Study Committee B2

OVERHEAD LINES

10670_2022

Upgrading the transmission capacity of existing high-voltage lines using insulated suspension chain ISC

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Motivation

The demands on tomorrow's electricity supply require the optimum use of existing electricity transmission systems. With the upgrading of existing high-voltage lines, the voltage will be increased e.g. from 50 kV to 110 kV or from 220 kV to 380 kV while retaining the existing mast geometry.

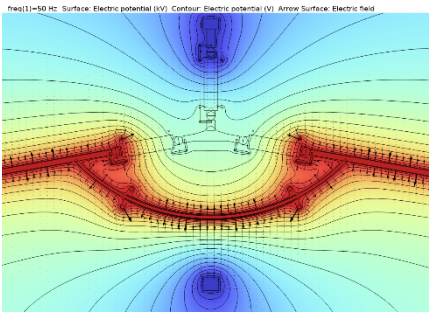
Method/Approach

It is very difficult in the current situation to find new routes for a high-voltage overhead line and to obtain a building- and an operating permit for it. Even the modification of an existing overhead line requires an extensive and time-consuming planning and approval procedure. It is therefore proposed to re-insulate an existing overhead line by means of an ISC, while maintaining the same suspension point, the same ground clearance and without the change of supports.

Upgraded 50 kV HV-Line to 110 kV

Engineering process

- Design of the ISC.
- Numerical field calculation
- Insulation coordination.
- Type test.



3-D- field plot

Experimental setup & test results

- Type test with AC dry/wet and LI passed.
- Special insulation coordination test passed.
- Pilot installation on existing 50 kV towers upgraded to 110 kV using ISC is successful in operation in Switzerland since September 2020.

Wet AC type test at FKH-Laboratory in Switzerland

Discussion

- The approach to upgrade a high-voltage line using an isolated suspension chain (ISC) has been a success. An intense engineering process using numerical field calculation and laboratory tests has show the feasibility of the proposed method.
- To ensure insulation coordination under all operating conditions, a special test was performed to ensure that there would be no flashovers along the ISC in the event of a lightning strike.
- Upgrading can be applied to other system voltages with the same approach by upscaling the geometry based on the results and experience from the pilot installation.

Conclusion

- Upgrading of existing high voltage lines using ISC is a technical and economical successful approach.
- Economical advantage utilizing existing towers.
- Short erection time.
- Doubling of transmission capacity.
- Avoids long approval procedure and planning work.
- Provides effective bird protection.

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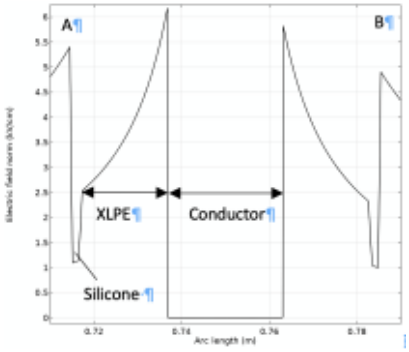
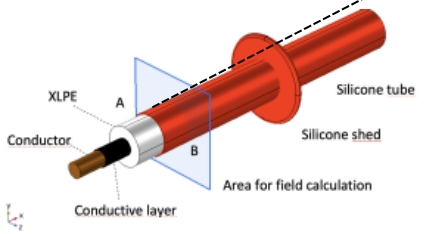
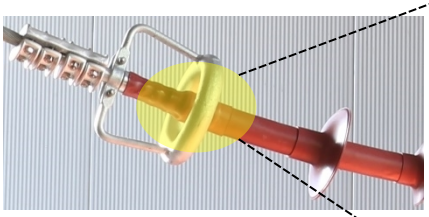
The ISC design

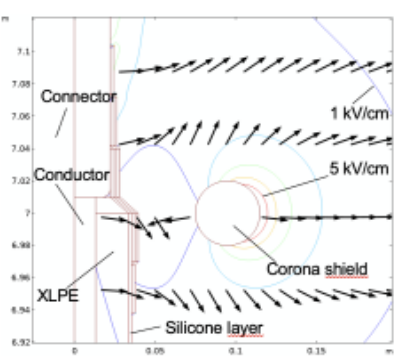
An ISC is a complex insulation system. It consists of three conventional insulators and a special cable section. The conventional insulators are arc-protected against possible damage caused by flashover due to pollution and lightning surges. The electric field along the cable section is essentially radially directed. In the area above the crossarm, the highest electric field strength prevails at the outer surface of the cable where it consists of a small section of insulating material (XLPE) covered with a silicone heat shrinkable sheath and the remaining clearance to the mast cantilever. At the ends of the cable section corona shields are attached to control the field strength..



Field strength along line A-B





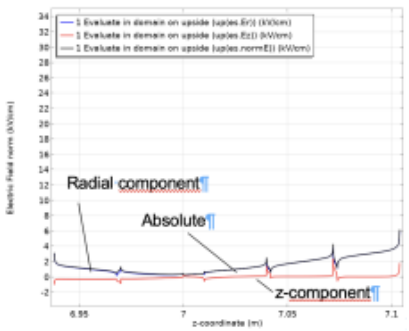


Field plot in the area of the corona shield

Field calculation

The field calculation was performed in 3-D and 2-D:

- Overall 3-D-field calculation.
- 2-D-field calculation
- Field strength values across the ISC at service voltage and type test.
- Field plot in the area of the corona shield with equi-field strength lines.
- Field strength along the surface of the ISC.
- **Results**
- The average field strength under service conditions is far below the inception field strength of 5,3 kV/cm for inhomogeneous fields.
- The maximum field strength is reached at type test with lightning impulse voltage 450 kV and amounts to 26,5 kV/cm. This is a field strength on the isolating surface of the silicone tube and therefore not critical.



Values of field strength along the ISC

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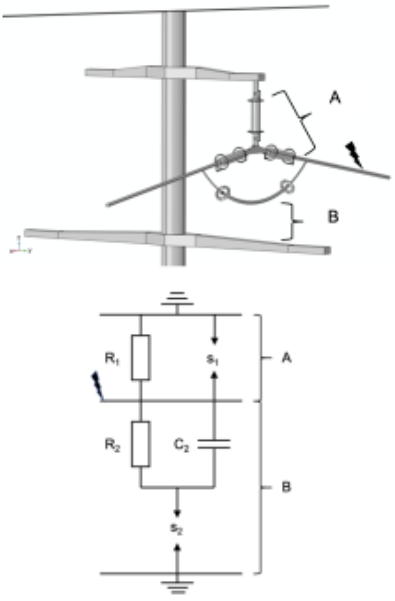
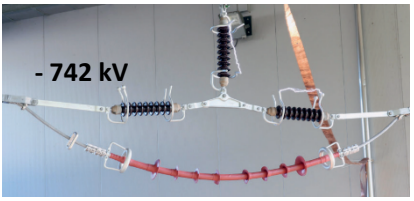
Insulation coordination

The aim of insulation coordination is to prevent flashovers along the surface of the silicone surface. Flashovers due to lightning surges should always lead to flashover of the conventional insulators. The insulation coordination procedure according to IEC 60071-1 cannot be used for an ISC as the conductor is insulated. Therefore, an adapted method was developed and verified in the laboratory. The insulation coordination is considered as follows: For normal operation the average field strength should remain below the limit of 5 kV/cm which is the limit for the average field for positive streamers. The maximum field strength at the edge of the silicone heat shrinkable tube should remain below the streamer inception field strength of 25 kV/cm. However, these values apply to the discharge between metal electrodes. An essential aspect is the coordination of the insulation systems A and B for lightning surges. In order to protect the silicone insulation of the cable, it should be achieved that in the case of high lightning surges only flashovers occur between the arcing protection fittings in area A. This objective was achieved during the coordination-type test through optimisation of the distances between the arcing protection fittings until no flashover occurred in section B.



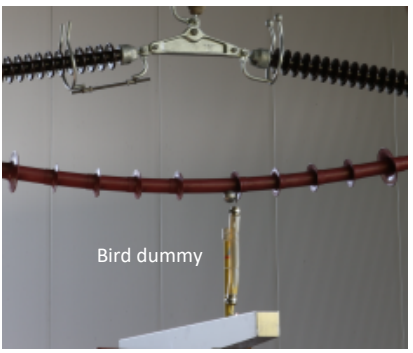
S_1 effective clearance between corona shields
S_2 clearance between mast cantilever and surface of the silicone tube
R1 Surface resistance of porcelain insulators
R2 Surface resistance of silicone tube
C2 Capacitance of the ISC-section



Insulation coordination test at FKH-Laboratory in Switzerland

Bird protection

With state of the art of overhead power lines, birds can touch the line and die when approaching or flying off a crossarm. With an ISC, on the other hand, there is no danger to birds. To prove this thesis, a bird was replaced by a dummy consisting of a resistor of 4.9 kOhm with an attached sphere of 5 cm diameter and placed below the ISC. Up to the highest operating voltage of 123 kV no flashover against ground and no discharge on the surface of the ISC occurred. For a bird, the parameters determined in the test are far below the permissible limit values for humans. It can therefore be concluded that birds which come between the ISC and the crossarm will be scared away and will not risk their life. Converting an overhead line to ISC thus contributes to environmental protection.



Bird test with a dummy at FKH-Laboratory in Switzerland

Conclusion

- Insulation coordination test successful performed.
- Birds will be scared away and will not risk their life when coming into contact with ISC.