AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electrical Power and Machines Engineering

The Effect of High Voltage Transmission Lines on Nearby (Gas-Oil) Pipelines & Methods of Mitigation

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

by

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Bachelor of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

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Associate Prof. Dr. Sabry Mosa Mohamed

Cairo - (2015)

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STATEMENT

This thesis is submitted as a partial fulfillment of Master of Science in Electrical Engineering Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Ahmed Adel Aboul Khair

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ABSTRACT

Electromagnetic fields produced by high voltage overhead transmission lines are still considered an important subject in several research areas due to their harmful effects on human health and environment. These Electromagnetic fields produces high level of induced voltages at nearly steel pipelines. This problem appeared obviously at the Natural Gas Transmission Network at the last 10 years where the pipelines share the same routes with high voltage transmission lines. The induced voltages at Gerga / Aswan pipeline and Taba / sharm pipeline reached to very dangerous levels and some technicians have been strongly shocked and exposed to death. Environmental Impact Assessment studies (EIA) are very important to be carried out before establishing of power line projects to evaluate the electromagnetic effects on the project environment especially on nearby pipelines as well as its social and health impacts. This thesis presents a comprehensive study to the induced voltages along a section of Taba / sharm Gas pipeline, 500 mm^2 cross section area and 208 km length which lies in the same right of way with an actual sophisticated overhead transmission line tower carrying four circuits (two 220 kV circuits and two 66 kV circuits) under different loading conditions. Three different mitigation methods were applied along the pipeline under normal and abnormal conditions (balanced, severe unbalanced loading and during different short circuit conditions). Mitigation techniques using cancellation wire, gradient control wires and using polarization cells were investigated. Results obtained showed that polarization cells give more efficient values for reduction of induced voltages using the suggested technique. A model was developed using the Alternative Transients Program (ATP) to simulate the whole system with the different mitigation methods. The effect of transmission lines maintenance scenarios on the induced voltage levels on the gas pipeline was also investigated. An economic impact assessment technique was developed to determine the appropriate and economic method.

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LIST OF SYMBOLS AND ABBREVIATIONS:

ATP : Alternating Transient Program

AGA : American Gas Association.

AC : Alternating Current

CCM : Conventional Circuit Model .

CSM : Charge simulation method

CP : Cathodic Protection

J : Current density

DC : Direct Current

E : Electric Field

EMTP : Electromagnetic transient program

EPRI : Electric Power Research Institute

EPR : Earth Potential Rise

EMI : Electro Magnetic Interference

ECT : Electrostatic Charge Tendency.

EHV : Extra High Volt.

F : Frequency.

FEM : Finite element method

FDM : Finite difference method

HVAC : High Voltage Alternating Current

LFI : Low frequency induction

LCC : Line Cable Constants.

Z_m : Mutual impedance

μ : Magnetic permeability of air.

Z_{ma} : Mutual impedance between the metallic pipeline and phase a.

Z_{mb} : Mutual impedance between the metallic pipeline and phase b.

Z_{mc} : Mutual impedance between the metallic pipeline and phase c.