Minutes of Meeting
Working Group on Lightning
L&I Subcommittee of IEEE PES T&D Committee
26 Jun 2007, Tampa FL

Introduction

John McDaniel (National Grid), the WG Chair, introduced himself and welcomed the participants.
The group of 44 from about seven countries, representing eleven utilities as well as academic and consultant groups, introduced themselves.

Update from Lightning and Insulator Subcommittee

Tom Grisham (Griscut), chair of L&I, gave a status report of the overall activity during his three-year term, which will be ending in 2008. He has consolidated the meeting schedule during PES annual meetings, with a single Insulator meeting and a single Lightning meeting. In Jan. 2008, Andy Schwalm (Victor Insulators) will take over as L&I chair. Generally, activity of Task Forces in updating standards and papers now takes place outside of meetings, leaving more time free for networking and developing links to activity in other areas. Increases in utility participation, publications and profile of L&I were the objectives of the WG/TF meeting plan.

Benchmarks

Tom commends the Lightning WG for keeping the ieee.org/pes-lightning web site up to date and noted that he would like to see this balanced with some additional technical content.

Attendance at the annual meetings (and the overall duration of the meeting, 4 hours Tuesday AM) has stayed about constant on the lightning side. It has been highly variable on the insulator side, ranging from a low of (13?) in Orlando 2007 to a high of 80 at this meeting.

Articles from L&I for T&D Magazine are welcomed and available as an extra option to the work in panel sessions that continues to be well received, especially at IEEE T&D Expo.

Upcoming L&I Plans

Updated plan needed by Jan 2008. Re-evaluate TF assignments, trim those of lower priority if necessary, conduct utility survey to see how L, I groups could best meet needs of industry.

Transmission Task Force Chair (Standard 1243)

Kurt Bell would like to step down as WG chair. A search for a new chair will be initiated by John McDaniel.

Tom McDermott gave an update of the FLASH 1.8.1 program. This program calculates the lightning performance of overhead transmission lines. t.mcdermott@ieee.org
The new version of IEEE FLASH, 1.9, works as FLASH 1.8.1 with a Microsoft Excel front end.

FLASH is now being updated to include estimating procedures for both Standard 1410 and Standard 1243. It is being written in Matlab as a hook to engage students with its ease of code modification, which has been a principle of the FLASH program from its origin in FORTRAN / BASIC.

The intention is to make the program as open source as possible. The compiled version will execute as a stand-alone version. However, a current version of Matlab would be needed to make modifications to the code. Examples of procedures that can be inserted include the CFO-Added method for insulator strength and calculation of

Distribution Task Force Chair (Standard 1410 / 2004)

This standard on improving the lightning performance of distribution lines is targeted for revision by late 2008 to be ready for ballot. Sections on calculations of induced overvoltage (Carlo-Alberto Nucci, University of Bologna) and insulation strength (Stan Grzbowski, Mississippi State) will be revised. John has received a number of comments on the difficulty and accessibility of conference papers listed in the guide. Consensus was that journal papers, and those exceptional conference papers accepted on the basis of full paper review, should form the basis of the revised bibliography.

Carlo-Alberto Nucci described some recent work targeted at the calculation of induced overvoltage. When lightning flashes terminate near horizontal conductors, the electromagnetic fields illuminate the line and cause voltages and currents to flow. The transient potentials can reach peak values of 300-400 kV, which are high enough to flashover distribution insulation of 100-200 kV BIL. The continued use of the IEEE peak-amplitude distribution is endorsed. The introduction of the rise-time distribution (correlated with peak current) is recommended.

With regard to shielding models, update to leader-progression model are recommended.

The Rusck model for conductor above perfectly conducting ground with 2-μs ramp wave forms the basis of induced overvoltage, with and without shieldwire (overhead groundwire or parallel neutral). A more complex approach is proposed using a return stroke electromagnetic field illumination model, a coupling model (Agrawal) incorporating lossy ground.

Ground resistivity becomes an input parameter to the model.

The first new figure proposed for the revised Std 1410 shows the flashovers/100 km/yr versus insulator strength (CFO) with two new curves, bracketing the original, red = ideal ground and blue assuming lossy (1000 Ωm soil) ground, using rise-time and peak current correlation of 0.49. The second curve shows the influence of the leader progression model. The Rizk LPM model is very close to the EGM result, with the Dellera-Garbagnati LPM being significantly different.

Generally, LIOV reproduces the existing IEEE 1410 graphs given the same input assumptions, such as lossless ground, close spacing of grounds (zero potential) on shieldwires and 2-μs ramp to flat-top crest.

The stroke current distribution plays an important role in the calculations. It is well known that the traditional measurements of surge currents on towers introduce bias into the measurements. A number of researchers have de-convolved the bias using the analytical methods. Normally, since transmission towers are similar to instrumented towers, this process is not followed (or appropriate) for lightning protection. However, this de-convolution process is correct for the distribution of peak amplitudes used in calculating induced overvoltages.

Juan Martinez notes that rise time definitions vary, noted that the CIGRE definition is maintained.
Reigh Walling notes that differences in CFO (wood to pole being high, grounded poles being low)
Stan Grzbowski suggests that CFO below 100 kV not be included as distribution lines will typically have
Maria-Theresa Corrios de Barros suggests a process for interpoltating among resistivity values.
Units – suggest terms of flashovers / km per year (rather than 100 km) – and with regard to use of computer programs, this is an appropriate way to move forward (especially now that the codes are widely available and have been calibrated against experimental data).

Next Transmission and Distribution Expo, April 22-24 2008, Chicago

The lightning group traditionally sponsors a panel session at the T&D Expo.

John McDaniel will update his paper on treatment of the worst feeders at ComEd
Suggested that John Williamson (NB Power) and/or Howard Richards (Newfoundland and Labrador Power) be invited to share application experience with TLSA, related to a large number of mechanical failures (John) with few energy failures at 230 kV unshielded (Howard)
Volunteers from Stan Grzbowski and Juan Martinez to prepare sessions.

Paper Presentations

07GM0979 - Y.J. Liu
345-kV overhead and underground transmission system – diagnosis of failures possibly caused by lightning overvoltages. BIL 1175 kV cable (IEC 62067) and 1300 kV for termination (IEEE Std 48) and joint (IEEE Std 404). GIS 1175 kV and Transformer 1050 kV BIL. Specific configuration including 2.7 km of XLPE cable was modeled with traveling wave model. Lightning arresters, GIS entered into EMTP. Transient voltages on cable joints reach 1.6 MV with considerable oscillation.

The 345-kV cable has had seven failures (so far) leading to $1B level of losses. The study shows that only one joint could fail, and that under severe conditions (150 kA) – leading to dismissing lightning as a major root cause and focusing remedial action on the true problems, found in the design and installation of the cable terminations.

07GM0342 – E. Perez
Detailed modeling of distribution system for lightning induced overvoltages including simulation of branched lines. Programs include LIOV (Bologna / Lausanne) with EMTP96, YALUK-ATP and LIV-ATP. Purpose is to optimize the application of surge arresters, say in 6 x 12 km area with feeder, branches, sub-branches. Genetic algorithm (GA) used as searching tool. YALUK-ATP used as evaluation engine to obtain objective function. Evaluated using 20-node three-phase network of about 7 km. There were 4845 combinations of surge arrester locations and it would be time-consuming to search each one. Evaluated lightning performance with 40 or 100 strokes. Improvement from random placement to optimal placement considerable at 200 kV BIL.

Discussion refers to placement of arresters at every pole, use of BIL versus CFO and issue of surge transfer from lines to stations.

07GM1452 – M. Hori
Hokuriku Electric Power Company on west coast of Japan is exposed to winter lightning with large peak currents, many positive, leading to multi-phase EHV outages. (must get PPT for web site….) . They experienced three transformer failures in spite of normal surge arrester protection. Resonance of transformer and feed components was evaluated as a possible cause but nothing obvious was found, leading to installation of monitoring equipment. Internal damage noted on transformer winding. Natural frequencies of the transformer were 10 and 30 kHz (Q = 10, 30 respectively). Four observation sites set up using E-field sensors and digitizer cards. IFT of voltage waveform shows strong peak at 10 kHz, confirmed with calculation of EMTP frequency scan and also inversion of travel times of line lengths. Recommended SPD in transformer, changes to winding and increased insulation level.

Discussion refers to photos of lightning (multiple upward leaders, possibly from positive (30% vs 70% negative) and flashover on three of six phases of EHV tower with vertical lightning to tower top.

07GM0535, J. Martinez
Investigated improvement in performance of 400-kV vertical (left-right-left) line with single OHGW and weak insulation (3.066 m). Present practice has 33% more dry arc distance. The model is built on EMTP simulation using the leader progression model, $1.3x10^6$ $m^2/(V^2s)$ and 570 kV/m. Source current used Heidler waveshape and recommended (CIGRE) correlation between rise time and peak current.

Estimates (N_g=1) Backflashover 1.65, shielding failure 0.66 per 100 km per year; local ground flash density was 3.3. Flashover currents as low as 80 kA, probability peak at 200 kA. With the high shielding failure rate, peak currents as high as 150 kA were found in the Monte Carlo simulation. Since for shielding failures much of this charge will flow through a single arrester, the charge duty could be considerably more than anticipated.

Considered 378-kV MCOV arresteres. Arrester energy about 650 kJ to stricken phase conductor. Stroke to tower about 80 to 100 kJ. Arrester energy rises to about 2400 kJ when 150 kA strikes phase conductor.

Significant improvement in line performance even with one arrester per tower.

Questions relate to exposure of phase with EGM (line is actually similar to AEP OVEC line used in Whitehead study), and to tail time (chop time) of flashover and its effect on multiple circuit flashover.

Next meetings will be in:

San Antonio, TX
T&D Expo April 20
Pittsburgh, July 20-24 2008
Calgary, Alberta July 20

September 14 is deadline to upload papers for T&D Expo.

Site opens Nov 5 and closes December 17, 2007 is deadline to upload papers for Pittsburgh Annual Meeting.