding node, and the tightness of the box against this background becomes not the main event, but a backup, because it is clear that if there is no water in the well, then there is nowhere to take it in the box.

The water that appears in the well can get into the box and cause cross-bonding to malfunction. Also, water in the well (or in the box) can theoretically get into the core of the wire connecting the cross-bonding node with the power cable joint, and then along this wire to reach the power cable joint, where it causes a main insulation short-circuit.

For example, on a number of 110-220 kV cable lines belonged to PJSC "FSK EES", there were faults on power cable joints, which strangely manifested themselves not during the operation of the line, but only after the fully serviceable line was switched off for some time. It is quite possible that cables cooled down after disconnection, an area of reduced pressure was created inside joints because of this, and water from the cross-bonding link box or from the cross-bonding well was sucked by joints through cores of connecting wires.

Considering the above, it is obvious that the trouble-free operation of the cable line and cross-bonding nodes can be guaranteed only when not only the box will have a high tightness, but also the well will be deprived of water.

You can offer a choice of several solutions to the problem:

– installation of link boxes not in underground wells, but in some above ground structures (for example, Fig.1);
– installation of boxes in the upper part of an underground reinforced concrete well (Fig.2).

Placing the transposition boxes above the ground (Fig.1), although convenient from the point of view of cable line maintenance, but in conditions of dense urban development and the risk of an automobile accident is hardly a good solution. Therefore, the scope of application of this option is rural areas, or better yet, the closed territory of industrial enterprises or electric power facilities.

Fig.1. Placement of screen cross-bonding boxes in outdoor structures.

Fig.2. Placement of boxes in the upper part of the underground concrete well.

Reinforced concrete wells (Fig.2) of the KKS type, due to their low cost and obvious mechanical strength, are currently used most often. Since for the convenience of mounting boxes and their maintenance, the well must be spacious enough [1] (boxes of two parallel cable line circuits are placed in one well at once). In practice it is not possible to make the well monolithic, and it is assembled from two parts: the lower and upper. The gap that forms between two parts of the well cannot be completely sealed. Entry points of wires connecting power cable joints (they are located outside the well) with cross-bonding boxes (they are in the well) are also poorly sealed. These factors are complemented by poor sealing of the usual cast-iron well cover, and as a result, the KKS is flooded with water (groundwater, rainwater, meltwater). Placing boxes at the top of the KKS well (Fig.2) is a good way to reduce the risk of their immersion in water, but still the risk persists.

Since the options in Fig.1-2 are not ideal, then we can suggest another one – this is to try to place link boxes in special plastic wells.

Cases of the use of plastics in the manufacture of cross-bonding wells have already been recorded. For example, Fig.3 shows a well that made of an ordinary reinforced concrete ring (with a bottom), which is closed from above with a plastic neck with a screw cap. This well, of course, is not sealed, but it has become one of steps on the way to a fully plastic well of the type Fig.4, which has 100% tightness.

Fig.3. A cross-bonding well with the use of concrete ring and a plastic neck.

Fig.4. A fully plastic well with 100% tightness.

Plastic wells (Fig.4) have been successfully used for a long time in urban water supply and sewerage systems, not only under lawns, but also under highways with heavy traffic. Plastic wells of small size are monolithic structures, and large wells consist of separate modules connected together through a sealing system directly at the installation site. Covers of such plastic wells are installed with the help of special sealing seals, thereby protecting them from water penetration.

Currently, the well in Fig.4 has already been finalized taking into account the needs of the cable industry – inside it has a platform for attaching cross-bonding link boxes. Places for mounting of connecting and grounding wires are equipped with factory seals, which are put into effect by tightening several bolts with a conventional wrench, i.e. there is no need to use MacroFlex mounting foam or heat shrinkage.

If there is a danger of significant mechanical impacts or vandalism from above, the well is covered with a reinforced concrete slab with a cast-iron lid equipped (or not), with a special lock. Thus, the well in Fig.4 has two covers at once: plastic – for tightness, cast-iron – for mechanical protection and against vandalism. If desired, to minimize the participation of construction equipment, such a slab can be independently cast around the well neck.

At a high level of groundwater, so that the well does not pop up, it is attached to a specially placed reinforced concrete slab from below, installed by machinery or cast directly in place. Inside the well, you can go down the stairs of the factory design or on stairs brought by a team of electricians.

Since plastic wells are smaller than reinforced concrete KKS, it is difficult to place cross-bonding link boxes of several cable line circuits at once in them, and therefore it is necessary to provide its own well for each cable circuit.

Plastic wells are more expensive than KKS, but they provide 100% tightness, avoid pre-pumping water from the well before servicing boxes, protect the cross-bonding link box and power cable joints from water penetration and associated main insulation short-circuits.

In addition to the well's resistance to water penetration, its ability to withstand the effects of an aggressive environment may be required, and here modern plastics also have an advantage over metal (Fig.1) and reinforced concrete (Fig.2).

3. SEARCH FOR SOLUTIONS FOR 6-35 kV NETWORKS

The tightness of wells is a primary task, but not the only one. Another task is to find a well design that would be as compact as possible, but at the same time allow mounting boxes and providing access to them during the operation of the cable line.

If wells are spacious in 110-500 kV power networks (when choosing them, the main attention is paid to the convenience of box installation and maintenance), then for 6-35 kV urban networks, due to the large number of these cable lines, wells must be compact, since otherwise the use of screens cross-bonding is in principle impossible.

To remedy the situation, it would be advisable for interested firms to undertake the development of various "inexpensive" compact screens cross-bonding options specifically for 6-35 kV networks. Apparently, it is impossible to do without the use of plastic wells here, and as an example, Fig.5 shows one of the solutions. In fact, in Fig.5 we are talking about combining in one element both functions of the plastic well and cross-bonding box.

An important problem that also has to be solved when creating cross-bonding nodes for 6-35 kV networks is a compact grounding device of acceptable resistance in terms of occupied area. Here it is necessary to evaluate all advantages/disadvantages of deep-type vertical grounding rods available on the market.

Fig.5. Compact fully plastic well/box for screens cross-bonding on 6-35 kV cable lines.

4. CONCLUSIONS

1. Screens cross-bonding is an advantageous way to increase the efficiency of 6-35 kV and 110-500 kV cable lines made with single-core cables having XLPE insulation.
2. Often, all the problems faced by operating organizations are trying to write off the insufficiently high tightness of cross-bonding boxes produced by enterprises. At the same time, it would be possible to get away from many problems if tightness was required not only from boxes, but also from wells.
3. The use of reinforced concrete wells, even taking into account measures to make them tight, is not able to save boxes from their periodic flooding. The solution to the problem could be the use of 100% tightness plastic wells in the arrangement of cross-bonding nodes, modified to meet the needs of power cable networks. Plastic wells will shorten the construction time of cable lines and increase their reliability.
4. The development of plastic wells may allow us to start solving problems of 6-35 kV networks, where currently, due to the lack of compact wells, screens cross-bonding is almost not used, and engineers suffer losses from inefficient operation of cable lines.

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