# METALLIC SCREEN SELECTION FOR 6-500 kV CABLES TAKING INTO ACCOUNT THE APERIODIC CURRENT

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*Currently, single-core cables with cross-linked polyethylene (XLPE) insulation and metallic screen are actively used in 6-500 kV power networks. The selection of the screen cross-section is one of the important tasks that have to be solved when designing cable lines.*

*Cable manufacturers strive to simplify the selection of the screen cross-section, and in their catalogs they give the dependence of the cross-section on the magnitude of the short-circuit current and the duration of its disconnection, but such calculations do not coincide between different catalogs. The article analyzes the possible reasons for these differences in calculations, and also indicates the low accuracy of the values of the short-circuit current used in the calculations. In particular, the article draws attention to the need to take into account the aperiodic component of the short-circuit current, and also gives the simplest ways of such accounting.*

**Keywords:** cable line, XPLE insulation, single-core cable, cable core, cable screen, cable thermal stability, cross-section selection, short circuit, aperiodic component.

## I. INTRODUCTION

The IEC standard "Calculation of thermally permissible short-circuit currents taking into account non-adiabatic heating" [1] is used quite rarely, since it is unnecessarily detailed. In particular, this standard contains a large number of empirical correction coefficients, and it is not always clear how they were obtained, and which of them is more correct to apply in one case or another.

In general, it can be noted that the desire of scientists and engineers to develop and use the most accurate methods of thermal calculation of a cable line, which are implemented in the IEC or in special computer programs, does not make much sense. The fact is that there is a significant uncertainty of the initial data, such as, for example, the magnitude of the network short-circuits current. Thus, accurate cable calculation methods (e.g. IEC [1]) are used for calculations based on very inaccurate source data – this approach looks strange.

Considering the above, it is justified to use simple methods for calculating cables, the accuracy of which, although not very high, is quite consistent with the uncertainty of the initial data. Therefore, a part of designers does not follow IEC standards, but are guided by cable factory catalogs, where the necessary dependencies of the cable screen cross-section on the magnitude of the short-circuit current and its duration are already given.

The article shows how the dependencies contained in the catalogs for selecting screen cross-sections are obtained. In addition, the reasons for the difference in cross-sections from different cable manufacturers are mentioned here, and proposals are made to clarify these dependencies in terms of taking into account the aperiodic component of the short-circuit current.

## II. SHORT CIRCUIT IN THE CABLE

The design of a single-core 6-500 kV cable is shown on Fig.1. It includes a conductive core (Cu or Al), insulation made of cross-linked polyethylene (XLPE), a conductive screen (Cu or Al), an outer sheath (polymeric etc.).

If the insulation of a single-core cable is damaged, the short-circuit current $I_K$ from the network passes through the cable core to the damage site, then through the damaged insulation enters the screen, along which it goes to its grounding located at one (Fig.2) or at both ends of the cable.

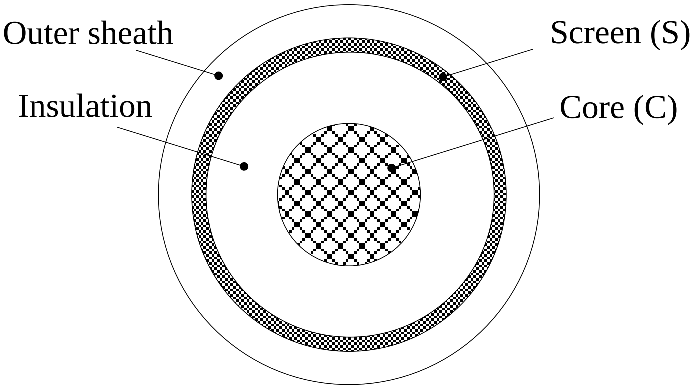

**Fig.1.** Design of a 6-500 kV single-core cable.

The core cross-section $F_C$ and the screen cross-section $F_S$ must correspond to the value of the short circuit current $I_K$, taking into account the duration of its flow $t_K$, otherwise it is possible to warm up the insulation of the cable adjacent to the core and the screen, in excess of the permissible temperatures on a significant length of the line (for example, for Fig.2, heating will be from the beginning of the cable to the place of short-circuit).

In clause 5.1.10 of the standard [2], the maximum temperatures in the short circuit regime of cables with XLPE-insulation are given: for the core 250°C, for the screen 350°C. The values are different for the core and the screen, although they are adjacent to the same cable insulation. This is due to the fact that the cooling of the screen (and the adjacent part of the insulation) is faster compared to the cooling of the core (which is located in the center of the cable cross-section and is separated from the surrounding cable space not only by the thermal resistance of the sheath, but also by the thermal resistance of the main insulation).

According to clause 5.1.10 of [2], checking the compliance of the core and screen cross-section with the short circuit current should be carried out according to the formula:

$$I_K = \frac{I_{K1}}{\sqrt{t_K}} \tag{1}$$

where $I_{K1}$ is the catalog value of the short-circuit current allowed for a given cross-section of the core (or screen) during the time $t_K = 1$ s.

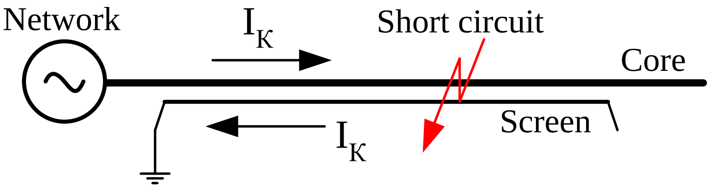

**Fig.2.** Single-core cable fault. For example, screen is grounded only at one side.

## III. CABLE SELECTION BY THE SHORT CIRCUIT CURRENT

Cable manufacturers in catalogs, as a rule, give a proportional relationship of the one-second current $I_{K1}$ and the cross-section of the cable core (or its screen). Such a connection $I_{K1} = K \cdot F$ occurs through the proportionality coefficient $K$.

As a result, formula (1) is transformed into the following, more user-friendly form:

$$I_K = K_C \frac{F_C}{\sqrt{t_K}}$$
$$I_K = K_S \frac{F_S}{\sqrt{t_K}} \tag{2}$$

The coefficients $K_C$ and $K_S$ have dimension $\mathrm{kA}\sqrt{\mathrm{s}}/\mathrm{mm}^2$, but further, for convenience and brevity, we will specify the dimension of kA/mm$^2$.

According to [3], when choosing the cross-section of the cable core (or its screen) in formula (2), it is necessary to use as the current $I_K$ the following values:

- for a 6-35 kV network with an isolated (compensated) neutral: a double phase-to-ground short-circuit current that equals to $\sqrt{3}/2 = 0.87$ of the three-phase short-circuit current;
- for a 6-35 kV network with a resistively grounded neutral: a single phase-to-ground short-circuit current;
- for a 110-500 kV with a grounded neutral: a single phase-to-ground short-circuit current.

For all cable manufacturers, when selecting the core cross-section, the same values of the $K_C$ are given in the catalogs (for example, for a copper core it is $K_C = 0.143$ kA/mm$^2$). As for the choice of the screen section, there is no consensus among firms here, and the $K_S$ coefficients in various catalogs are not the same. For example, for a copper screen, values in the range from $K_S = 0.153$ to $K_S = 0.203$ kA/mm$^2$ can be found in catalogs. As you can see, the minimum and maximum values of $K_S$ differ by about 30%, which means that the screen cross-sections selected by (2) will also differ by up to 30% in different catalogs.

The design of single-core 6-500 kV power cables with XLPE- insulation, as well as the technologies and materials used, are identical from numerous manufacturers. Therefore, the difference of up to 30% of the values of $K_S$ for the screen given in the catalogs cannot but cause surprise (despite the fact that the values of $K_C$ for the cable core are completely the same). To figure it out, we will independently derive the well-known formula (2).

## IV. JUSTIFICATION OF FORMULA (2)

### *Heat generation*

At short circuit, heat is released in the cable screen

$$Q_S = {I_K}^2 R_S t_K$$

where $I_K$ and $t_K$ – are the magnitude and duration of the short-circuit current,
$R_S = (\rho_S/F_S) \cdot l_K$ – resistance of the screen with cross-section $F_S$ and length $l_K$,
$\rho_S = \rho_{S20} \cdot [1 + \alpha_S \cdot (T - 20)]$ – is the resistivity of the screen material,
$\rho_{S20}$ – is the resistivity of the screen at a temperature of 20°C,
$\alpha_S$ – is the temperature coefficient of the screen resistance,
$T = 0.5 \cdot (T_1 + T_2)$ – is the average temperature of the screen during its heating from the initial temperature $T_1$ to the final $T_2$.

### ***Heat absorption***

Let's assume that all the heat released in the cable screen went only to heating the screen itself, and the insulation and sheath remained at the initial temperatures (such heating of the screen is called adiabatic):

$$Q_S = C_S \cdot \Delta T_S$$

where $\Delta T_S = T_2 - T_1$ – heating of the screen from the initial temperature $T_1$ to the final $T_2$,
$C_S = c_S \cdot m_S$ – is the heat capacity of the screen,
$c_S$ – is the specific heat capacity of the screen material,
$m_S = \gamma_S \cdot V_S$ – is the mass of the screen,
$\gamma_S$ – is the specific density of the screen material,
$V_S = F_S \cdot l_K$ – is the screen volume.

### ***Heat balance***

Equating the release and absorption of heat in the screen, after the transformations we obtain the well-known formula (2) and the expression for the coefficient included in it:

$$K_S = \sqrt{\frac{\gamma_S \cdot c_S \cdot (T_2 - T_1)}{\rho_S}} \qquad (3)$$

where the proportionality coefficient $K_S$ depends on the screen material ($\rho_S$, $c_S$, $\gamma_S$) and on the cable insulation properties ($T_1$, $T_2$).

### ***Example of screen calculation***

We will perform calculations by (3) using the typical data for a copper screen:

$$\alpha_S = 0.0039 \text{ p.u.}$$
$$\rho_{0S} = 1.72 \cdot 10^{-8}\ \Omega\cdot\text{m}$$
$$c_S = 380 \text{ J/(kg·K)}$$
$$\gamma_S = 8890 \text{ kg/m}^3$$

In [4] it was shown that if, in normal operation mode, the core temperature of 90°C is permissible for XLPE-insulation, then the screen temperature is usually lower and can be 75÷85°C, and its specific value depends on the method of laying the cable (in the ground, in the pipe), on the thermal resistance of the ground, on the screens bonding and grounding scheme. Next, as the initial temperature of the screen, preceding the heating of the screen with a short-circuit current, we take the average value $T_1 = 80$°C.

As the screen final temperature for XLPE-insulation according to the standard [2], we take the temperature $T_2 = 350$°C. At the same time, the average temperature of the screen at which it is necessary to calculate its resistivity $\rho_S$ will be

$$T = 0.5 \cdot (T_1 + T_2) = 215°\text{C}$$

Calculations by (3) performed for a copper cable screen give $K_S = 1.74 \cdot 10^8$ A/m$^2$ or $K_S = 0.174$ kA/mm$^2$. With the help of coefficient $K_S$, for various typical cross-sections of the screen $F_S$ according to the formula (2) at time $t_K = 1$ the maximum permissible short-circuit currents $I_K$ were obtained – they are given in the last column of Table 1.

**Table 1.** Permissible short-circuit current $I_K$ by (2) for copper core and screen at $t_K = 1$ c.

| $F_C$ or $F_S$, mm$^2$ | $I_K$, kA | |
|---|---|---|
| | Core (Cu) | Screen (Cu) |
| 35 | 4.9 | 6.1 |
| 50 | 7.1 | 8.7 |
| 70 | 9.9 | 12.2 |
| 95 | 13.4 | 16.5 |
| 120 | 16.9 | 20.9 |
| 150 | 21.2 | 26.1 |
| 185 | 26.1 | 32.2 |
| 240 | 33.8 | 41.8 |
| 300 | 42.3 | 52.2 |
| 400 | 56.4 | 69.6 |

### *Example of core calculation*

If expression (3) was obtained for the cable screen, then exactly the same expression can be obtained for the cable core:

$$K_C = \sqrt{\frac{\gamma_C \cdot c_C \cdot (T_2 - T_1)}{\rho_C}} \tag{4}$$

where the proportionality coefficient $K_C$ depends on the core material ($\rho_C$, $c_C$, $\gamma_C$) and on the insulation properties ($T_1$, $T_2$).

The calculations for the copper core according to (4) will differ from the calculations for the copper screen according to (3), since other temperature values should be used. So, for XLPE-insulation cables, the core temperature can be $T_1 = 90°\mathrm{C}$, and for short-circuits according to the standard [2], we take $T_2 = 250°\mathrm{C}$. Then the average core temperature is

$$T = 0.5 \cdot (T_1 + T_2) = 170°\mathrm{C}$$

Due to the difference in the temperature conditions of the cable core and the screen, the coefficient for the core $K_C$ turned out to be less than for the screen $K_S$, and amounted to $K_C = 0.141$ kA/mm$^2$. With its help, the middle column of the Table 1 is filled in. As can be seen, for cores with a cross-section of more than $F_C = 400$ mm$^2$, checking thermal stability makes no sense, since there are almost no places with short-circuit currents $I_K > 50$ kA in the power system.

### *Comparison of formula calculations with company catalogs*

In the catalogs of ABB, Nexans, Yuzhkabel, Sevkabel, Electrokabel, the coefficient $K_C = 0.143$ kA/mm$^2$ is used to check the correspondence of the core cross-section $F_C$ to the short-circuit currents, which quite accurately coincides with the value $K_C = 0.141$ kA/mm$^2$ obtained here by formula (4). A good match with all firms gives reason to believe that the formula (4) for the core is correct. It means that formula (3) for the screen, obtained similarly to formula (4), should also be trusted.

In fact, the situation with cable screen is more complicated than with cable core, and the $K_S$ coefficient calculated by the formula (3) differs markedly from one cable company to another. In the Table 2 the few details that are available on the cable catalog pages are summarized. As you can see, the difference in the coefficients $K_S$ in the catalogs is really there, however, first of all, it is due to the lack of consensus on the initial $T_1$ and final $T_2$ screen temperatures at short-circuit.

Earlier, using [1,2], it was explained that it is better to put in the calculations for (3) values $T_1 = 80°\text{C}$ and $T_2 = 350°\text{C}$. Sevkabel took the same position. The position of other plants is either radically different (ABB), or unknown (Electrokabel, Nexans). Despite the inconsistency in the values of the initial and final screen temperatures, the formula (3) itself deserves trust (as well as formula (4)).

In particular, the calculations for (3) performed for different $T_1$ and $T_2$ are shown in the last column of Table 2 (for those cases where there was information about temperatures $T_1$ and $T_2$ in the catalog). One can see that coefficient $K_S$ from catalogs have a good match with its calculations according with (3).

For example, consider the first row of the Table 2 – if we put temperatures $T_1 = 50°\text{C}$ and $T_2 = 250°\text{C}$ into the formula (3), we get $K_S = 0.161$ kA/mm$^2$, which coincides well with the corresponding value $K_S = 0.165$ kA/mm$^2$ from the ABB cable catalog. Thus, we emphasize once again that formula (3), although very simple, actually gives fairly accurate results that do not contradict what cable factories get (the main thing is to agree on which temperatures $T_1$ and $T_2$ to include in the calculations).

**Table 2.** The initial data for the selection of the screen cross-section by different companies.

| Cable factory | Information from catalog (only for copper) | | | Calculation of $K_S$ by formula (3) for $T_1$ and $T_2$ |
|---|---|---|---|---|
| | $T_1$, °C | $T_2$, °C | $K_S$, kA/mm$^2$ | |
| ABB | 50 | 250 | 0.165 | 0.161 |
| | 70 | 250 | 0.153 | 0.151 |
| Sevkabel | 80 | 350 | 0.178 | 0.174 |
| Yuzhkabel | 70 | 350 | 0.203 | 0.178 |
| Electrokabel | ? | ? | 0.203 | ? |
| Nexans | ? | ? | 0.200 | ? |

In fact, the difference between coefficients $K_S$ given in numerous catalogs (Table 2), may be due not only to the lack of consensus on the initial $T_1$ and final $T_2$ temperatures, but also to cooling issues. Recall that formula (3) is obtained without taking into account the cooling processes of the screen, which occur during prolonged short-circuit.

It can be shown that taking into account the cooling of the copper cable screen, made according to IEC [1], leads to an increase in the coefficient $K_S = 0.174$ by $\varepsilon = 1.05 \div 1.15$ times. The exact value of $\varepsilon$ depends on interpretation of the IEC calculation methods [1]. Therefore, it is possible that the coefficient $K_S = 0.203$ available in the Table 2, is related precisely to the fact that we observe the consequences of accounting for cooling processes according to IEC.

As for the cable core, accounting for cooling according to IEC, as you know, changes almost nothing for it. The coefficients $K_C$ for the core due to cooling can be increased only by $\varepsilon = 1.01 \div 1.03$ times, but no more. Therefore, the calculations for all sources coincide and fit into the range $K_C = 0.141 \div 0.143$ (indicated for the core made of copper).

It should be understood that in order to determine the exact screen cross-section $F_S$ according to formula (2), it is necessary to have a correct idea not only of the coefficient $K_S$, but also of the short-circuit current $I_K$ itself. Unfortunately, the short-circuit currents $I_K$ included in the calculations are most often incorrect, since when determining them:

- incorrect values of the longitudinal impedances of the cables were laid (this is especially true for the zero sequence impedances $R_0$ and $X_0$, information on the calculation methods of which is completely absent in the catalogues of factories);
- the aperiodic component of the short circuit current was not taken into account.

The absence of consideration of the aperiodic component of the short-circuit current means that the selection of the screen section $F_S$ is carried out without taking into account all sources of heating of the screen, i.e., the screen section turns out to be less than actually required. Against this background, the consequences of the use of IEC [1] seem dangerous, because IEC [1] further reduces the cross-section of the $F_S$ screen, doing this by taking into account cooling. Therefore, the calculation of the cross-section $F_S$ by a simple formula (3), which does not take into account the cooling process of the screen and thus does not allow to underestimate the cross-section of the screen $F_S$, becomes even more attractive.

## V. ACCOUNTING FOR THE APERIODIC COMPONENT OF THE CURRENT

Under the term "short-circuit current", as a rule, only the effective value of the periodic component of the short-circuit current is understood. Therefore, all calculations according to (2), as well as according to the catalogs of cable plants and IEC, are based on information about the effective value of the periodic component of the current of the $I_K$ network in which the cable will be laid. At the same time, as is known, in the short-circuit current, in general, there is also an aperiodic component (Fig.3), the value of which depends on the moment of occurrence of short-circuit (near zero or near the maximum value of the sine phase-to-ground voltage), and attenuation depends on the ratio of the resistance of the network and its inductance (time constant $\tau_K$).

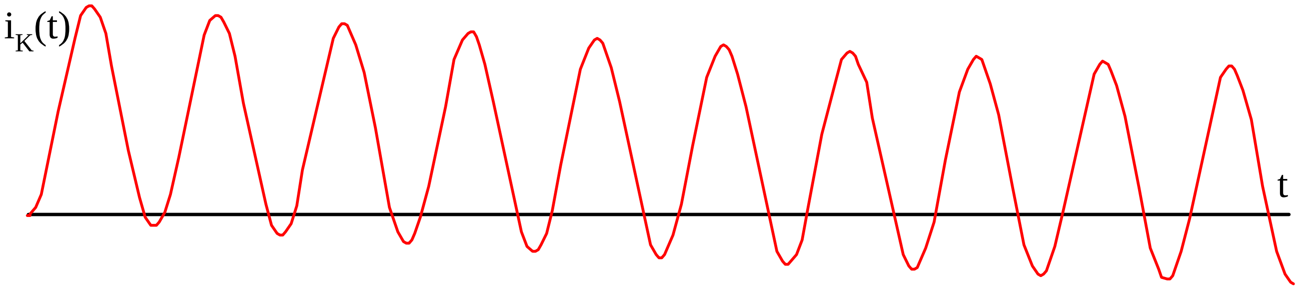

**Fig.3.** Oscillogram of the short-circuit current having periodic and aperiodic components.

The aperiodic component of the short-circuit current passes through the cable core and screen and causes them to heat up in addition to the heating caused by the periodic component. Let's define the role of the aperiodic component in heating the core and screen.

The heat that is released in the resistance $R$ (of the cable core or screen) from the current $i_K(t)$ flowing through it can be found by the well-known expression

$$Q(t) = R \cdot \int_0^t i_K(t)^2 \cdot dt$$

where in the general case, the current has its periodic and aperiodic components

$$i_K(t) = i_P(t) + i_A(t)$$

$$i_P(t) = \sqrt{2} \cdot I_K \cdot sin(\omega t + \psi),$$

$$i_A(t) = \sqrt{2} \cdot I_K \cdot sin(\psi) \cdot exp(-t/\tau_K),$$

where $I_K$ – is the effective value of the periodic component of the short-circuit current,
$\omega = 2\pi f$ – is the circular frequency for $f = 50$ Hz,
$\psi$ – is the initial angle of the sinusoid of the short-circuit current.

If a short-circuit occurs at a time at which $\psi = 0$, there will be no aperiodic component of the current. If a short-circuit occurs at a time at which $\psi = \pi/2$, the aperiodic component will have the largest possible value, equal at the initial moment of time to the amplitude of the periodic component $\sqrt{2} \cdot I_K$ and then gradually fading.

During the transformations, it can be obtained that during the short circuit time $t_K$ in the resistance $R$ of the core (or screen) the short-circuit current, which generally has periodic and aperiodic components, will release heat

$$Q(t_K) = {I_K}^2 \cdot R \cdot (K_A \cdot t_K), \qquad (5)$$

where $K_A$ is the correction factor for heat from the aperiodic current

$$K_A = 1 + \frac{1 - exp(-2t_K/\tau_K)}{t_K/\tau_K} sin\,\psi$$

If there is only a periodic component of the short-circuit current (case $\psi = 0$), then according to (5) heat $Q(t_K) = {I_K}^2 \cdot R \cdot t_K$ – this expression exactly matches the one used while obtaining well-known formulas (2), (3), (4).

If there are both periodic and aperiodic components (case $\psi \neq 0$), then the heat released in the core and screen will be $K_A > 1$ times greater than before, which means that the heating $\Delta T$ of the core (screen) by the short-circuit current will increase by $K_A > 1$ times.

The aperiodic component will have the strongest effect on heating at $\psi = \pi/2$ – this case will be considered further for estimates of $K_A$.

Taking into account (5), the known formula (2) can be refined:

$$I_K = K_C \frac{F_C}{\sqrt{t_K K_A}}$$
$$I_K = K_S \frac{F_S}{\sqrt{t_K K_A}} \qquad (6)$$

It can be seen that taking into account the aperiodic component of the short-circuit current when choosing the screen section can be done by putting additional reserves in the value of the short-circuit time $t_K$. The coefficient $K_A$ depends on the time constant $\tau_K$, which in turn depends on the network scheme, but in the first approximation can be assumed to be equal to 75 ms for substation busbars and 315 ms for power plant busbars. The calculation of $K_A$ is given in Table 3. It can be seen that taking into account the aperiodic component of the short-circuit current gives an increase in heat dissipation in the resistance of the core and the screen, especially noticeable at small times $t_K$ of short-circuit.

**Table 3.** Correction factor $K_A$ in formula (6) when selecting the screen cross-section.

| $t_K$, s | $K_A$, kA | |
|---|---|---|
| | Substation | Station |
| | $\tau_K = 0.075$ s * | $\tau_K = 0.315$ s * |
| 0.1 | 1.698 | 2.481 |
| 0.2 | 1.373 | 2.133 |
| 0.4 | 1.187 | 1.725 |
| 0.6 | 1.125 | 1.513 |
| 0.8 | 1.094 | 1.391 |
| **1** | **1.075** | **1.314** |
| 1.2 | 1.063 | 1.262 |
| 1.4 | 1.054 | 1.225 |
| 1.6 | 1.047 | 1.197 |
| 1.8 | 1.042 | 1.175 |
| 2 | 1.038 | 1.157 |

* – the specified time constants are typical for networks mainly with overhead lines, and not with cables. The author does not have data on time constants for cable networks.

An increase in heat generation means an increase in the heating of the core and the screen. For example, without taking into account the aperiodic component of the current during the short-circuit, the cable screen was heated from $T_1 = 80°\text{C}$ to $T_2 = 350°\text{C}$, i.e. at

$$\Delta T_S = T_2 - T_1 = 270°\text{C}.$$

Then, if taking into account $K_A = 1.698$, the heating of the cable screen will increase proportionally to

$$\Delta T_S = 1.698 \cdot 270 = 460°\text{C}$$

This means that after heating, the screen temperature will be about

$$T_2 = \Delta T_S + T_1 = 460 + 80 = 540°\text{C}$$

where the figures are given without taking into account the heat removed from the screen into the XLPE-insulation and outer sheath, i.e. assuming the adiabatic nature of the process.

It is obvious that the aperiodic component of the short-circuit current of the network requires consideration when checking (when selecting) the cross-sections of the cable core and the screen, especially for a small short-circuit time. However, first of all, it is necessary to determine the rules for choosing the short-circuit time $t_K$ laid down in the calculations, on which $K_A$ and the role of the aperiodic component significantly depend.

The time $t_K$ of disconnection of the short-circuit is determined by which protections (main, backup) will disconnect the cable line and what time delays they have. It would also be appropriate to link the choice of the time $t_K$ included in the calculations with the degree of responsibility of the cable line, because for the most important lines it is possible to make excessive time reserves, and for secondary lines it is possible to select cross-sections with minimal time exposures, saving on the screen cross-section and its cost.

## VI. CONCLUSIONS

1. Currently, when selecting (checking) the cross-sections of the core and the screen, the formula (2) is used, where only the periodic component of the network short-circuit current is taken into account and the possible presence of an aperiodic component in the current is not taken into account.

2. The role of the aperiodic component in heating the core and the screen depends on the time $t_K$ of switching off the line short-circuit. With a short time, the role of the aperiodic component increases significantly, and the final temperature of the cable core and screen, the cross-section of which is selected according to the common well-known formula (2), can significantly exceed the permissible values of 250°C and 350°C, respectively.

3. Currently, the fact that the insulation of the line is saved from overheating is that:

- the cable lines are underloaded and before the short-circuit the temperature of the core and the screen is not 80÷90°C as in (2), but not more than 20÷30°C;
- the cross-section of the core and the screen is often mistakenly checked at a time of 1 s, which is given in the catalogs of companies only as an example (whereas in fact the time of switching off the short-circuit is less, and even taking into account the longest levels of relay protection does not exceed 0.6÷0.8 s).

4. To account for the aperiodic component, it is recommended to use the formula (6), where can be taken:

- coefficients $K_C = 0.141\ \text{kA}\sqrt{\text{s}}/\text{mm}^2$ (copper) and $K_S = 0.174\ \text{kA}\sqrt{\text{s}}/\text{mm}^2$ (copper);
- coefficient $K_A$ according to Table 3 depending on the time $t_K$.

If needed, it's easy to evaluate $K_C$ and $K_S$ for the case of aluminum by (3) and (4).

5. Unfortunately, there are currently no clear rules for choosing the time $t_K$ and there is no consensus among designers about which relay protection (primary or backup) should be guided by. Therefore, when checking the thermal resistance of the cable core and screen cross-section, the appearance in formula (6) of a new coefficient $K_A$, included in the product $K_A t_K$, is a convenient occasion for industry specialists to discuss and reflect in the standards the rules for choosing $t_K$.

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