Paper 078:
Innovative insulated cross-arm: requirements, testing and construction

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STRASBOURG APRIL 26TH TO 28TH
ICOLIM 2017
INTERNATIONAL CONFERENCE ON LIVE MAINTENANCE

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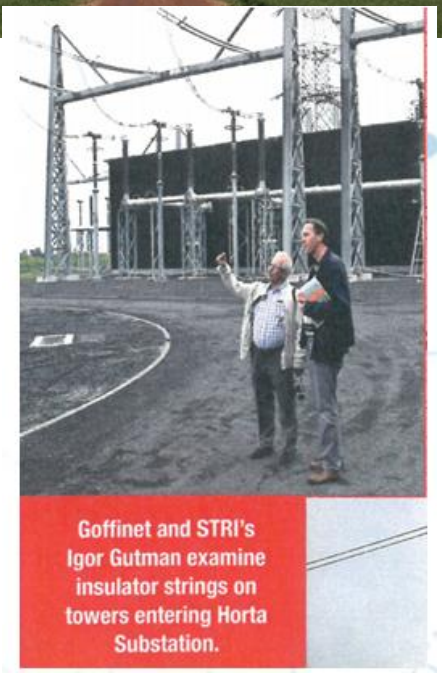
Introduction

- First inquiry for new tower designs was launched by Elia (the Belgian TSO) in the beginning of 2008. The requirements were:
  - **Minimum visual effects (similar to the existing 150 kV tower silhouette).**
  - Low EMF and noise levels under the line.
  - A transport capacity of maximum 3 GVA/circuit.



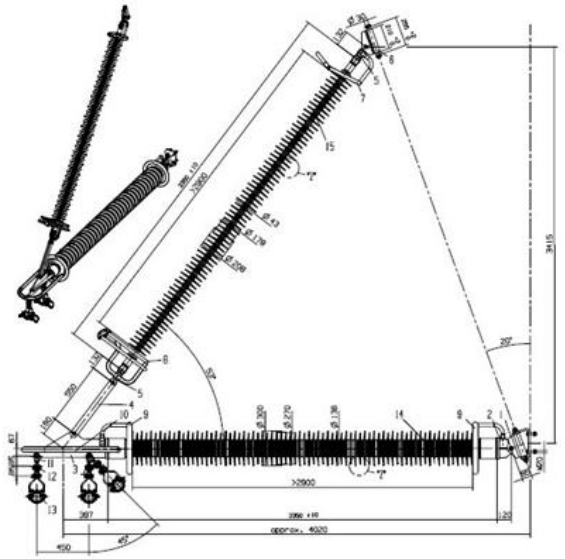
Goffinet and STRI's Igor Gutman examine insulator strings on towers entering Horta Substation.

Scope of research and development for the cross-arms

- Development of proper specifications.
- Analysis of proposals for the tender.
- Quality control of the manufacturers.
- Evaluation of different designs from maximum E-field point of view.
- Type testing according to the specification.
- Development of new test methods and verification of the complete design.
- Demo and construction.

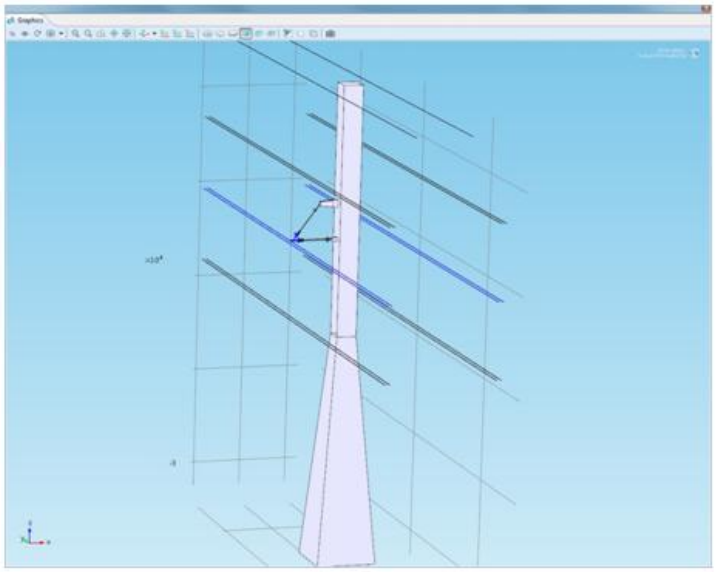
Development of the specification

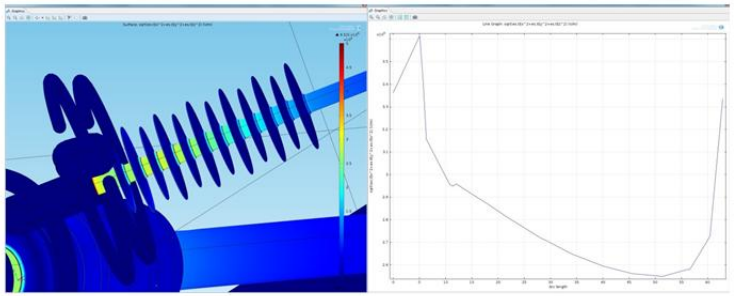
- Long-term performance of composite insulators:
  - Limits of E-field.
  - Multi-stress tracking and erosion test.
- Electrical and mechanical testing (from materials to separate tension and post insulators).
- Full-scale dielectric and mechanical tests:
  - Corona, RIV and WDCI tests.
  - Special mechanical tests.
  - Dry LI, wet SI and wet PF tests.
- Pollution tests (option for new section).



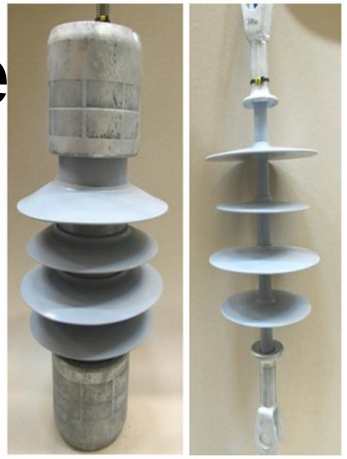
Limits of E-field (calculations)

- Elia's specification:
  - Sheath of insulator housing: 4.2 kV/cm (maximum average along 10 mm).
  - End fitting seal: 3.5 kV/cm.
  - End fitting and grading/corona ring: 18 kV/cm.
- Calculations in Comsol (Coulomb).
- Verification by full-scale Water Drop Corona Induced (WDCI) test.
- Proposal handed over to CIGRE WG B2.57.

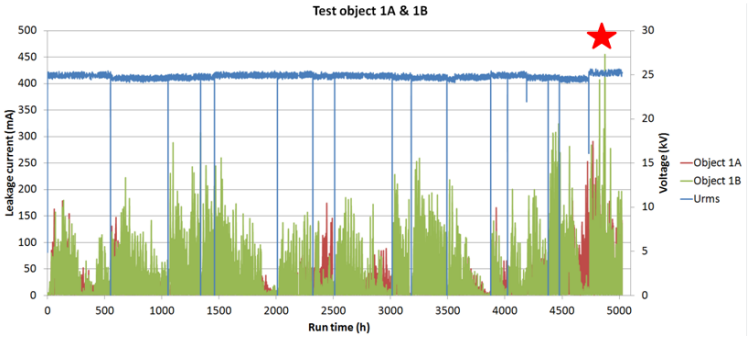


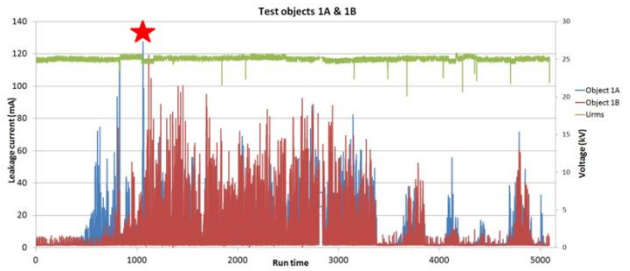


Long-term ageing performance



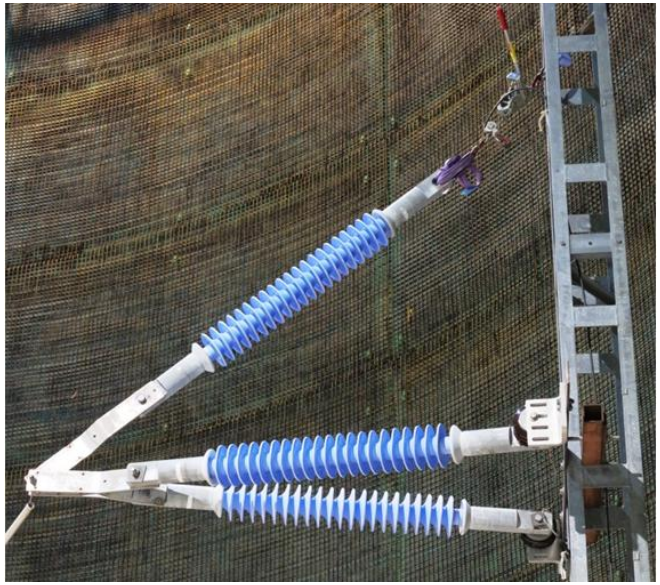
- Comparative testing of two insulators with large difference in diameters:
  - Standard direct spray at 20 mm/kV.
  - Indirect spray at 20 mm/kV.
  - Indirect spray at 15 mm/kV.
- Heavy erosion not observed in service can be observed in the test on the insulators with larger diameters (uneven distribution of fog due to direct spraying).
- High level currents are not typical for the ageing type of test, converting it in a more pollution type test mode.
- Proposal will be handed over to IEC TC 36 “Insulators”

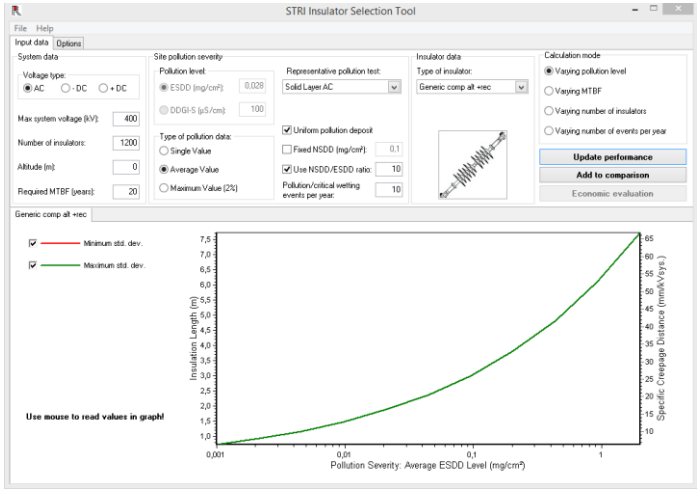




Pollution performance

- Background:
  - No standard tests for composite insulators available.
  - Rapid non-standard procedures are needed for complicated structures.
- Rapid pollution test was developed and applied.
- Proposal handed over to CIGRE WG D1.44.
- The results are applicable for statistical dimensioning.

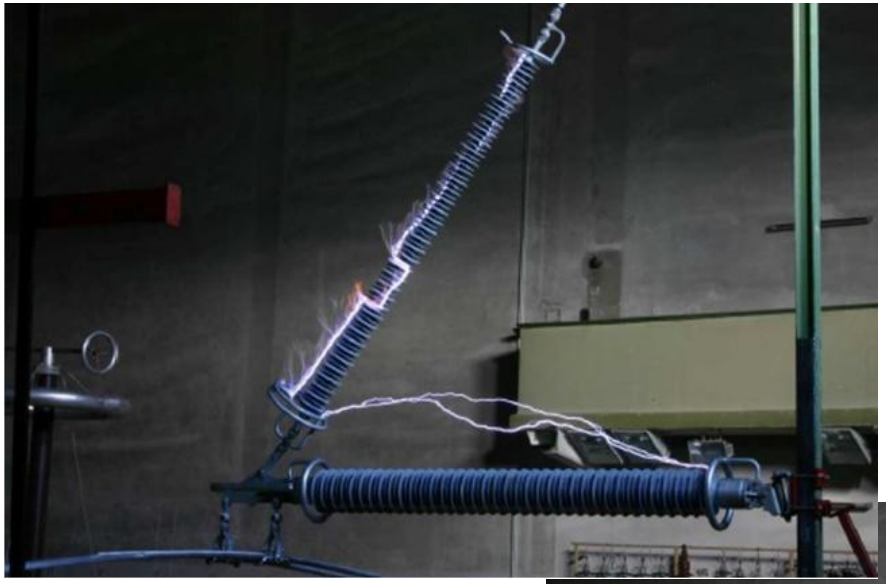


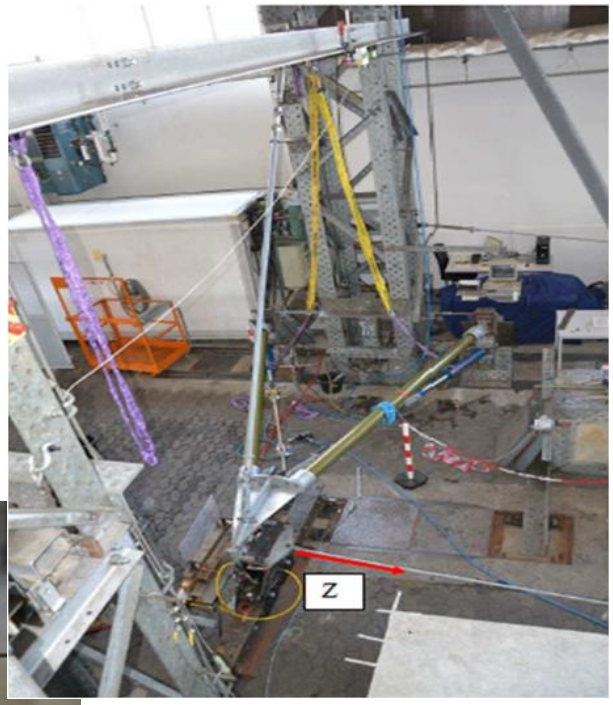


Full-scale electrical testing (corona)

- Background:
  - No standard tests for verification of E-field calculations.
  - No verification procedures for complicated structures.
- Water Induced Drop Corona was developed and applied (CIGRE WG B2.57).
- Test results confirmed the results of calculations.
- Cross-arm is corona-free.

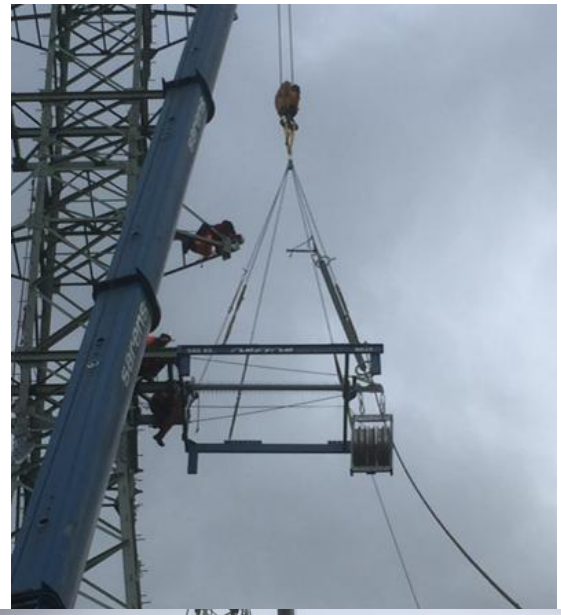
Full-scale electrical testing (dielectric/mechanical)

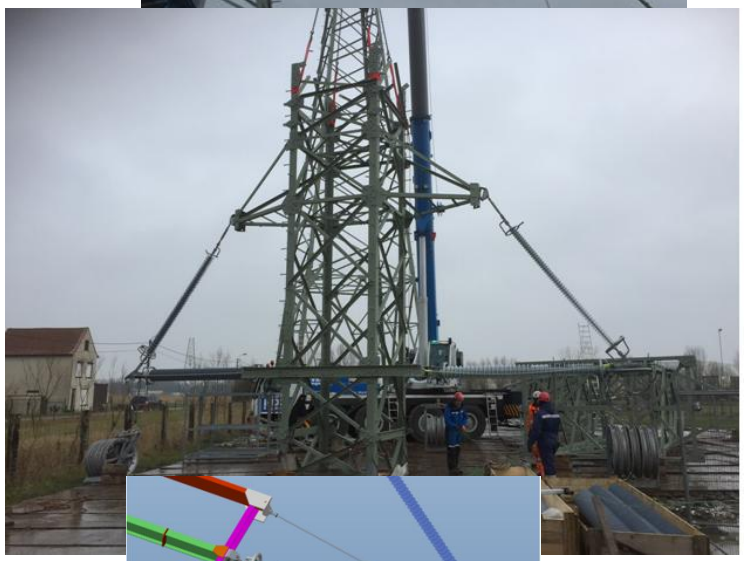


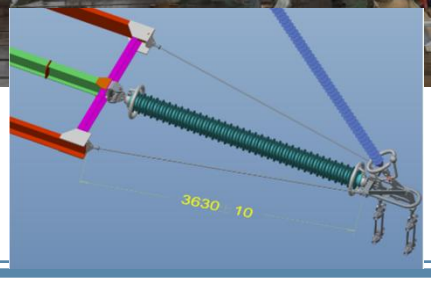


Installation

- Big challenge was faced using complete new cross-arms arrangement requiring new working methods and tools:
  - Flexible mounting platform
  - Attachment the insulated cross-arms directly on tower body at ground level in order to erect each level in one movement
  - Blocking system made of guy insulators (to avoid pivoting during pulling operations).







Summary

- To assure the reliability of the new design careful verification of materials, individual insulators and complete cross-arms were performed.
- These included both electrical tests and mechanical tests and some tests were specially developed for this type of application. The scientific part of the project resulted in a few innovative test methods presented for CIGRE/IEC for international acceptance.
- Two different manufacturers passed the complete test program and were evaluated for the quality control procedure.
- The innovative structure of the cross-arm allowed for the compact overhead line with the height of new 380 kV towers of approximately the same as existing in the area towers of 150 kV convenient overhead line.
- Keeping also low levels of electric and magnetic fields the new line was relatively easy accepted by local public. At the same time a new line allows for almost 10 times higher transfer capacity of energy.
- **This may be an interesting example for other European utilities experiencing low public support of new overhead lines.**

Thank You!