Study Committee A3

Transmission and Distribution Equipment

Paper 10843_2022

Experience of Composite Insulators on HV Substation: Some French Examples

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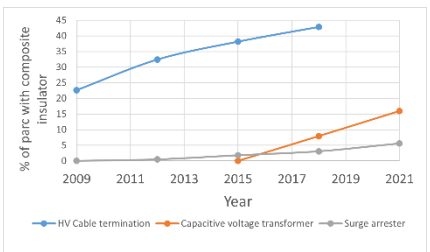
Motivation

Composite housings are nowadays a solution implemented in electric grids worldwide for their performance in polluted environment, safety and reduced maintenance costs. Thousands of composite insulators have been installed since more than 20 years in French grid with a very good return of experience.

RTE has been an early precursor to experiment the use of composite insulators in the HV equipment with silicone composite insulators for the housing of HV Circuit Breaker 72,5 kV class since 1993, in Balaruc substation. Since 1980s EDF and later RTE, decided to submit the composite insulators to be installed on network for the 5000 hours accelerated ageing test according to IEC 62730.

A second long term ageing test started at Martigues EDF station in 2008 and 2016, which is still ongoing on 400 kV insulators with different designs and silicone housing materials (HTV, LSR), creepage distance and shed profile.

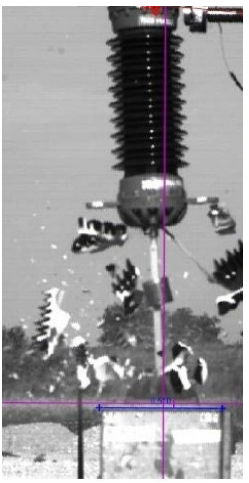
The paper analyzes the different experiences and relevant results and compares IEC standard tests and utility accelerated ageing test with natural test station experiences. The future perspective is to perform a larger study on the composite insulators for various HV applications installed on the French network and eventually to develop in situ diagnostic of the external housing and improved apparatus monitoring.



Adoption of composite insulator for HV equipment of RTE network (72 kV to 420 kV)

Why Composite Insulators?

- High pollution performance
- Earthquake resistant
- Light weight
- No burst and material emission in case of failure
- High Resilience



Rupture of insulator housing during a destructive mechanical stress test and projection of debris

Applications

- Cable Terminations
- Circuit Breaker
- Instrument Transformers
- Bushings
- Surge Arresters
- Fiber optical signal columns
- Housing of test equipment

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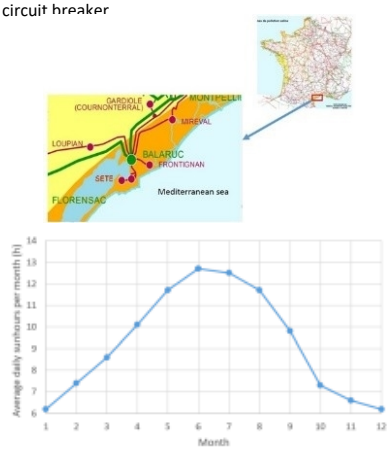
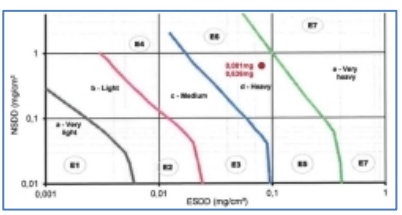
Investigation in Balaruc Substation

In order to investigate the aging mode of composite insulators, a circuit breaker equipped with this technology in Balaruc substation has been selected. The substation (225/63 kV) of Balaruc is in south of France, Mediterranean coast close to Sète & Montpellier. The circuit breaker chosen for study is the very first 72,5 kV Live Tank Circuit Breaker equipped with HTV extruded silicone sheds on hollow core composite insulators manufactured by Sediver in early 1990s. The circuit breaker has been installed since 1993 in RTE network with a standard maintenance mode, without periodic cleaning of insulator. There are so far no major incidents on the circuit breaker.



Location and average daily hours of sun

One shed was cleaned in order to quantify its level of pollution by the ESDD/NSDD measurements. The measurements were performed by measuring the conductivity of dirty water collected with cottons used to clean the surface, combined with weight and chemical analysis of non-soluble remained pollutants according the procedure presented on IEC/TS 60815-1(2008) Annex C. As indicated, the level of the insulator pollution has been measured as class d-heavy class:



Characterization of pollution level of the insulator by using IEC/TS 60815-1 (2008)

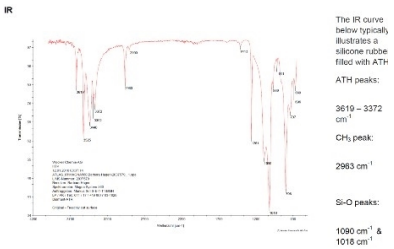
Visual Inspection Results

Characterization of pollution level of the insulators by applying IEC/TS 60815-1 (2008)

Inspection of hydrophobicity of 72,5 kV hollow core composite insulators, measurement in 2019 (left) vs. measurement in 1996 (right)

Semi-destructive Sampling

- Hardness according to ISO 868:2003
- TGA according to ISO ISO 9924-3:2009
- Angle of water drops according to IEC 62073: 2016 method A
- Density (1,57 g/cm³) according to ISO 2781:2018 method A
- FTIR (silicone material fingerprint)



FTIR spectra measurement (typical for HTV with the signature of ATH = Al(OH)3 around 3500…3000 cm-1)

The target was to evaluate this exceptional long excellent experience with extruded sheds HTV silicone (first generation of HTV silicone, vulcanized at high temperature). A "new" silicone sample from the same period (unpolluted, not in service) was used as a reference to perform the Soxhlet analysis, and to compare above measurement (hardness, density, mechanical properties) with onsite aged sample. Similar comparison has been performed on HTV silicone rubber shed samples from Martigues ageing test (Chapter 3). Table 1 shows the comparison of new and aged samples taken form Balaruc and Martigues. The purpose of the Soxhlet analysis on silicone sheds is to evaluate the percentage of low molecular weight (LMW) compounds of silicones which are responsible for the important hydrophobicity characteristics (loss, recovery, transfer) of the housing performance.

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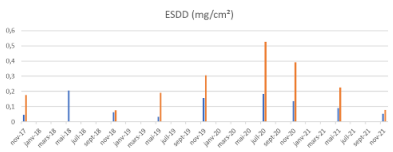
Investigation at EDF MARTIGUES

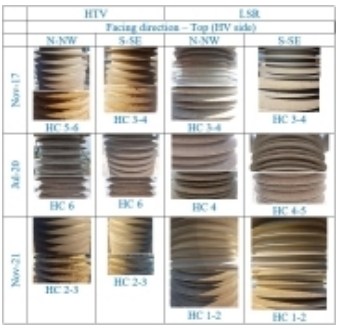
For more than fifty years, EDF R&D has been carrying out ageing tests and studies of the long-term behavior of equipment under extreme natural external stress at the EDF Lab Martigues site (close to Marseille). The location meets several criteria perfectly suited to this type of study. The region is one of the sunniest in France with over 2800 hours of sunshine per year. This means that the materials are exposed to high levels of ultraviolet radiation. The test facility is about 10 meters from the shore. As a result, exposure to salt spray is maximum, particularly during episodes of south-south-east wind. Huge industrial complexes are in this area. The large petrochemical plant of Lavera is located two kilometers northwest of the site. The prevailing wind regime (north-northwest) carries the industry's emissions in the direction of the test station. The materials being tested are subject to a combination of marine and industrial pollution. The site pollution assessment is carried out according to IEC 60815-1 Ed. 2008 Annex E using a Directional Dust Deposit Gauge device. The measurements classify the site mainly at level d (heavy) and sometimes at level c (medium). In real time, the measurement of leakage current on a reference insulator string calibrated in the laboratory allows to evaluate the current pollution level site.

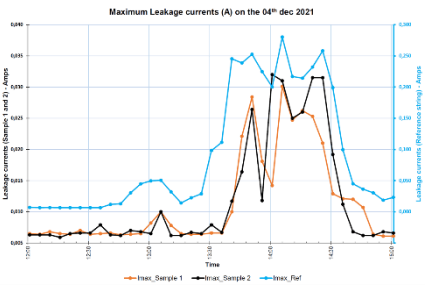
Industrial sites, the EDF R&D test station, the local wind rose

The columns installed in the test area



ESDD measured on insulators with LSR (orange) and HTV (blue) housing (the housing profiles were different). The orange material/profile seems to collect more pollution in terms of ESDD





Recorded leakage currents on sample 1, sample 2 and the reference insulator during pollution event

Conclusions

- Ageing Performance: the long-term performance in harsh environmental conditions is good for both HTV and LSR housings
- Experience was gained from installations in substation and test station for more than 20 years
- The condition assessment was performed by means of periodical inspections and material analysis (application of fingerprinting tools in accordance with TB595)
- The results of the investigations in Martigues test station are similar to the ones obtained from the 5000h multiple stress test. A scale factor may be derived during the next inspection intervals
- Composite hollow core insulators with HTV and LSR silicon housing have been proven to have a very good service performance under high polluted conditions. No flashovers or power outages occurred.
- Future IEC standards should include recommendations and tests for the assessment of ageing performance.