TYPICAL MISTAKES WHEN PERFORMING GROUNDING OF SINGLE-CORE 6-500 kV CABLES. PART 2

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Typical mistakes that are made during the selection, construction and operation of cable lines were indicated in the article [1]. In the article [1] were discussed screens bonding/grounding schemes, number of cross-bonding cycles, functions of surge arresters. Today, the author examines mistakes that often occur when using grounding link-boxes, cross-bonding link-boxes, cable joints and connecting wires. Let's continue.

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

1. SELECTION OF GROUNDING LINK-BOXES

The use of cable line end screens link-boxes is convenient for operating organizations that, when testing the cable line (its main XLPE insulation or cable outer sheath), have the opportunity to carry out all necessary switching due to the manipulation of jumpers inside the link-box. These line end boxes can be both with metal-oxide surge arresters (ELB-MOA) and without them (ELB). Box without MOA is called a grounding box and can be used at both ends of the cable line or at the end of the line free from MOA.

In addition to the incorrect choice of MOA characteristics (in those ELB where MOAs are provided), there are two more typical errors:

- screens of cable line entered into the box from its above, which creates conditions for moisture penetration inside the box;
- after entering the box, the copper screens of the cable line are terminated with aluminum tips, which creates conditions for electrochemical processes, increasing the resistance of the contact connection and its temperature, and contact burnout.

For example, both of these mistakes were made in the south of St. Petersburg on a 110 kV cable line, screens of which had a two-sides grounding. At one end of the cable line (on the transition tower of the overhead line – Photo 1), after a year of operation of the box, due to the ingress of water droplets from above directly onto the Cu-Al contact pair, its transient resistance has noticeably increased. This led to overheating of contacts of phases A and B by currents of 50 Hz induced in screens, loss of screens grounding of these phases on the transition tower of the overhead line. Since the screen of phase C remained grounded, the induced current (about 50-100 A) continued to flow in it, which, without compensation by currents of screens of phases A and B, fell on the housing of the box and then went into the grounding circuit of the tower. Due to the poor grounding of the box body associated with its painting, the current went into the tower through the arc (Photo 2).

The specified regime existed for many months, posing a threat to the safety of people (step voltage) and equipment (corrosion of the tower and foundation of the overhead line).

Photo 1. The end link-box, where connecting wires pass from upper surface and the Cu-Al pair applied. Due to the ingress of water and electrochemical processes, screens of phases "A" and "B" burned off from the grounding bus.

Photo 2. Damaged end link-box (Photo 1) in the parking lot. From the housing through the arc to the body of the tower and then into the ground flows the current of the screen phase "C", which is about 50-100 A.

2. SELECTION OF CROSS-BONDING LINK-BOXES

The most important requirements for the cross-bonding link-box (CBLB-MOA) are:

- tightness (resistance to water ingress);
- availability of MOA class 6 kV of sufficient energy capability;
- the possibility of lid multiple opening/closing without loss of tightness in order to switch the current-carrying jumpers inside the link-box, including in order to turn off the MOA for the time of testing the cable sheath with a DC voltage of 10 kV, which is dangerous for the typical MOA class 6 kV;
- mechanical strength of the box and its internal connections, that is important when the ground (soil) moves and leads to the "heaviness" of connecting wires between cable line screens and the box.

Given the above, the application is erroneous:

- non-collapsible screens cross-bonding, when screens are removed from one cable joint and enter another without the use of link-boxes;
- fill-type link-boxes, where the inner cavity is filled at the installation stage with a special insulating compound;
- boxes without support insulators, on which the wound-up cable screens could be securely fixed in order to prevent their movements;
- boxes with MOA, the voltage class of which differs from 6 kV (for example, 1.5 or 3 kV);
- boxes whose dimensions are large (or inconvenient) and do not allow them to be lowered through the hatch into the already mounted well for cross-bonding link-box.

To minimize the risk of water penetration into the screens cross-bonding link-box, it is recommended to place it in the upper part of the well (Photo 3). This also allows you to perform work inside the box without pumping accumulated water out of the well and not going down into it, but simply kneeling on the ground at the mouth of the hatch. Photo 3 is noteworthy because it was taken on a 110 kV installed cable line passing under a lawn a few meters from a very busy sidewalk in the north of St. Petersburg, however:

- the well did not have a lid for a long time;
- even in the dry summer, the well was filled with water;
- the lid of the link-box is screwed with only two bolts out of 18, i.e., careless installation completely eliminates the tightness of the box and the normal operation of cross-bonding.

3. SELECTION OF CABLE JOINTS AND CONNECTING WIRES

Another class of mistakes is caused by incorrect arrangement of cable terminations and cable joints, as well as their incorrect connection with end link-boxes (ELB-MOA) and cross-bonding link-boxes (CBLB-MOA).

Mistakes when choosing a connecting wire

To remove screens of the power cable from cable terminations and cable joints and made their connection to boxes, in recent years, a connecting wire (CW) with polyethylene insulation has been specially developed. This connecting wire is single-core type cable, that

has a copper core (without a metallic screen), covered with a layer of polyethylene, which performs functions of both insulation and cable outer sheath.

Since the sheath of the any 6-500 kV power cable has a strength of class about 6 kV, the same requirements apply to the connecting wire: it is made for class 6 (10) kV.

Since there is practically no 50 Hz voltage on the core of CW connected to the screen of the power cable, the absence of metallic screen in the design of CW does not reduce the reliability of its insulation.

The cross-section of the copper core of CW, as shown in [2], is sufficient to take equal to the cross-section of the copper screen of the power cable because these conductive parts are connected in series.

Typical mistakes are refusals from the CW of required cross-section and the use of:

– 0.4 kV or 1 kV voltage class wires instead of connecting wire of 6(10) kV;
– connecting wires with an increased core cross-section of 400 mm^2.

The wire cross-section of 400 mm^2 with a margin exceeds the screen cross-section of any of the 6-500 kV power cables currently produced by the industry. This is convenient for a number of cable suppliers who do not want to store drums with wires with a cross-section of 50, 70, 95, 120 mm^2, etc. in a warehouse, but store only one – with a connecting wire with a cross-section of 400 mm^2, which is certainly suitable for any power cable line, and besides, it costs noticeably more, which increases sales volumes.

In fact, the use of 400 mm^2 wires in grounding schemes not only increases the cost of the object, but also complicates installation, since such a wire has significant bending radii, it is inconvenient to put it into cable wells and link-boxes. In addition, not all link-boxes are designed for entering wires of this huge cross-section, have insufficiently large holes in the housing and unsuitable tips.

Coaxial connecting cables (instead of single-core connecting wires CW) have exactly the same disadvantages, the use of which, although convenient for a particular manufacturer, causes limitations and difficulties in practical work.

Mistakes in the installation of cross-bonding (coaxial connecting wires)

Cable joints for screens cross-bonding have a screens separation (rupture). Screens from the left and right side of the rupture are output from the cable joint by use of two single-core connecting wires (CW).

Some manufacturers of cable joints make the mentioned above screens output not by two single-core wires but with one of coaxial type which has both core and screen of equal cross-sections. Apparently, the original reason to use coaxial wire was to reduce competition in the market of cable components. However, according to the author, such a solution is unsuccessful and significantly complicates the installation for the following reasons:

– the coaxial wire is more difficult to cut than two single-core connecting wires;
– the coaxial wire has a large diameter and significant bending radii, which impose serious restrictions on the entry of such coaxial cables into the cross-bonding well and link-box.

Photo 3. A cross-bonding link-box with two bolts instead of 18, placed in the upper part of the well.

Mistakes in the installation of cross-bonding (cross-bonding kits)

A cable joint for screens cross-bonding is a special joint having a special design and installation instructions.

It is not yet known how many attempts to homemade remake a conventional cable joint into a cross-bonding one, therefore, each of such attempts will be obviously untenable and erroneous because of serious questions like: "How far to spread screens of the left or right parts?" or "To clean or not the semi-conductive layer on top of the cable insulation?". This is a minimal list of questions that no one except the joint manufacturer will answer.

Photos 4 and 5 show one of attempts to implement a homemade screens cross-bonding of the 110 kV line. Since the need for cross-bonding was thought about after the installation of the line and connecting joints, it was decided to supplement the cable line with homemade "cross-bonding kits". As a result, the cable sheath was opened in two places along the route, screens were cut, they were attached to the core and the screen of the coaxial connecting wire, which was brought into wells and CBLB-MOA boxes hastily placed next to joints.

To seal the cable in places with an open sheath, it was wrapped with tape somewhere (Photo 4), somewhere placed in a corrugated pipe or even in wooden boxes (Photo 5) and abundantly filled with silicone both. In the XXI century, it looks wild, considering the cost of a 110 kV cable line and its installation, totaling 1 million euro per each line kilometer!

Mistakes in the installation of one-side grounding

Many cases are already known when in schemes with screens one-side grounding at the end of the cable line where screens should be ungrounded, they were left inside the cable termination without any output to outside. This decision is incorrect for two reasons:

- there is no MOAs to protect cable outer sheath from impulse overvoltages, usually placed in the end link-boxes (ELB-MOA);
- there is no possibility of full-fledged maintenance of the entire cable line, which involves access to cable screens at both ends of the cable line in order to assemble bridges and other schemes for searching/locating for cable outer sheath damage.

Photo 4. Homemade cross-bonding 110 kV joint. The phase of the cable is shown; the coaxial connecting wire outputs screens to outside; the scotch tape with which the place of screens output and the coaxial wire are wound. The third cable with a crease is visible from above – the output of screens of another phase.

Photo 5. Homemade cross-bonding of 110 kV cable joint – plywood boxes filled with silicone and wrapped with polymer wrap.

4. CONCLUSIONS

1. It is necessary to prohibit the connection of cable joints or cable terminations with cable link-boxes using:
   - connecting wires of insulation class 0.4 kV, 1 kV, 3 kV;
   - connecting wires with a cross-section of 400 mm^2;
   - coaxial type connecting wires.

   The connection must be always made by a single-core connecting wire of insulation class 6(10) kV with a core cross-section equal to the power cable screen cross-section.
2. It is necessary to prohibit the use of end cable boxes with entrances through the top cover, in order to prevent moisture penetration inside the box.
3. It is necessary to abandon the use of non-collapsible cross-bonding, which does not have boxes, and also prohibit boxes filled with compound or without support insulators.
4. It is necessary to exclude the alteration of cable joints and terminations, carefully monitor the use of joints/terminations for their intended purpose, prohibit any "kits", etc.

REFERENCES

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