Methodological Bases of the Fire Hazard Reduction in Internal and External 0.38 kV Electrical Networks with Unbalancing Power Consumption

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Abstract. The article shows that the operation modes in three-phase four-wire 0.38 kV electrical networks are objectively associated with unbalancing power consumption. As a result, significant additional electrical energy thermal losses occur in the neutral conductor’s internal electrical networks and external electrical networks elements, which not only increase the electrical energy consumption, but also create conditions for the fire-hazardous occurrence single-phase short circuits. A mathematical model is proposed, an algorithm and a program for calculating the limit zero sequence values flows in external neutral conductors and internal 0.38 kV electrical networks are developed. Numerical calculations are made and tabular these limit values data for different conductors’ sections made of various conductive materials are presented. The unbalancing operation modes calculations in operating external and internal 0.38 kV electrical networks have been made, on the basis of which the proposed methodology has been tested. The technical means use effectiveness for the operating modes balancing in existing electrical networks with unbalance power consumption is proved.

1. Introduction

According to the numerous literary sources published data, it has been established that the 0.38 kV voltage three-phase four-wire electrical networks operating modes are objectively unbalancing. The unbalancing power consumption reasons in the electrical networks under consideration may be different. The main ones are the uneven single-phase electric receiver’s distribution across three network phases, as well as their switching random nature during power consumption. It is known from the electrical engineering theory that the criterion for occurrences an unbalancing mode is the occurrence in the positive, negative and zero sequences currents and voltages symmetrical components network \cite{1}. The negative and zero sequences voltages significantly reduce the power quality, which leads to an increase in the established indicators \cite{2-4}. The negative and zero sequences currents create active power additional losses, which not only lead to increased electrical energy overspending, but also, under certain conditions, create the fires possibility \cite{5-9}. The unbalancing power consumption nature is determined by the electrical receiver’s type. And if in industrial premises, where motor and other three-phase symmetrical loads prevail over single-phase electric receivers, the currents and voltages negative sequence components have the greatest values \cite{7-13}, then in rooms containing...
mainly communal single-phase electric receivers, it is the zero sequence currents and voltages symmetrical components that take the greatest importance [14-19]. The criterion for evaluating additional active power losses is the power loss coefficient, which represents the active losses ratio in an unbalance mode to the corresponding losses caused by the positive sequence currents flow only [20]:

$$K_p = 1 + K_{2i}^2 + K_{0i}^2 \cdot (r_1 + 3 \cdot r_N),$$

Where $K_{2i} = \frac{i_2}{i_1}$, $K_{2i} = \frac{i_2}{i_1}$ - accordingly, the current unbalance coefficients for the negative and zero sequences; $r_1$, $r_N$ - are the active resistances of phases (positive sequence) and zero conductor, respectively. For power transmission lines having a neutral conductor cross-section equal to the phase conductor cross-section, expression (1) is converted to: $K_p = 1 + 3K_{2i}^2 + 4K_{0i}^2$. As noted above, the currents negative sequence in electrical networks with a household load usually does not reach large values, and its share in the loss coefficient is not particularly dangerous from the increased view heat point generation. Zero-sequence currents, summing up in a neutral conductor, can reach large values [7;9;11;16;18], especially considering the fact that the modern 0.38 kV power transmission lines implementation is carried out by insulated wires, and, consequently, the heat transfer process from a heated neutral wire core to the environment largely depends on the thermal insulation characteristics.

When installing internal electrical wiring in residential, office and some industrial premises, the single-phase electric receiver’s uniform distribution tendency is violated in almost all cases. At the same time, the resulting unbalancing power consumption is enhanced by these electric receivers switching probabilistic nature. At the design stage, when choosing a conductor cross-section, it is necessary to check its on the permissible heating. This test task is to determine the maximum permissible current that can be passed through a given cross-section conductor, provided that the maximum possible surface this conductor temperature is not exceeded. At the same time, all reference data give the such value an allowable current, provided that the coefficient $K_p=1$. That is, the cross-section is always selected without taking into account zero-sequence flows in a neutral conductor in a 0.38 kV network. Thus, firstly, the selected conductor neutral wire cross-section is artificially underestimated, and secondly, the circuit breaker protecting this line will also be selected incorrectly, since it is also selected based on the operating current that does not take into account the zero sequence currents. The flowing three zero-sequence currents overheat the insulation, which leads to its melting and causes a single-phase short circuit. In the event that the circuit breaker in the network main part is selected incorrectly (i.e. it has not been tested for the operation sensitivity under conditions minimal short circuit), the protection device does not work in a short circuit case in any remote the network part. As a result, fires occur both in individual houses in rural settlements, cottage settlements, urban apartments, and in some agricultural and industrial premises. So, in [21] it is shown that more than 20% of fires in the enterprises premises and their accompanying consequences occur due to the rules Violations and electrical installations operation devices, while a such fires significant part occurs due to short circuits arising from unbalancing power consumption. In the modern world, according to the Fire Statistics World Center at the Insurance Economics International Association (Geneva) and the Fire Statistics (CPS) Center, 8-9 million fires occur annually. According to [22], the average time interval between two fires or fires in residential buildings and structures in the USA is 85 seconds, and in Russia – 305 seconds. At the same time, the death main share toll falls on residential buildings and the average time interval between deaths in fires in residential buildings and structures was, respectively, 208 minutes in the USA and 51 minutes in Russia. This indicates the fire prevention problem absolute urgency in all countries. Fire statistics in Russia show that fires occur 80% in residential premises. Here, the death and people injury from smoke and fire is 9 cases out of 10. According to the Center for the CTIF Fire Statistics, more than 100 people per 1 million people in Russia die in fires, which is 6 times more than in the United States. At the same time, the fires number per year per 1 million people in Russia is about 2000 [22]. In addition to what has been said, the
following should be noted. Most often, in rural electric 0.38 kV networks, the 0.38 kV number outgoing lines from a 10/0.4 kV transformer substation buses reaches 4-6, which have different unbalancing power consumption levels. In this case, the power transformer neutral point, from which the neutral wire departs, may unacceptably overheat, which can lead either to the neutral wire unpacked from the transformer neutral, or to a fire directly on the 0.4 kV tires. Since we are talking about the fact that three zero-sequence currents flowing through a neutral conductor significantly increase its temperature, therefore, it becomes necessary to determine the zero-sequence current limit values at which the neutral wire insulation begins to lose its insulating properties.

The article purpose is to develop a methodology and a tool for calculating the zero-sequence currents limit values for three-phase four-wire various sections insulated conductors used for power transmission in electric networks with municipal power consumption. To achieve this goal, it is necessary to solve a tasks number:

- To establish the relationship between the permissible the zero-sequence current limit value and the conductor’s cross-sections.
- To calculate the zero-sequence currents limit values corresponding to the accepted the power transmission lines cross-sections used in internal (intra-house) and external 0.38 kV electrical networks.
- Based on real measurements in existing 0.38 kV networks, to calculate the unbalancing mode and set the threshold zero sequence values flows for the external and internal (intra-house) studied sections electrical networks.
- Consider the using possibility balancing devices with automatically changing parameters in the studied electrical networks to reduce the unbalancing consequences power consumption.

2. Materials and methods
When current flows through a neutral conductor: \( I_N = 3I_0 \), a thermal energy Joule amount is released in it, defined as:

\[
Q_1 = (3I_0)^2 \cdot r_{0N} \cdot l \cdot \tau
\]  

(2)

On the other hand, the generated heat is transferred from the neutral wire surface to the surrounding space. Very conditionally (rather approximately), air can be considered the surrounding space, although in fact heat will be transmitted inside the insulated wire. Taking into account the accepted assumption, we will assume that heat is transmitted by radiation according to the following law:

\[
Q_2 = \varepsilon_{above} \cdot c_0 \cdot F_{Sur} \cdot \left[ \left( \frac{T_1}{100} \right)^4 - \left( \frac{T_2}{100} \right)^4 \right] \cdot \tau
\]  

(3)

In expressions (2) and (3): \( I_0 \) – is the zero-sequence current, \( r_{0N} \) – is the neutral conductor material resistivity; \( l \) – is the neutral wire length; \( \tau \) – is the transmission time; \( F_{Sur} \) – is the surface wire area; \( T_1 \) and \( T_2 \) – are the emitting and receiving surfaces temperatures, respectively. The permissible heating radiating surface temperature, taking into account the correction factor [23] for a wire in rubber (PVC) insulation, is: \( T_1 = 65^\circ\text{C} + 273.15 = 338.15^\circ\text{K} \). The receiving surface temperature (at a medium temperature equal to 20\(^\circ\text{C}\)) is: \( T_2 = 20+273.15 = 293.15^\circ\text{K} \); \( c_0 = 5.67 \text{ W/(m}^2 \cdot \text{K}^4) \) – the completely black body radiation coefficient; \( \varepsilon_{above} = \frac{1}{1+\left(\frac{\varepsilon_1}{\varepsilon_2}\right)^4} \) – the reduced blackness degree in a closed radiation heat exchange system consisting from two gray bodies [22]; \( \varepsilon_1 \) and \( \varepsilon_2 \) – integral blackness degrees of the two gray bodies (the first body is polished aluminum - conductor material, the second is conductor insulation - PVC).

According to [24], after a certain time, the heat amount released in the conductor will be balanced by the heat radiated from its surface. In accordance with the thermal balance that has occurred, it is possible to determine the maximum the zero-sequence current value passing through a neutral
conductor with unbalancing power consumption: \((3I_0)^2 \cdot r_{0N} \cdot l \cdot \tau = \varepsilon_{ab} \cdot c_0 \cdot F_{Sur.} \cdot \tau\).

From here:

\[
I_0 = \frac{\varepsilon_{ab} \cdot c_0 \cdot F_{Sur.} \cdot T}{9 \cdot r_{0N} \cdot l} = \frac{1}{3} \cdot \sqrt{\frac{\varepsilon_{ab} \cdot c_0 \cdot \pi \cdot d \cdot T}{r_{0N}}}
\]  \(4\)

Were \(T = \left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\), \(F_{Sur.} = \pi \cdot d \cdot l\).

The resulting dependence \((4)\) characterizes the following. When calculating the unbalancing the 0.38 electrical network particular section operation mode, based on the developed methods and programs [25-28], the positive, negative and zero sequences currents and voltages symmetrical components are calculated. The obtained values comparison for zero-sequence currents with the calculated limit value according to expression \((4)\) for the neutral conductor selected section allows to conclude that this section corresponds to the unbalancing power consumption real level and ignition risk the occurrence (or absence).

3. Results and Discussion

Based on the presented expressions \((2) – (4)\) according to the algorithm (figure 1), the zero sequence current limit value calculating program for a neutral conductor different sections has been developed. The program is implemented in MATLAB.

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**Figure 1.** The calculating permissible zero sequence current algorithm block diagram.
The calculation made according to the specified program allowed to obtain the maximum permissible values for the current in the neutral wire (equal to three zero-sequence currents) for different sections conductors copper and aluminum made (figure 2, table 1). The current values obtained indicate that if they are exceeded, the surface the neutral conductor temperature will exceed the maximum value (65°C), which will lead to the conductor insulating properties violation and, corresponding to the short circuit’s conditions and the fire-hazardous situations creation.

![Figure 2. Dependence of zero sequence current limit value in a neutral conductor with PVC insulation on its cross section.](image)

Using the data in table 1 allows determining the maximum permissible the current value in the neutral wire for the buildings and structures internal wiring. In addition, the proposed software allows you to set the current limit in the neutral wire and for outdoor 0.38 kV electrical networks in various ambient temperature ranges (table 2). In order to analyze the unbalancing power consumption real mode in the current 0.38 kV network, the measurement data was used (The research was carried out on TS “Smolenshchina” KTPN p. Smolenshchina T-1 (0.4 kV tires). Gardening “Puteets”, uch. No. 20. Protocol No. 2484/047 of 10/15/2021). A certified Resurs – UF2M device (factory No. 2337) was used as a measurement tool.

| Cross section, mm² | The maximum current value in a neutral conductor with an aluminum core in PVC insulation, A | The maximum current value in a neutral conductor with a copper core in PVC insulation, A |
|--------------------|-------------------------------------------------|--------------------------------------------------|
| 2.5                | 2.625119                                        | 3.411836                                         |
| 4                  | 3.744561                                        | 5.228995                                         |
| 6                  | 5.06812                                         | 6.563987                                         |
| 10                 | 7.465301                                        | 9.796973                                         |
| 16                 | 10.44642                                        | 13.48627                                         |
| 25                 | 14.48978                                        | 19.20515                                         |
| 35                 | 18.95858                                        | 24.69701                                         |
| 50                 | 24.85739                                        | 32.30685                                         |
| 70                 | 31.9688                                         | 41.51998                                         |
| 95                 | 40.22467                                        | 52.24841                                         |
| 120                | 47.87216                                        | 62.32222                                         |
The study was carried out on a power transformer 0.4 kV tires. The transformer power \( S_{\text{nom}} \) is 160 kVA. Measurements duration is 1 day with a 10 minutes interval. The power transformer has the following characteristics: Idle power: \( P_d = 510 \text{ W} \); short circuit power: \( P_{sc} = 2650 \text{ W} \); no-load current: \( I_{ac} = 2.4\% \); short-circuit voltage: \( U_{scl} = 4.5\% \). The positive (negative) and zero sequences total complex resistances are: \( Z_{1T}=Z_{2T}=0.0166+j0.0417 \text{ Ohms} \), \( Z_{0T}=0.151+j0.367 \text{ Ohms} \). The 10 kV line is a 70 mm\(^2\) AC wire made with a 1.25 km long, which the positive (negative) sequences total complex resistances are: \( Z_{1L1}=Z_{1L2}=0.579+j0.346 \text{ Ohms} \). The 0.38 kV 0.57 km long line, made with an insulated SIP 2A wire, with a 3x35+1x50 mm\(^2\) cross section, has positive (negative) and zero sequences full complex resistances, equal respectively: \( Z_{L1}=Z_{L2}=0.641+j0.0793 \text{ Ohms} \); \( Z_{L0}=0.72+j0.691 \text{ Ohms} \). The 0.38 kV line load is private landholdings with different storeys houses (mainly single-storey houses) with communal consumers. In addition, there is a small sawmill where a three-phase asynchronous electric motor with a 12.3 kW capacity is used. To calculate the network unbalancing modes under study, the computer program "Modulomethod" was used, developed on the methods basis [20;25-26].

### Table 2. A neutral conductor current limit values in a three-phase four-wire 0.38 kV power transmission line made by an isolated conductor.

| Insulated conductor core type | Cross section, mm\(^2\) | Maximum permissible current value (A) at ambient temperature values, (°C) |
|------------------------------|--------------------------|------------------------------------------------------------------|
|                              | -20          | -15       | -10      | -5        | 0         | 5         | 10        | 15        | 20        | 25        | 30        | 35        |
| **Al**                       |              |           |          |           |           |           |           |           |           |           |           |           |
| 2.5                          | 3.30         | 3.23      | 3.17     | 3.09      | 3.02      | 2.93      | 2.84      | 2.74      | 2.63      | 2.50      | 2.37      | 2.22      |
| 4                            | 4.70         | 4.61      | 4.52     | 4.41      | 4.30      | 4.18      | 4.05      | 3.90      | 3.74      | 3.57      | 3.38      | 3.16      |
| 6                            | 6.36         | 6.24      | 6.11     | 5.97      | 5.82      | 5.66      | 5.48      | 5.28      | 5.07      | 4.83      | 4.57      | 4.28      |
| 10                           | 9.37         | 9.20      | 9.01     | 8.80      | 8.58      | 8.33      | 8.07      | 7.78      | 7.47      | 7.12      | 6.73      | 6.30      |
| 16                           | 13.12        | 12.87     | 12.60    | 12.31     | 12.00     | 11.66     | 11.29     | 10.89     | 10.45     | 9.96      | 9.42      | 8.82      |
| 25                           | 18.19        | 17.85     | 17.48    | 17.08     | 16.64     | 16.17     | 15.66     | 15.10     | 14.49     | 13.82     | 13.07     | 12.24     |
| 35                           | 23.80        | 23.35     | 22.87    | 22.35     | 21.78     | 21.16     | 20.49     | 19.76     | 18.96     | 18.08     | 17.10     | 16.01     |
| 50                           | 31.21        | 30.62     | 29.90    | 29.30     | 28.55     | 27.75     | 26.87     | 25.91     | 24.86     | 23.70     | 22.42     | 20.99     |
| 70                           | 40.14        | 39.38     | 38.56    | 37.68     | 36.72     | 35.68     | 34.55     | 33.32     | 31.97     | 30.48     | 28.94     | 27.00     |
| 95                           | 50.50        | 49.55     | 48.52    | 47.41     | 46.21     | 44.90     | 43.48     | 41.92     | 40.22     | 38.35     | 36.28     | 33.97     |
| 120                          | 60.10        | 58.97     | 57.75    | 56.43     | 54.99     | 53.44     | 51.74     | 49.90     | 47.87     | 45.65     | 43.18     | 40.43     |
| **Cu**                       |              |           |          |           |           |           |           |           |           |           |           |           |
| 2.5                          | 4.25         | 4.17      | 4.09     | 3.99      | 3.89      | 3.78      | 3.66      | 3.53      | 3.39      | 3.23      | 3.06      | 2.86      |
| 4                            | 6.48         | 6.36      | 6.23     | 6.09      | 5.93      | 5.77      | 5.58      | 5.38      | 5.16      | 4.92      | 4.66      | 4.36      |
| 6                            | 8.24         | 8.09      | 7.92     | 7.74      | 7.54      | 7.33      | 7.09      | 6.84      | 6.56      | 6.26      | 5.92      | 5.54      |
| 10                           | 12.30        | 12.07     | 11.82    | 11.55     | 11.25     | 10.94     | 10.59     | 10.21     | 9.80      | 9.34      | 8.84      | 8.27      |
| 16                           | 16.93        | 16.61     | 16.27    | 15.90     | 15.49     | 15.05     | 14.58     | 14.06     | 13.49     | 12.86     | 12.16     | 11.39     |
| 25                           | 24.11        | 23.66     | 23.17    | 22.64     | 22.06     | 21.44     | 20.76     | 20.02     | 19.21     | 18.31     | 17.32     | 16.22     |
| 35                           | 31.01        | 30.42     | 29.79    | 29.11     | 28.37     | 27.57     | 26.69     | 25.74     | 24.70     | 23.55     | 22.28     | 20.86     |
| 50                           | 40.56        | 39.80     | 38.97    | 38.08     | 37.11     | 36.06     | 34.92     | 33.67     | 32.31     | 30.80     | 29.14     | 27.24     |
| 70                           | 52.13        | 51.15     | 50.09    | 48.94     | 47.70     | 46.35     | 44.88     | 43.27     | 41.52     | 39.59     | 37.45     | 35.07     |
| 95                           | 65.60        | 64.36     | 63.03    | 61.58     | 60.02     | 58.32     | 56.47     | 54.46     | 52.25     | 49.82     | 47.13     | 44.13     |
| 120                          | 78.24        | 76.77     | 75.18    | 73.46     | 71.59     | 69.57     | 67.63     | 64.56     | 62.32     | 59.42     | 56.22     | 52.63     |

Based on the calculations made, using the MATLAB graphic editor technology, constructed the parameters under study time diagrams (figures 3 and 4).

**Figure 3.** Time diagrams changes the phase currents in the 0.38 kV line under study.
Figure 2 shows phase currents changes diagrams in a 0.38 kV line. As can be seen from the diagrams presented, the "A" phase is the busiest (the average current value for the measurement period was 42.91 A). In the other two phases, the change in currents is not so obvious, on average, in the phases "B" and "C" 25.67 and 21.97 A, respectively. According to the established current unbalance level, figure 4 shows the zero sequence current change diagram in the line under study.

The analysis of Figure 4 shows that the zero sequence current during the study takes different values from a 1.41 A minimum to a 13.25 A maximum. At the same time the average current value for the measurement period was 6.71 A. Consequently, the current in a neutral conductor equal to three zero sequence currents averages 20.2 A. Taking into account the fact that the measurements were carried out from 16:00 on October 14 to 16:00 on October 15, 2021, and the average ambient temperature during this time period was 50°C, therefore, based on table 2, the maximum permissible current in the neutral wire network under study should not exceed 27.75 A. Based on the conducted studies, it was found that the real average current value does not exceed the limit value, nevertheless, in the 11.8% measurement interval time, the actual current value goes beyond the established limits, namely in 17 ten-minute time intervals. At the same time, the permissible average value limit current (27.75A) was 4.05 A. It is obvious that such an unbalanced load in the warm season will create more critical conditions in the conditions of emergency situations in the studied network, which creates real conditions for the occurrence of fire-hazardous situations directly at the neutral point of the power transformer, where the neutral wire is fixed.

The permissible current decreases in the electrical network under study can be achieved either by redistributing connected consumers across the network phases, or by increasing the neutral conductor cross-section. But a more effective means can be considered a special balancing device inclusion in the network, which change parameters automatically in accordance with the change in unbalancing power consumption [29-31]. Using the "Modulomethod" program, the studied indicators calculation was performed in the absence and a balancing device inclusion in the electrical network (figure 5).

Figure 4. The time diagram of zero sequence current changing in the 0.38 kV line under study.

Figure 5. Changes time diagrams the zero-sequence current in the 0.38 kV electrical network neutral conductor before and after switching on the balancing device.
The figure 5 analysis showed that the a balancing device connection in the load node reduces the current in the network under study neutral wire from a 6.712049 A average value (the zero sequence current is 20.2 A) decreases to 0.021834 A value. That is, the balancing effect is 96.75%.

Let's consider what happens to the active and reactive power losses in the electrical network elements under consideration, and what effect a balancing device has on these losses magnitude.

Figures 6 and 7 show the active and reactive power losses changes in the network elements (power transmission line and power transformer) when the absence (figure 6) and balancing device inclusion in the network (figure 7).

The figure 6 analysis showed the following. When the BD absence in the network, the average (during the measurement period) active power losses value was: in the power line – 2.113599 kW, in the power transformer - 0.988338 kW, in the entire network - 3.101938 kW. Reactive power losses in the network elements: in the line – 0.25547 kvar, in the transformer - 8.4625 kvar, in the network - 8.730274 kvar.

The balancing device inclusion in the network allows obtaining the following indicators values (figure 7): active power losses in the line - 0.007653 kW (the balancing effect - 96.38%); in the transformer - 0.539565 kW (balancing - 45.4%); in the entire 0.38 kV network - 0.547218 kW (balancing - 82.36%). Reactive power losses: in the power line – 0.000947 kvar (balancing - 96.3%); in the power transformer - 0.944344 kvar (effect - 88.84%); in the whole network - 0.94529 kvar (effect - 89.17%). In general, the 0.38 kV network section under study full power total losses decreases from 9.2647 kVA to 1.0923 kVA when the balancing device is turned on. That is, the balancing effect is 88.21% for the entire network.
In conclusion, let's look at the change in nature specific example the unbalancing power consumption in an individual residential building, and how the mode balancing can affect the internal wiring fire-hazardous situation reduction and power consumption in general.

As an example, the measurements of electrical energy parameters at the input to a residential building are considered. The research was carried out from 9:00 p.m. on 18.03.2019 to 8:30 p.m. on 25.03.2019. The private house is located at a 30 m distance from a complete transformer substation, on which a 10/0.4 kV power transformer with a 160 kVA capacity is installed. From the 0.4 kV transformer bus bars to the input-distribution device (IDD) at home, power is supplied by an insulated wire with aluminum cores, with a 4x16 mm² cross section. From the IDD to the main switchboard (MSB), power is supplied by a flexible cable with copper cores in PVC insulation and a 20 m length with a 4x6 mm² cross section. The consumers loads at home are single-phase electric receivers distributed in a three-phase voltage system. The total installed consumers capacity is 25 kW.

The motors are absent. The studies were carried out on the MSB tires at home a certified Resurs - UF2M device by means, which measurement data on the hard disk was recorded during the specified period with a 10 minutes time interval. The ambient temperature during the experiment was -12°C.

As can be seen from figure 8, from 13:10 on 20.03.2019 to 18:10 on 21.03.2019, there was a power supply interruption caused by an emergency situation at the transformer substation. Due to the circumstances, the analysis was carried out for the entire measurement period, minus the electricity under-supplying time.

Consider how the current changes in the house cable neutral wire. Figure 9, shows the zero-sequence current change time diagram in the electrical network under study, and figure 9, b shows a possible change in the same current if a balancing device is installed on the GRS tires, which parameters are automatically calculated in accordance with the unbalancing power consumption level.
The figure 9 analysis showed the following. During the study period, the zero sequence current average value was 3.638701 A, hence the total current in the neutral conductor is 10.916103 A. In accordance with table 2, the current limit value in a neutral conductor at the specified temperature for a cable with copper cores is 8 A. As can be seen, the current unbalance real mode is close to critical from the fire-hazardous situation occurrence view point.

4. Conclusion
The conducted research allowed:

- To substantiate the methodological basis for the fire-hazardous situations occurrence in the buildings and structures internal wiring, as well as on 0.38 kV electrical networks substation equipment with unbalanced power consumption.
- Obtain current limits numerical values in a neutral conductor for different cross sections;
- To prove by 0.38 kV networks unbalancing modes calculation examples the effectiveness using special balancing devices for minimizing zero sequence flows.

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