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Investigating the effect of solar flares and magnetic storms on high-voltage electrical equipment

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ABSTRACT: The article analyzes the harsh climatic factors affecting the operation of high-voltage power lines in Uzbekistan with hot, dry weather and polluted atmosphere. Based on the analysis of all climatic factors affecting the operation of insulation and other nodes of overhead lines and high-voltage equipment in general, the severity of these factors is shown both in terms of insulation and energy efficiency. Another significant factor has been identified that has a very strong impact on the operation of overhead lines and high-voltage equipment, which was not previously listed in the list of influencing factors in any literature.

I. INTRODUCTION

It should be noted that currently, a significant part of the equipment of power plants, substations, and main lines has served its service life, they are significantly worn out and require replacement. However, for some reasons, they cannot be replaced and their work in the power system is required for many years. This, in turn, requires the operating organization to conduct more frequent and high-quality tests of equipment, and the development and implementation of advanced methods for diagnosing the condition of equipment under operating voltage directly under operating conditions. Important factors that reduce the reliability of main and other high-voltage power lines are the severe climatic conditions of our region: prolonged dry hot weather with intense solar radiation; pollution of insulation from industrial and field sources, especially considering that in Uzbekistan, as in the whole of Central Asia, there are vast territories with salt marshes and semi-salt marshes soils, as well as the presence of the Aral Sea and its surroundings with an abundant content of salt dust [1,2].

In this regard, based on the scientific analysis of all factors affecting equipment and power lines of high and ultrahigh voltage, it was necessary to identify the dominant processes in terms of improving the reliability of their operation, developing scientifically sound techniques, modern methods and devices to increase their energy efficiency [3].

II. MATERIALS AND METHODS.

The developed method makes it possible to calculate the values of geoinduced currents in high-voltage power lines depending on the configuration and parameters of the replacement circuit of the power supply system, as well as the orientation angles of the transmission lines relative to the direction of the geoelectric field power lines. Estimation of the values of GIT in power transmission lines of different voltage classes will allow us to study the stability of power supply systems during geomagnetic storms of varying intensity [7].

III. SYSTEM ANALYSIS

The average duration of the daylight period for Uzbekistan in winter (December-January) is about 9 hours, and in summer it is more than 16 hours. Accordingly, the duration of the temperature transition time from the minimum value (early morning) to the maximum value (afternoon) for December – January is only 7.0-7.5 hours. The duration of the time from the maximum temperature value to the minimum is 16.5-17.0 hours, that is, the curve of the daily temperature course for the winter period has a sawtooth character. In spring, as the temperature increases, the duration of the time to reach the maximum increases to 9-10 hours, and only by summer (July), it reaches 12 hours, that is, both half-periods of the curve of the daily temperature graph become equal to each other and this curve practically takes a sinusoidal shape [4].

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Significant part of the equipment of power plants, substations, and main lines has served its service life, is significantly worn out and requires replacement. However, for several reasons, they cannot be replaced and their work in the power system is required for a number of years. This, in turn, requires the operating organization to conduct more frequent and high-quality tests of equipment, and the development and implementation of advanced methods for diagnosing the condition of equipment under operating voltage directly under operating conditions [5].

Important factors that reduce the reliability of main and other high-voltage power lines are the severe climatic conditions of our region: prolonged dry hot weather with intense solar radiation; pollution of insulation from industrial and field sources, especially considering that in Uzbekistan, as in the whole of Central Asia, there are vast territories with salt marshes and semi- saline soils, as well as the presence of the Aral Sea and its surroundings with an abundant content of salt dust [6].

In this regard, based on the scientific analysis of all factors affecting equipment and power lines of high and ultrahigh voltage, it is necessary to identify the dominant processes in terms of improving the reliability of their operation, developing scientifically sound techniques, modern methods and devices to increase their energy efficiency. The results of the scientific analysis of multifactorial effects on the elements of main power lines should lead to an increase in the reliability of both overhead high-voltage power lines and substation equipment, primarily responsible power transformers, switches, arresters, and surge arresters. Solving the loss equations taking into account the actual temperature of the wires of the phases of the lines when exposed to hot weather for a long time, intense solar radiation, and practically no wind in hot weather will show ways to significantly reduce electricity losses in power transmission lines and the need to solve environmental problems along ultrahigh voltage transmission lines [8].

Industrial sources of pollution. The degree of contamination of the insulation of overhead lines and equipment depends both on the properties of pollutants emitted by industrial enterprises and on the concentration of these substances in the atmosphere. A particular danger from the point of view of a significant increase in the amount of pollutants on the surface of insulating structures is represented by chemically active substances that corrode the surface of the coating of polymer insulators, as well as protective coatings of end caps and screen fittings.

Based on several studies carried out by sanitary and geophysical services, a calculation method was proposed [7], which allows to determine the concentration of emissions at various distances from industrial enterprises, depending on wind speed and pipe height. This technique can serve as an auxiliary material for assessing the contamination of line insulation in the area of operation of industrial enterprises. At the same time, it should be borne in mind that the degree of contamination of the insulator surface is determined both by the pollution of the atmosphere at a given time and by the total accumulation of pollution over a long time.

Sources of pollution from salty reservoirs. On the territory of Uzbekistan, the Aral Sea, located in the north-west of the Republic, is a large salty reservoir. The pollution of the atmosphere on the coast of this sea is determined by the salinity of the water, which is quite high. In addition, it is known that due to the drying of the sea and the withdrawal of water, hundreds of thousands of square kilometers of the seabed area have been exposed and this loose, excessively salty "soil" pollutes the atmosphere of the region for hundreds of kilometers around. At the same time, the atmosphere is particularly heavily polluted, and therefore the insulation of lines in areas exposed to particularly strong and frequently recurring winds. Mists also bring salt deposits, which, drying on the surface of insulators, increase the conductivity of insulation when it is moistened.

IV. RESULTS.

On the other hand, high values of relative humidity in late autumn, winter and early spring contribute to the penetration of moisture particles through microcracks into the inlet node and the fiberglass insulation structure. Thick fog, rain, and wet snow, dissolving the layer of contamination on the insulation surface, can lead to the overlap of insulators.

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V. CONCLUSION

It is shown that external insulation contaminated with salt deposits, when it is moistened by rain, sleet, fog, causes the appearance and development of surface discharges, often developing before the entire insulation is blocked and an emergency shutdown of a high-voltage line or equipment.
Our research in recent years has shown that, in addition to the above factors, solar flares and their manifestations on earth – magnetic storms - have a significant impact on the accident rate of high-voltage power lines, which have not been considered or taken into account so far in any power system. There is also no information on this problem in the literature. Based on the scientific analysis of all factors affecting equipment and power lines of high and ultrahigh voltage, the dominant processes were identified in terms of increasing the reliability of their operation.

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