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Solving the Environmental Electromagnetic Safety Issues in 110–500 kV AC Cable Power Lines

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General public exposed to power frequency (PF) electromagnetic fields (EMF) electromagnetic safety is a significant problem, especially in terms of EMF magnetic component impact, in connection with the increased health risks. Main sources of PF EMF are the operating plants involved in generation, transmission and use of electrical energy, where overhead and cable power lines (OTL and CL) are the greatest importance.
Human protection from PF EMF adverse effect is based on three principles: protection by time, protection by distance and protection by technical protective measures and means use.
Protection by time in Russia is realized in hygienic norms both for PF EMF occupational and general public exposure. Hygienic standards in the RF in part are different from international and some national standards. Russia has one of most strict PF electric and magnetic field (EF and MF) maximum permissible level of occupational and general public exposure.
PF EF general public adverse effect protection by distance is realized in the RF for OTL by organized sanitary-protection zones (now it is named "sanitary breaks") that are on both sides of the OTL from 20 m for 330 kV OTL to 55 m for 1150 kV OTL.
For CL cases sanitary-protective zone is not defined, security zone (SZ) is established only. SZ comprise 1 m only (horizontally from the extreme cables, regardless of the voltage class), which does not provide protection by distance against the generated by CL PF MF adverse effects. This problem is of particular relevance due to the fact that CLs are the source of PF MF mainly, that were classified by International Agency for Research on Cancer (IARC) in 2002 as potential carcinogens (2b") on leukemia for children, which led to WHO

recommendations for “precautionary principle” introduction in general public hygienic regulation.

This makes it necessary to adequately address the issues of electromagnetic safety ensuring not only in OTL passage zone, but also in 110-500 kV CL with high load passage zone, the design stage including.

Insufficient development of mathematical methods of generated by the CL MF intensity values determining the laying depth estimation is additional problem in addressing issues of electromagnetic safety. It is shown that not accounting of MF elliptical polarization, i.e., the calculation of the magnetic field vector result module as the square root of the sum of the squares of the modules of the MF strength components along coordinate axes (Pythagoras), without taking into account temporal parameters of these components leads to errors of 41.4% in the direction of increasing the received result of the transition from elliptical polarization to circular. MF H_{max} intensity at the major axis of the polarization ellipse calculation algorithms are given.

For example, double circuit 500 kV CL with the currents value modules in phases 1 kA and laid at 2 m depth in the soil triangle for each circuit with a distance b = 1 m between the circuits shows that the ground surface of the satisfy hygienic standards of PF MF H_{max} are provided in SZ and on its boundary under calculation by precise method only. Under calculating by Pythagorean Theorem standards at the SZ border is not met.

For the same CL, but under cables location triangle in plastic tubes is shown that permissible limit values in CL passage zone as well as on the SZ border can't be achieved. The options considered to modify the values of CL laying distances *b* and depth *h* are the best solutions to this problem.

It is shown that for the considered CL simultaneous with a large stock compliance with maximum permissible levels in OZ and in its boundary is possible by change in the cable phase sequence of one of its chains.

It is shown that for standard with horizontal arrangement of box joints and cables CL coupling at 1.925 m depth the largest MF value at the earth's surface reaches the 61.3 A/m, and the ratio of its ellipses polarization varies from 0.89 at the axis line at x = 0 to 0.08 at x = ±2.86 m. To comply maximal permissible value, this box joint must shut down expensive and ineffective for field sources shielding ferromagnetic screen.

For double circuit CL cables and box joints optimal arrangement in the vertices of equilateral triangles with a certain change in phase sequence to reduce the PF MF levels of on the earth surface to values not exceeded hygienic norms technical solution is suggested. This box joint buried only 0.5 m greater than the horizontal, ensures compliance with hygienic standard values inside the SZ over the CL, and on its border, without installing costly ferromagnetic screen.

Arrangement for double circuit CL triangle coupling with phase rotation circuits change patented in the Russian Federation №145065.