Practical Aspects of Modernization of Electrical Equipment of the Substation

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Abstract. Currently, one of the important problems for domestic energy is the replacement of an outdated fleet of equipment at substations of electric power systems (EPS). The paper addressed the issue of upgrading the "Ice" substation in part of the selection of switches, checking the reliability of switches and the reliability of the substation in general. The substation characteristic is given, the changes in the main scheme of the substation electrical connections are substantiated, switches for all substation voltages are selected according to the current short circuit currents. To assess the degree of reliability of the selected switches, the substation is determined by their probability of refusal. Based on the assessment of the likelihood of failures and other equipment for the substation, the estimated time of trouble-free operation was determined, the average time of trouble-free operation and the average substation recovery time.

1. Introduction

Operation of morally obsolete electrical equipment can lead to false responses of protection or their failure, reducing the reliability of the EPS. The proposed topic for replacing, reconstructing and modernizing electrical equipment at the substation in order to increase the reliability today possesses the relevance and is considered by many authors [1-9].

The purpose of our work is to study the scheme of the electrical network of substation “Ledyanaya” the Amur Energy System and the study of the main issues of the modernization of electrical equipment.

The subscribing 220/35/6 kV “Ledyanaya” is in operation since 1968 in the system of traction transit of 220 kV Amur-Ice-Shimanovsk and is located 45 km from the city free to the village of Shimanovsk. The average operation of the equipment at the substation is 15-20 years, therefore, based on the date of commissioning of the substation, it can be assumed that the equipment at the substation is morally outdated.

The main groups of consumers in the electricity supply area are the Ministry of Defense - the Center for Military Space Forces - a category I receiver, which is part of a special group, as well as enterprises of agricultural production of the adjacent villages Buzuli, Dmitrievo and Rasteraovo and their household load. The number of exhaust air lines of 35 kV - five, the number of feeders of 6 kV - six. Such consumers and the load speak of the importance of the substation in the area.

The Ice Floor 220/35/6 kV substation is included in the dissection of duplex lines, separators are installed in transformers' circuits, and a switch in the jumper. The scheme is quite reliable, but a
serious disadvantage of this scheme with separators and shortguts is a high time of inclusion of a short-circuit (0.4-0.5) C and disconnecting a separator (0.5-1.0) C, as a result, a break in electricity supply It turns out significant, which adversely affects consumers of category I. Operating experience also showed that these devices are not reliably working in unfavorable weather conditions (frost, ice). In addition, when the support and rod isolation is transmitted, a breakdown of moving and ceramic parts is possible.

Given the disadvantages of the existing high voltage distribution unit for the High voltage of substation 220/35/6 kV “Ledyanaya”, it is proposed to modernize this part of the scheme with a replacement of separators and short-circuit on modern switches, checking the reliability of their operation.

2. Results and discussion

Switches are essential switching machines and are intended to be turned on, disconnecting and re-enabled electrical connections. These operations switches must be performed in normal mode, as well as with short circuits [10].

| Table 1. Calculated and catalog data of switches. |
|--------------------------------------|--------------------------------------|
| Estimated data | Catalog data |
| **Switch SSW-220CI-25/1250TC1** |
| $U_{set} = 220$ kV | $U_{nom} = 220$ kV |
| $I_{p,max} = 65.608$ A | $I_{nom} = 1250$ A |
| $I_{n,o} = 4.76$ kA | $I_{off,nom} = 25$ kA |
| $i_{s} = 0.335$ kA | $i_{n,nom} = 12.73$ kA |
| $i_{y} = 10.815$ kA | $i_{incl} = 65$ kA |
| $I_{n,o} = 4.76$ kA | $I_{incl} = 25$ kA |
| $I_{n,o} = 4.76$ kA | $I_{syn} = 25$ kA |
| $i_{s} = 10.815$ kA | $i_{syn} = 65$ kA |
| $B_{k} = 3.852$ kA$^{2}$c | $B_{k} = 1875$ kA$^{2}$c |
| **Switch C-350-630-10T1** |
| $U_{set} = 35$ kV | $U_{nom} = 35$ kV |
| $I_{p,max} = 317.213$ A | $I_{nom} = 630$ A |
| $I_{n,o} = 4.992$ kA | $I_{off,nom} = 10$ kA |
| $i_{s} = 0.351$ kA | $i_{n,nom} = 3.535$ kA |
| $i_{y} = 11.341$ kA | $i_{incl} = 26$ kA |
| $I_{n,o} = 4.992$ kA | $I_{incl} = 10$ kA |
| $I_{n,o} = 4.992$ kA | $I_{syn} = 10$ kA |
| $i_{s} = 11.341$ kA | $i_{syn} = 26$ kA |
| $B_{k} = 4.236$ kA$^{2}$c | $B_{k} = 300$ kA$^{2}$c |
| **Switch SO-11-2500-31,5T3** |
| $U_{set} = 6$ kV | $U_{nom} = 10$ kA |
| $I_{p,max} = 449.371$ | $I_{nom} = 630$ A |
| $I_{n,o} = 10.264$ kA | $I_{off,nom} = 20$ kA |
| $i_{y} = 19.855$ kA | $i_{incl} = 52$ kA |
| $I_{n,o} = 10.264$ kA | $I_{incl} = 20$ kA |
| $I_{n,o} = 10.264$ kA | $I_{syn} = 20$ kA |
| $i_{s} = 19.855$ kA | $i_{syn} = 52$ kA |
| $B_{k} = 24.23$ kA$^{2}$c | $B_{k} = 300$ kA$^{2}$c |
The refore, when selecting switches, it is very important to check for the compliance of their parameters to long working and short-term emergency modes that may occur during operation. According to [10, 11], the main parameters of the equipment that must correspond to the conditions of the working (long-term) mode are rated current and voltage, and when checking switches to thermal and dynamic persistence for the calculated form of a short circuit (SC), a three-phase SC is taken. The selection of switches is made according to the most important parameters: installation voltage, long-term current, turning off the ability. Calculation and selection of switches we carry out according to the methods described in [10, 11] with the orientation of the regulatory documents [12, 13, 14]. First of all, checks on a symmetric shutdown current. Then the possibility of disconnecting the aperiodic component of the SC current is checked. Also, switches are checked for electrodynamic resistance and thermal resistance. Table 1 shows the calculated and data directory data for a voltage of 220 kV, 35 kV, 6 square meters.

The selected switches correspond to all parameters [10-14]. However, in addition to compliance with the parameters, they must have a proper level of reliability [15-21]. Under reliability, the property of equipment, installation or systems perform the specified functions, maintaining its operational performance in the areas that are specified in the regulatory documents. As a rule, the reasons for failures of switches are:

- displacement of drives;
- mechanical damage;
- wear of the extinguishing chambers;
- burning contacts;
- overlapping isolation with external and internal overvoltages [15-17].

We define the likelihood of failover failure, as well as the likelihood of a substation in general (taking into account the probability of refusal of other elements of the substation: lines (L), disconnectors (D), transformers (T), switch (S), tire section (ST)) without taking into account intentional shutdowns (Table 2).

| Probability of refusal | Meaning |
|------------------------|---------|
| qS2                    | 0.0003224 |
| qS9                    | 0.0003208 |
| qS23                   | 0.000317  |
| qD3, qD10              | 0.000007991 |
| qS4, qS11, qS6, qS13   | 0.000002055 |
| qCII5, qCIII2          | 0.000001712 |
| qL7, qL14              | 0.0001199  |
| qS15, qS16             | 0.00005806 |
| qD15, qD16, qD19, qD21 | 0.000006849 |
| qST17, qST18           | 0.00001598 |
| qL20, qL22             | 0.0001005  |
| qS190                  | 0.00005769 |
| qS21                   | 0.00005769 |
| qT3, qT23              | 0.0006323  |
| qL1                    | 0.0007516  |
| qL8                    | 0.0006189  |

3. Conclusion
Thus, with the selected circuit breakers, the probability of failure of the «Ledyanaya» substation, taking into account the automatic transfer of the reserve, is 0.06545.
The estimated time of trouble-free operation of the substation according to the calculations is 43.6 years, and the average time of trouble-free operation is 4.56 years.

The average recovery time, that is, the time during which the substation will be restored – 13.03 hours.

The substation 220/35/6 kV “Ledyanaya” is an important part of the distribution system and transformation of electricity, which includes electrical installations, devices. The electrical equipment of the substation should have sufficient reliability and good time of trouble-free operation for high-quality power supply consumers. Therefore, at the substation “Ledyanaya”, the circuit breakers were modernized and the reliability of their operation and the substation as a whole was assessed, which will ensure the uninterrupted operation and service of consumers at a high level.

4. References

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