

ABSTRACTS of SESSION 6

Paper n°1

Lightning protection of overhead 35 kV lines by antenna-module long flashover arresters

Abstract: A long-flashover arrester (LFA) of a new antenna-module type is suggested for lightning protection of 35 kV overhead lines. The model, designated LFA-AM, combines advantages of earlier LFA-Antenna and LFA-Modular types, getting triggered as the lightning channel approaches the line. The discharge develops in a number of relatively small modules so that a flashover of a module leaves the insulation of the arrester's cable unaffected by the voltage. Efficient performance of the new arrester was proved by its tests on a large-scale 35 kV line simulator, involving a 4 MV, 14 m long leader discharge from a 6 MV impulse generator.

Keywords: Overhead distribution lines, Lightning protection, Long Flashover Arresters.

Paper n°22

A methodology to the calculation of lightning performance of conventional and non-conventional transmission lines

Abstract: It is presented in this paper a new methodology for the calculation of the number of direct flashes incident to distribution or transmission lines conductors, as well as for the calculation of the number of short circuits in the line provoked by these flashes.

Keywords: Lightning, Transmission Line, HSIL, Non-Conventional Bundle

Paper n°38

Lightning protection problems for 110 AND 220 kV overhead lines in areas with permafrost low-conductivity soils and methods of solving them

Abstract: Findings of research in lightning proofness of twin-circuit 110 and 220 kV overhead lines, footing resistance being 70-100 Ohms, typical for the northern part of Tyumen Oblast, are described in this report. Furthermore, possible methods to solve the problem of poor lightning proofness are proposed. The investigation was aimed at:

- ? assessment of operational and calculated lightning proofness characteristics of overhead lines for these conditions; and
- ? assessment of lightning proofness enhance-ment using both traditional (insulation strengthening, footing resistance reduction) and non-traditional measures (suspension lightning arresters, modified tower design).

Overhead lines operation experience as far as lightning outage is concerned has been studied. Nu-merical (computer) simulation of lightning vulnerabil-ity and field tests of natural and artificial tower grounding conductors for pulse currents have been carried out.

Keywords: lightning proofness of overhead lines, grounding resistance, lightning outage rate.

Paper n°40

Lightning transients In control circuit wiring in HV substations

Abstract: This paper presents the mathematical model of a direct lightning stroke into an open air high-voltage HV substation. Lightning current flowing through the conductive-earthed structures over the ground and in grounding grids induced transients in control, measurement

and secondary circuits. Some calculation results of these transients in low-voltage cables are presented.

Keywords: Lightning protection, lightning overvoltages, control systems, HV substation

Paper n°52

Effects of Lightning Strokes to Transmission Lines on Distribution Cable Systems

Abstract: Lightning surge can be transfer from one side of transformer to the other side of transformer through transformer couplings. Therefore overvoltage transfer from high voltage side of transformer will affect distribution cables, which are not directly exposed to the lightning overvoltage. The resulting overvoltage may damage the distribution systems. In this paper by choosing proper models for different parts of system in the EMTP simulation has been done for different conditions and the results have been discussed.

Keywords: Lightning stroke, Transmission line, Cable system

Paper n°65

Non-conventional measures for improvement of lightning performance of transmissio lines

Abstract: This paper describes the evaluation of some non-conventional practices to improve the lightning performance of transmission lines, comprising the employment of auxiliary conductors and modification of grounding electrodes configuration. The results are obtained by simulation, employing a hybrid electromagnetic model to determine the amplitude of the overvoltage developed across insulator strings, due to direct strikes. The efficiency of such practices was evaluated for the actual conditions of a 230 kV line. Passed one rainy season since their implementation, the number of lightning associated outages was drastically diminished.

Keywords: Lightning performance of transmission lines, Non-conventional practices to improve line performance, Grounding behavior for lightning currents.

Paper n°70

A methodology based on severity indexes to determine critical spots along transmission lines concerning lightning performance

Abstract: This paper is dedicated to a comparative analysis of the results provided by the application of a methodology for identifying critical spots along transmission lines, in terms of lightning performance to two different lines. This technique is based on processing Lightning Location System indications and some line parameters.

Keywords: Lightning Performance of Transmission Lines, Lightning Location System, Lightning Protection

Paper n°72

Damages in equipment of a hydroelectric power plant substation due to lightning - qase study

Abstract: This work presents some solutions proposed for lightning protection of a hydroelectric power plant substation. Analyses of the substation damage reports denoted that two types of events may involved: direct strikes to the substation telecommunication tower and direct strikes to the 13.8kV unshielded distribution line (used for substation internal services power supply). The occurrences caused the establishment of significant overvoltage

values at the substation grounding grid. Additionally, this work presents some solutions for equipment protection. Simulation results predicted voltage mitigation at the grounding grid (for the investigated occurrences) up to 70% in case of implementation of the proposed solutions.

Keywords: Lightning protection of substations, GPR mitigation.

Paper n°88

Evaluation of the effects of the lightning discharges in the overhead-line conductors used in electric rural distribution

Subject:

This paper presents some experimental results of the behaviour investigation of typical overhead-line conductors used in rural distribution when subjected to atmospheric discharges.

Paper n°101

Effect of multiple lightning impulse currents on zinc oxide arrester blocks

Abstract: This paper presents the effect of multiple lightning impulse currents on zinc oxide (ZnO) surge arrester blocks. In order to investigate the dynamic characteristics of ZnO arrester blocks with respect to multiple impulse voltages, we have been designed and fabricated the multiple combination wave generator. The multiple combination wave generator can produce quintuple 1.2/50 μ s impulse voltages of 100 kV and quintuple 8/20 μ s impulse currents of 12 kA. The electrical and physical properties of ZnO arrester blocks were evaluated. The multiple impulse failures of ZnO arrester blocks are mainly caused by the surface flashover. In the case of multiple impulse voltages, the charge enhancement near the joined edges of ZnO arrester block and metal electrodes plays a decisive role on the surface flashover or breakdown initiation and developments. Also, it was found that the changes in the residual voltage and quiescent current of ZnO arrester blocks after the injection of the quintuple 8/20 μ s impulse currents of 10 μ s were markedly occurred.

Paper n°124

Evaluation of fuses for protection of lightning current arresters close to transformers of high rated power.

Abstract: Class I lightning current arresters in low voltage power systems need a protection by a fuse if the actual short circuit current at the location of the arrester is higher than the rated short circuit current. The aim of this paper is to focus on the installation problems near a transformer station with high rated power.

Keywords: Class I arrester, mains follow current, evaluation of a fuse

Paper n°131

Breakdown characteristics of air spark-gaps stressed by short tail lightning impulses : test results and comparison of different time to sparkover models

Abstract: The paper reports the results of an investigation carried out in order to determine the critical flashover voltage, and the relevant standard deviation, of the rod-rod air gaps (10 and 20 cm) under standard lightning impulse (LI: 1.2/50 μ s) and an impulse voltage with short tail (STLI: 1.2/4 μ s). The volt-time characteristics of these spark-gaps are also determined under LI and STLI and the experimental test results are compared and discussed. Models based on the disruptive effect, as proposed by Kind [4], and modified by Chowdhuri [6], are

considered and applied in order to predict the Volt-time characteristics under standard and non standard lightning voltages. The viability of the application of these models to the insulation under consideration is considered and discussed.

Paper n°136

Lightning surge response on actual 500kV transmission tower with overhead ground wires

Abstract: This paper quantitatively shows the effect of the configuration of current lead wire used for measurement on tower surge response of an actual 500kV transmission tower with overhead ground wires. The measured voltages across insulator strings of each crossarm depended on the configuration of auxiliary current wire. The above measurements confirmed that 45-60% of the injection current flowed into ground wires. Assuming that surge impedance of ground wires is constant under lightning surge, this suggests that the tower surge impedance is affected by lightning path.

Keywords: Tower surge impedance, Lightning, Voltage across insulator strings, Tower surge response

Paper n°145

Observation of lightning over-voltages at a Japanese EHV station

Abstract: This paper describes observation results of lightning overvoltages at an EHV switching station of Kansai Electric Power Co. The observation results show that the lightning overvoltage due to a back flashover is not always higher than operation voltage of surge arrester. This paper investigates an influence of electromagnetic fields generated by return-stroke current in a lightning channel on the lightning overvoltage.

Keywords: Lightning overvoltage, Back flashover, Direct lightning hit, Lightning-induced voltage, Observation, EHV station

Paper n°160

Lightning current evaluation for arrester application in buildings with medium voltage supply

Abstract: In this work numerical calculations of the lightning stress of a typical electrical system used in a building was carried out, if a medium voltage supply unit is located inside the building. The impedances of all electrical circuits have an essential influence on the protection quality of the building. So a different transient current distribution is given in comparison to a closely meshed earthing situation. Due to the single feeder situation in most cases one cannot proceed from the parallel connection of all grounding systems as this is the case with closely meshed networks in the low voltage level usually. Apart from theoretical considerations a system model is provided. The results are compared on the basis of the standards and give new ideas for the application in the field of the overvoltage protection in buildings, when the low voltage system and the medium voltage system are connected or close together.

Keywords: Lightning protection, overvoltage, arrester, modelling, numerical calculation.

Paper n°176

Optimisation of the High Voltage Substation - Direct Lightning Stroke Protection System

Abstract - This paper presents results of the study dealing with the application of lightning rods for the substation direct stroke protection. Lightning rod locations and heights are determined using simulation software sigma ssh. This software uses a three-dimensional

Monte Carlo electro geometric modelling. Study results for one particular 275 kV and one 500 kV substation are presented.

Keywords - Lightning, Direct stroke shielding, Substation, Lightning rod, Shield wire

Paper n°182

Response of pole-type distribution transformers to lightning overvoltages

Abstract: Pole-type transformers on a power distribution line are vulnerable to lightning overvoltages, and their response draws great concern. In this paper, an equivalent circuit of transformers whereby one can cope with their response to overvoltages both on medium-voltage and low-voltage lines is presented. The dependency of the response of transformers on the rated power is investigated. By comparing response of the transformer calculated by using the developed circuit with that calculated by using a circuit represented by capacitance, the characteristics of the developed circuit are demonstrated.

Keywords: Pole-type transformer, lightning overvoltage, distribution line, equivalent circuit

Paper n°185

Development of 22kV tubular lightning protection devices

Abstract: Kyushu Electric has newly developed a tubular lightning protection device for overhead distribution lines, which functions by discharging inside the tube. This development will significantly contribute to a reduction in arrester production costs as well as enhancement of discharge withstand current ratings. While the authors have already created a 6.6kV tubular lightning protection device, which does not lead to AC follow current after the lightning impulse current flows. There is a focus on the development of a 22kV tubular lightning protection device “tube horn” which leads to AC follow current for half cycle after the lightning impulse current flows.

Keyword: Lightning protection, distribution line, power quality, expulsion-type arrester

Paper n°188

Line surge arrester application pilot project

Abstract - This paper describes a pilot project of line surge arresters installation on a 123 kV overhead line Ston- Komolac in Croatia. Determination of the arrester number and selection of their installation configuration was based on the software simulations. Line lightning performance is determined for the different arrester installation configurations, taking into account measured tower footing resistance. Line surge arresters with a gap and gapless line arresters are used. In order to follow this project certain number of surge arrester monitors was envisaged.

Keywords - Lightning performance, Line surge arrester, Lightning location system

Paper n°201

Lightning performance of overhead power distribution lines considering effect of nearby trees

Abstract: Some theoretical researches have been done to clarify the manner of a lightning stroke attachment to power lines considering nearby trees. But few experimental researches have been done related to the above problem. Several Japanese electric power companies have observed the manner of lightning stroke attachment on power distribution lines using still cameras. Recently, the attachment manner of a lightning stroke was observed at a location where trees grow nearby overhead distribution line. In this case protective effect of

trees can be expected, but the fact was contrary to the expectation. In order to develop better lightning protection methods of power distribution lines, we have investigated about the manner with which a lightning stroke approaches power distribution lines. Experimental results shows that the existence of nearby trees do not always give better lightning performance. Sometimes the existence of nearby trees leads to extra outages of power distribution lines. The flow chart of the calculation program for a lightning performance of overhead power distribution lines taking the effect of nearby trees into account is described.

Keywords: Lightning, lightning protection, distribution line, tree

Paper n°209

Lightning-Induced Overvoltages on MV Distribution Lines: Spacer-Cable Versus Conventional Line Configurations

Abstract: In this paper, it is presented a comparative study concerning the influence of lightning-induced voltages on two different medium voltage line configurations, namely spacer-cable and conventional lines. Main results indicate that the presence of two periodically grounded conductors makes spacer-cable lines more sensitive to the variation of grounding parameters than conventional lines. In most cases, this fact contributes to reduced levels of induced voltages on the spacer-cable configuration.

Keywords: Lightning-induced voltages, distribution lines, spacer-cable lines.

Paper n°214

High performance triggered lightning current arresters

Abstract: Triggered lightning current arresters are used to build up compact multistage surge protective systems with energetically coordinated type 1- and type 2-arresters. A new triggered spark gap generation with high distance electrode configuration and its behaviour concerning lightning current capability, protection level and power following current is presented in this paper. In connection with enhanced type 2-arresters an extensive protective system with several new benefits is created.

Keywords: SPD, Triggered spark gap, type 1-arrester, energetic coordination

Paper n°237

Examples of errors causing lightning damages in electrical installations

Abstract:

Examples of erroneously made electrical installations are presented. Most of them were the causes of lightning damages. A discussion of design and mounting errors is provided. Photographs of lightning destructive actions are shown.

Keywords: Grounding, lightning protection system, equipotentialization, overvoltage protection, damages.

Paper n°242

Evaluation and improvement of lightning protection on transmission and distribution lines Using lightning detection network

Abstract : Very high records of outage of transmission and distribution lines have taken place at the oil company region located in central Sumatra. The operational area of this oil company located along the equator line and has a very high lightning density. Medium voltage 13.8 kV

line which has a very high outage rate connected directly to the electrical pumps on the field. The failure of the supply caused very high loss of daily oil production.

A one whole year study was carried out in this region and lightning detection network was installed which has 5 sensors that cover the whole area of the region. Lightning characteristic for the evaluation and improvement of the lightning performance of the power lines were derived from this Indonesia Lightning Detection Network using Time of Arrival Technology. The improvement of overhead lines lightning performance was carried out in two ways. The first one is using a conventional way which is commonly used to improve the lightning performance of the lines, such as ; installing the overhead ground wire, installing lightning arrester on the poles, increasing insulator levels to have higher the critical flashover values and improving the grounding system. The second one is using freestanding mast (fsm) or extended tower equipped with air terminal, which is connected to the grounding system using insulated down conductor. This arrangement will prevent the ground wire and poles being hit directly by lightning. No line parameters will be "read" by the lightning current and no back flashover (low inductance of cables) and shielding failures (higher coverage area of the air terminal) will take place. Installation of the second protection system in 13.8 kV lines at site Bangko could give significant improvement of the lightning performance.

Paper n°250

Estimation of lightning-caused stresses in MV distribution line

Abstract: An approach is developed for the estimation of lightning-associated overvoltage stresses coming from MV overhead distribution lines. Analysis is performed for surges caused by both direct and nearby lightning, taking into consideration their attenuation along the line due to effects of corona and finite ground conductivity. Calculations are made considering a typical 10-kV line in Ukraine, represented by a single wire. Numerical results are presented in terms of voltage surge amplitudes and front steepnesses, and period of their occurrence at the considered point (end, middle of the line). Discussion is provided on possible applications (surge protective devices, etc.) and further developments.

Keywords: Lightning, surges, distribution MV line.
