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LIGHTNING DISCHARGE DENSITY ON THE TERRITORY OF AZERBAIJAN

Hydro meteorological information about lightning days and period of lightning days, on the supports of OVL 110, 220, 330 kV and high objects on the territory of the republic (on the radio-television tower and lighting conductors) on the basis of statistic material, a map of lightning strokes about constant lightning strokes on the territory of the republic during a year on the 1 km2 surface was compiled. The drawn up map can be used in power engineering and other objects projecting.

1. INTRODUCTION

Enhancement of the protection reliability of different objects against lightning is impossible without knowing exactly whether the territory of these objects is exposed to lightning or not. On the specified territory activation of lightning as meteorological characteristics during one year, number of lightning days and during lightning seasons the number of lightning hours are calculated. However, to assess probability of the objects exposition to lightning, the calculation of middle annual lightning discharge is taken into account. Therefore, it would be necessary to provide with regulators which will give information about lightning stroke on the considered territory. This method with radio engineering equipment intends to record lightning discharge, a lightning recorder and a lightning territory record system are involved. Nowadays, to obtain information about the number of lightning discharge in our country the main system intended in SİQRE lightning recorders are considered.

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Currently, in some countries (USA, Japan, France, German, etc) maps showing the intensity of the lightning discharge were achieved to define lightning in a diversified system of production according to certain standard.

By means of this system, kind of lightning (inside and between clouds) can be distinguished; polarization and amplitude of lightning current between cloud and ground can also be identified.

Since September of the year 1991 technical system BLİDS by SİEMENS company is used to identify lightning stroke of on all territory of Germany and it helps to distinguish inside and between clouds kinds of clouds and polarization and amplitude of lightning between cloud and ground. Using BLİDS system, taking measurements on the territory of Germany 12 plants were used, and these plants were 200-300 km far from each other. In this area measurement accuracy was 250 m, to the direction of its borderline was 1000 m. The efficiency of lightning on the surface ground reaches 98% [1].

As a result of lightning stroke direct on the OVL supports or on the lines, switching off of the line which in some cases cause interruptions in power supply of consumers. To reduce such interruptions it would be useful to have information about lightning strokes and its parameters. It is known that in operating process to provide reliable operation of power engineering and other objects, besides other information, to protect the object from lightning the territory of the object, information about intensity of lightning is used.

2. ANALYSIS

As it was stated in [2] and in other sources related to this sphere intensity of lightning on the territory where is the object is identified according to record of the number of lightning days and duration of lightning days and when it is known a special number of lightning strokes on the surface ground on 1 km^2 (unit surface) is expressed. According to the information recorded in hydro meteorological plants and stations situated on the territory of the republic (over 20-50 years) the first two parameters shown here can be identified using special drawn up maps. According to the recordings (in hydro meteorological plants) the drawn up map about duration of lightning days on the territory of the republic was given in [3]. Using this map is possible to calculate the number of lightnings on the territory of surface ground on $1km^2$.

Under field conditions identification of these parameters can be defined in different ways: by means of plengasion net of electromagnetic field formation as the result of lightning discharge; by counters registering lightning discharges, etc.

Currently, in some countries over the world forming plengasion net within certain radius, registration of lightning discharge is carried out. In most cases identification of lightning strokes on the surface ground is difficult. Amplitude-frequency characteristics of receiving devices used in such nets is difficult to keep identically in other devices. It is difficult to use these nets in different countries. To define a number of lightning strokes on the surface ground according to CİGRE is recommended to register electromagnetic field with frequency 10 kHz.

OVL is considered to be one of the objects covering more surface ground. It is also known that ETL on the certain territory of OVL attracts lightning strokes (approx. $6h$ length, h-height of the support). This characteristic is also referred to certain high objects on the surface ground.

As it was mentioned above to record a number of lightning strokes on the surface ground and their parameters, rigid or flexible ferromagnetic registers are located on HVL supports on the certain distance.

As it was mentioned, ETL and its supports exposed to lightning strokes. A number of lightnings on the line from one side depends on potential of leader channel, amplitude value of lightning current, height of wire.

In different sources the length of area $10 \cdot h_{a.h}$ [4], $6h_{a.h}$ [2,5,7], $8h_{a.h}$ [6] and $(4h_{a.h} + b)$ was taken [8]. Here - $6h_{a.h}$ is average height of protection line or wire dip, in meters, b- is distance between lines and wires.

So, these values are very different from each other. It can be considered that in comparison of some values which were defined according to this model to the result of research under field conditions causes false results. Especially in reports, during one lightning day or one lightning hour, a special number of lightning strokes on the surface ground is taken as one unit value excluding mountains, foothills and plain areas.

Taking into account what was mentioned above the length l direct to OVL is calculated by the formula:

$$N = S \cdot n \cdot n_{l.h} . \qquad (1)$$

Here $n_{l.h}$ – is duration of lightning days during a year [hours]; n - special number of lightning strokes for ground surface 1km^2 during one hour and a value for plain regions is 0,06 [4], 0,067 [2, 5], for mountain regions is 0,01-0,02 [4]. It is recommended to calculate a quantity value in the mentioned map. S - is an area which attracts lightning strokes of OVL, km^2.

$$S = (6-10)h_{a.h} \cdot l \cdot 10^{-3} . \qquad (2)$$

Here l [km] - is a part of the line length; $h_{a.h}$ - protection from lightning, is a height of wire dip on the surface ground, in meters. Average height of lines on the surface is calculated by the following formula:

$$h_{a.h} = h - \frac{2}{3} f \ . \tag{3}$$

Here h [m] – is dip height of the line on the support; f – is dip axis of the line (wire).

Dip axis of the line can be defined in different ways. According to the value of dip axis especially depending on voltage line, between supports, span length (distance between supports) on the affect of the speed of the wind to line (wire), sleet load, etc the design influences of the line is determined. As a result of line weight formed load is determined as follows [4]:

$$g_1 = \frac{G}{1000F} \ , \left[\mathrm{kg/m \cdot mm^2}\right]. \tag{4}$$

Here G – 1 km length of the line weight [kg], F-cross-section of the line [mm^2].

Depending on the affect from the load of wind speed $(v = 10\, m/s)$ special value is determined as follows:

$$g_2 = \frac{6{,}25 \cdot C_x d}{1000F} \ , \quad \left[\mathrm{kg/m \cdot mm^2}\right]. \tag{5}$$

Here C_x – accepted for lines (wire) with aerodynamic efficiency and diameter $D \geq 20\,\mathrm{mm}$.

In this case the special burdens arising from weight of the line and affect of the wind are possible to calculate with the following formula.

$$g_3 = \sqrt{g_1^2 + g_2^2} \ , \ \left[\mathrm{kg/m \cdot mm^2}\right]. \tag{6}$$

Thus, it is possible to set axis dip for the same kinds of lines (wires)

$$f = \frac{g_3 \cdot l^2}{8\sigma} \ , \ [\mathrm{m}]. \tag{7}$$

Here l – span length, σ – force influences on the line under lightning conditions $\left[\mathrm{kg/mm^2}\right]$. By this method, e.g. by calculation performed with 220 kV voltage, span length 400 m line and *C-70* line, f=3.6 m was determined.

It is also possible to calculate it by identifying span length line and value of distance between wires.

In case when no information about axis dip is available, its approximate price can be calculated by using Table 19 [9]divide into 2.5. Span length of 100 m in the middle of span distance between line and wire is at least 2 m, if 150 m – 3.2 m is accepted, 200m -2 m, 300 m- 5.5 m and 400 m-7 m is accepted.

Research works conducted by this method for parts of OVL and the results was calculated from the number of lightning stroke and obtained results as a result of the research was compared with the actual materials.

To compare the actual value received for registration account during 100 lightning hours on the territory 100 km is calculated by the following formula:

$$N = (6 \div 8) h_{a.h} \cdot L \cdot n_{l.h} \cdot n \cdot 10^{-1} \quad \left[1/\text{km}^2 \cdot \text{year}\right]. \tag{8}$$

Actual materials were obtained by registration ferromagnit method conducted more than 10 years on the supports of OVL parts. During report about lightning days and lightning hours average values covering more than 40 years of one circuit were taken from meteriological information.

As mentioned above, a number of the lightning stroke to the surface ground and the lightning current parameters identification by means of ferromagnetic recorders was carried out during the years of 1964-1976 and 1987-1988 on OVL supports and during 1971-1982 on the basis of research work on the radio-television towers and lightning conductors situated on the territory of the republic.

Here as in OVL the number of lightning strokes of separate objects is calculated as follows:

$$N = n \cdot S\ . \tag{9}$$

Here *n*- certain parts of the surface ground at certain time (for 1 hour) is a special number of lightning stroke and *n*=0.067, *S*- is a place of the object [km^2] which attracts lightning stroke. For separate objects:

$$S = \pi R_{ekv}^2\ . \tag{10}$$

Here R_{ekv} – is a equivalent height which attracts a leader of lightning discharge of the object.

Thus,

$$N = \pi n R_{ekv}^2 \tag{11}$$

As it was given in [11] $R_{ekv.}=3h$ was considered for small objects with a height of 150 m and smaller, but lightning channel directed to the object with height $H_0=5h$. Here *h* – is height of the object [m].

If the object is on the surface ground the height of lightning discharge to the object, i.e. from which height the leader of the object which attracts the equivalent value of radius given in [12] is determined by the given formula:

$$R_{ekv} = \sqrt{h^{/}\left[h^{/} + 2a\exp\left(bm + b^2\frac{\sigma^2}{2}\right)\right]} \tag{12}$$

Here *a* and *b* are constant values, and *a* = 10, *b* = 0.65; m, and σ – is average value of lightning current amplitude; *m* = 3,14, σ = 1.11 were taken. $h^{/} = h + \Delta h$ - the effective height of the object, *h* - the height of the object, Δh - is length of the leader from the object to the direction to lightning discharge and its value depends on potential of lightning leader channel.

Taking into account the above-mentioned research on the basis of the registered lightning strokes to the surface ground during a year, a number of lightning strokes can be calculated by the following formula:

$$n = \frac{N}{N_{r.p} \cdot S \cdot 10^{-3}}, \left[\frac{\text{lg.strokes}}{\text{km}^2, \text{year}}\right] \tag{13}$$

Here *N* is a number of lightning strokes registered during research; $N_{r.p}$ – a number of the research period.

All reports about insensity of lightning on the territory of the republic were conducted on the basis of information given in [13]. As it was mentioned above, on the territory of the Republic lightning strokes 110 ÷ 330 kV on OVL, along with recordings on the radio-television and lightning conductors to research intensity of lightning, special counters were made in the laboratories and they were installed on the territory of 12 meteriological plants and 5 different objects of the Republic on the different heights of sea levels (27 m ÷ +1550 m) [14]. The effective radius of counters is 15 km and during 1973-1974 a total amount of lightning discharge in the same area, i.e. lightning discharge between clouds and the ground along with lightning discharge between inside and different load clouds were registered. From the obtained results it was determined that during one lightning day a number of lightning discharge on plains (27 ÷ +300 m on the sea level), as well as on the mountain areas (800 ÷ 1500 m) in compared with the foothill areas (300÷800 m) was quiet a lot.

According to the research conducted by optical and oscillographic method near Shusha town, lightning discharge between clouds and clouds and the ground was determined 4:1 ratio [10]. The value of this parameter especially depends on physical-geographical and climatic characteristics of the research district. Therefore, the value of this parameter which depends on the location of the research district in the mountainous, foothill or plain areas and passing of frontal or local lightning clouds at the same area is shown differently in different sources. According to the information given in [15], lightning discharge from frontal type of lightning clouds only 31% reaches the surface ground.

The results of the investigation carried out by ferromagnetic registration on ETL of 110, 220, 330 kV on different heights above sea level, as well as in radio-television towers and lightning conductors, and the results received from counters during 2 years which were installed in hydro meteorological and other objects on the territory of Republic were carried out according to the above-mentioned method and on the basis of these results a map of lightning strokes density was compiled (Fig. 1).

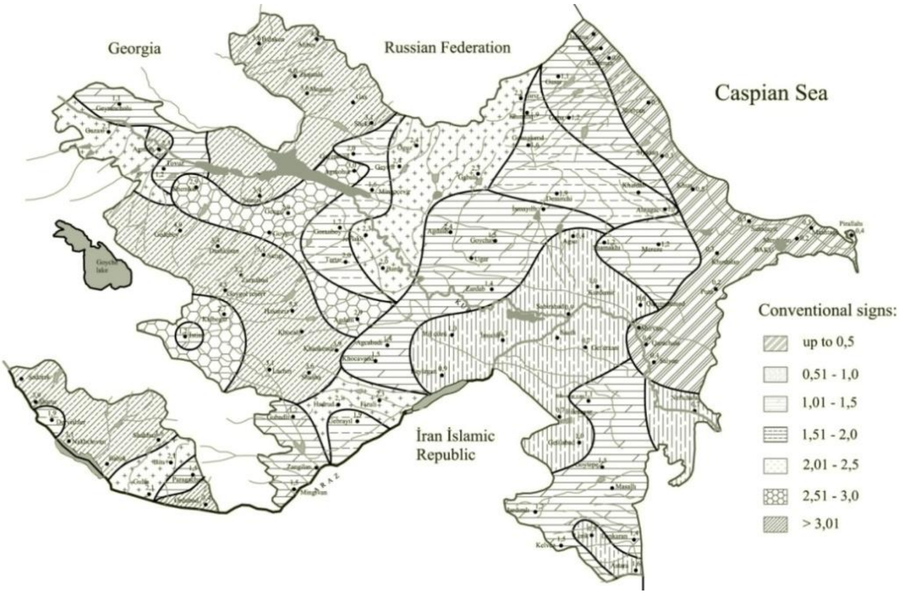

Fig. 1. The map of lightning strokes about constant lightning strokes on the territory of the republic during a year on the 1 km2 surface

From the drawn up map to the direction of Kur-Araz lowland special density reduction of lightning but in foothill and mountain areas its increasing is observed. Average calculation of a special number of lightning strokes during a year in the certain parts of the surface ground was shown in the map, in the same way as in the maps drawn up before (the average number of lightning days and average period of lightning days), as well as on the areas of meteriological plants.

CONCLUSION

The drawn up map can be used during lightning protection projecting as initial material for new construction of power engineering and other objects.

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CZĘSTOŚĆ WYŁADOWAŃ ATMOSFERYCZNYCH NA TERYTORIUM AZERBEJDŻANU

Hydro meteorological information about lightning days and period of lightning days, on the supports of OVL 110, 220, 330 kV and high objects on the territory of the republic (on the radio-television tower and lightning conductors) on the basis of static material, a map of lightning strokes about constant lightning strokes on the territory of the republic during a year on the 1 km2 surface was compiled. The drawn up map can be used in power engineering and other objects projecting.