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GROUND POTENTIAL RISE AROUND LARGE FUEL TANK DURING LIGHTNING STRIKE

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Abstract - In this paper a numerical method to simulate the lightning strokes to the large fuel tanks is proposed. Scalar potential nearby tanks with different grounding systems were computed based on field theory approach. CDEGS software Technologies was used for simulation. The results of calculation give the possibility to find the potential differences between the electronic devises with different ground references.

1 – INTRODUCTION

The main damage to structure, life hazard and electric hazard of systems in oil and gas factories are caused by surge currents and voltages during lightning stroke. Additionally, lightning protection in these factories is very important in view of possibility occurrence of the explosive vapour-air mixtures at normal work conditions [3].

There are two basic mechanisms by which lightning may caused damages, fire or explosion at a site. The first is a direct lightning stroke to the structure or surrounding installations. The second is caused by magnetic and electric fields during lightning stroke to nearby structure or installation. These fields induced voltage/current surges into power and signal lines or loops constructed by conductive elements. According the standards, during lightning stroke, the surge current should be safety dissipated in the soil by the grounding system. This may be reached in the ways, which are presented bellow.

1. Tank is connected to the grounded metallic piping systems without metallic joints.
2. Large tank (over 20 feet) with having metal bottom with adequate contact with ground.
3. Metallic tank insulated from ground and connected to the grounding system

In all these cases flows of lightning current caused the ground potential rises outside the tanks. These rises are very dangerous for:

- systems of process monitoring, measurement and control or electric installation,
- people, which are near the tank during storm (step and touch voltage around the tank),

In electronic systems the potential differences appeared between pieces with different ground references.

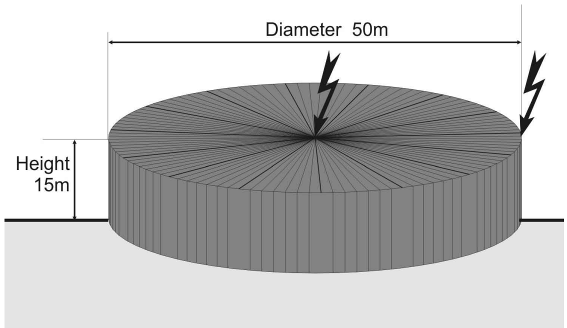
Taking these facts into account, in this paper method for calculation of ground potential rises caused by lightning currents around the tanks are presented.

2 - NUMERICAL SIMULATION

The specific numerical model of the tank in concern (built with straight cylindrical conductors of appropriate electrical parameters) is shown in Fig. 1.

Metal tank, with diameter 50 m and height 15 m was presented as an inter-connecting conductor grid, forming a cage. Computer simulations are performed for two models. In the first model, the bottom of tank was setting on homogeneous soil (Fig. 1a).

a)



b)

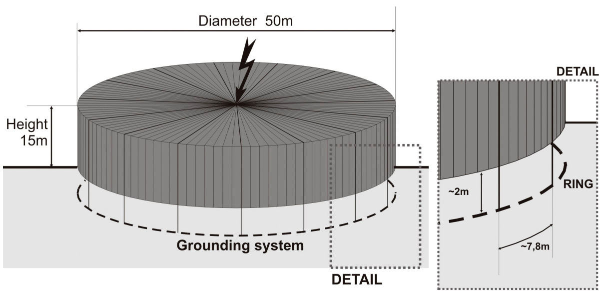


Figure 1 – Simulation models used in calculation, a) bottom of tank direct on the ground, b) isolated bottom connected to the ring earth electrode

In the second model, the bottom of the isolated tank is earthed. The earthing system consists of ring earth electrode around the tank buried at 2 m depth in homogeneous soil (Fig. 1b). In both models established ground structure as uniform ground with resistivity ρ=100Ω·m and relative permittivity ε_r=1.

Numerical simulations were performed by MultiFields software package, which is a part of CDEGS package [6]. In the case of theoretical model, a direct lightning stroke was simulated by an ideal current source with the following double-exponential function:

$$i(t) = \frac{I}{\eta}\left(e^{-\alpha t} - e^{-\beta t}\right)$$

where: *t - time, α= 2049,38 s^{-1}, β=563 768,3 s^{-1}, I=100kA, η=0,976.*

According to the standard IEC 61312-1 [5], such a waveform is characterized by the peak value 100 kA, front time 10 µs and time to half value 350 µs (for the III protection level). In analized models this current source was connected to the middle and to edge of the roof.

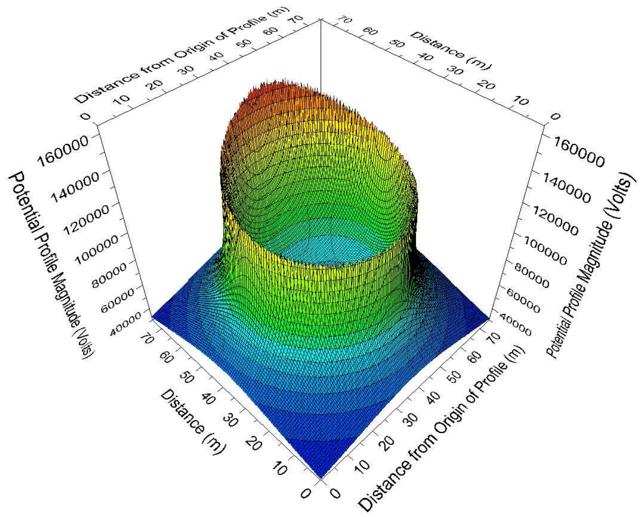
3 - COMPUTATION RESULTS

Ground potential rises caused by surge current were computed for define observations points outside these tanks with two types of grounding systems.

For tanks contacted directly with the ground the maximal values of lightning transient scalar potential, exceed 164 kV, were obtained during stroke to the edge of the roof. For this case, three-dimensional perspective for the scalar potential distribution around the tank was presented in Fig. 2a.

About 1,22 time lower maximal values, near 135 kV, are obtained for the stroke to the middle of the roof (Fig. 2b).

a)



b)

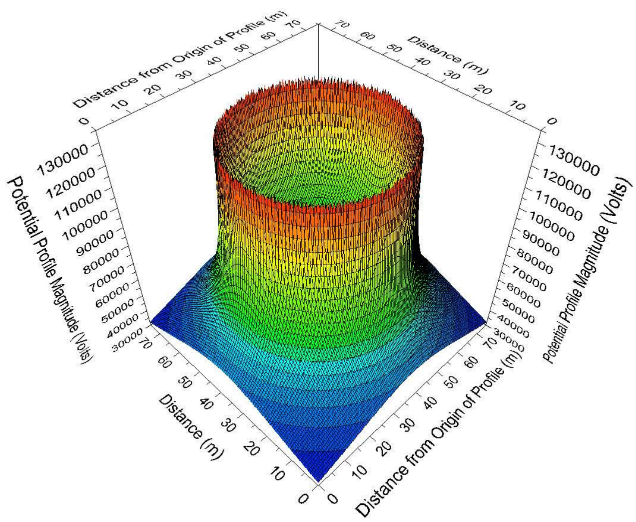


Figure 2 - Scalar potential outside the tank, a) stroke to the edge of roof, b) stroke to the middle of roof

For the isolated tank connected to the ring earth electrode and discharge to the middle of the roof (Fig. 1b) the maximal obtained values of scalar potential reached 204 kV.

Some example of scalar potential near the tank's wall is presented in Fig. 3.

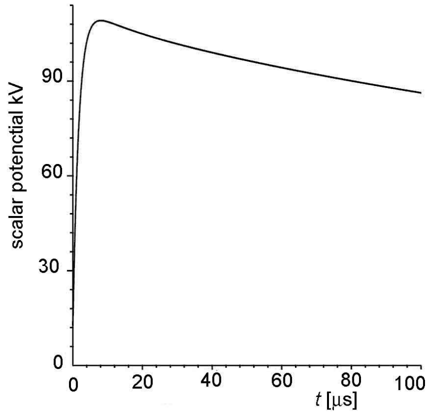


Figure 3 - Scalar potential near the wall

In both models, a very fast decrease of scalar potential is observed with the increase of distance from the tank.

4 - CONCLUSIONS

A numerical procedure, based on the fields approach, has been proposed to calculate the scalar potential caused by lightning stroke into the fuel tank.

The computations revealed that during lightning stroke to the middle of the tank's roof the scalar potential near the tank might be very high and reach the values:

- 204 kV for isolated tank,
- 135 kV for tank with direct contact with ground.

It should be pointed out that the distribution of scalar potential is strongly dependant on soil resistivity and the shape of lightning currents and further detailed analysis for these cases will be taken.

5 – REFERENCES

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