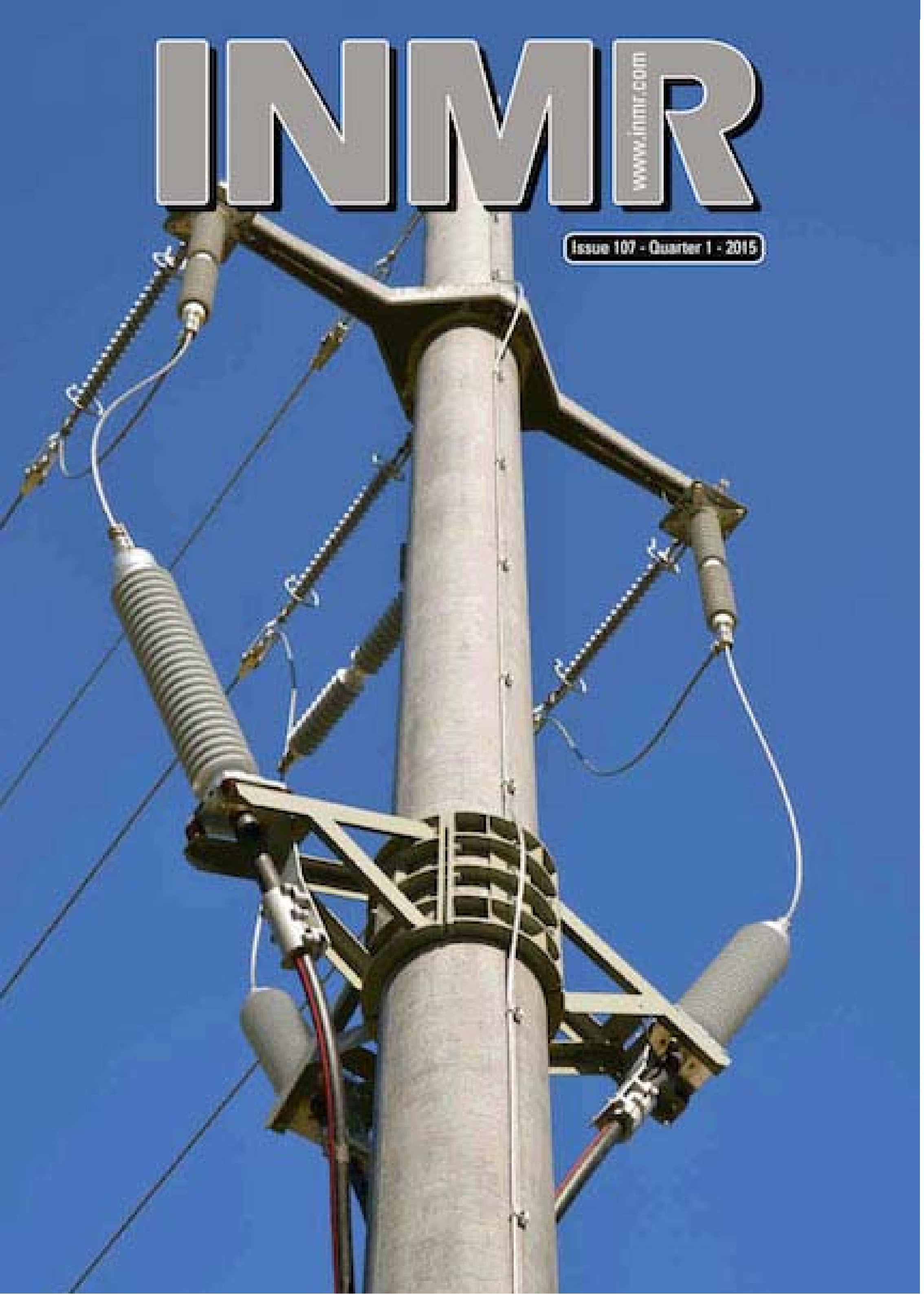
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Co-operation with Local Academia Delivers Benefits for Greek Power Utility

The topic of how power utilities can benefit from greater co-operation with local academia has been reported on in a number of technical journals. Lately, this issue has also become the subject of discussion at last summer's General Session of CIGRE.

Close contact between power supply companies and staff as well as students in the engineering departments of universities has been common practice in countries such as China for years. There, it is normal find doctoral or post-doctoral students engaged in research projects aimed at better understanding or resolving problems that cause disruptions to service on local power networks. Chinese universities also co-operate frequently with domestic manufacturers to help them develop new materials or components. In Europe, the potential benefit of such collaborative projects between utilities and universities is also understood and supported by public bodies.

For example, a cornerstone joint research effort between a power utility in Greece and local academia – POLYDIAGNO – has been co-financed by the European Union as well as the Greek National Fund. In this case, the goal behind the co-operation between the Hellenic Electricity Distribution Network Operator (HEDNO/PPC) and the Technological Educational Institute of Crete (TEIC) as well as the Foundation for Research & Technology (FORTH) has been to evaluate ageing mechanisms of different naturally-aged composite insulators removed from service under severe maritime conditions (see article on p. xx). INMR contributor, Raouf Znaidi, reports on the scope and some of the initial findings of this collaborative effort.

Kiriakos Siderakis, Assistant Professor at TEIC's high voltage laboratory, explains that the ongoing research project with HEDNO has been implemented in three distinct phases. The first, referred to as the selection phase, was conducted by staff from the network operator and involved inspection and diagnostics to identify which specific insulators would be targeted for closer investigation. The second phase then consisted of testing and physical analysis of these pre-selected aged or degraded insulators according to the relevant international standards. This work was conducted both at the local HV laboratory and at the Center of Materials Technology & Photonics. Finally, the last phase – referred to as 'combined testing' – took place at the Talos Outdoor Test Station near Heraklion (see p.XX). This allowed for additional refinement to test results as well as final diagnostics.

Siderakis reports that, prior to HV testing, a combination of visual inspection as well as qualitative hydrophobicity classification measurements were performed on each of the naturally aged composite insulators removed from 150 kV lines. The most commonly observed defects were signs of ageing such as surface discoloration and degradation of sheds and, in some cases, severe corrosion of metal fittings and hardware.

Selection of 150 kV composite insulators removed from service.

There were also several units provided by HEDNO that forcefully demonstrated what could happen if a composite is not handled properly during storage or transport to a site. In this case, either partial or even complete destruction of several sheds were attributed to attack by birds or, given the scale of damage, more likely rodents.

At the time of INMR's visit to TEI's HV Laboratory, leakage current monitoring was underway on 5 partially cut polymeric sheds. Real time hydrophobicity measurements based on contact angles were

Severe damage to several sheds attributed to attack by wildlife.

Table 1: Results of Inclined Plane Tests

Insulator Reference	Leakage current Ave. RMS (mA)	Leakage current Max. RMS (mA)	Observation
A. Field-aged	8.2	45.6	Continuous LC activity + light erosion
B. Field-aged	4.6	36.5	
C. New	4.1	31.6	

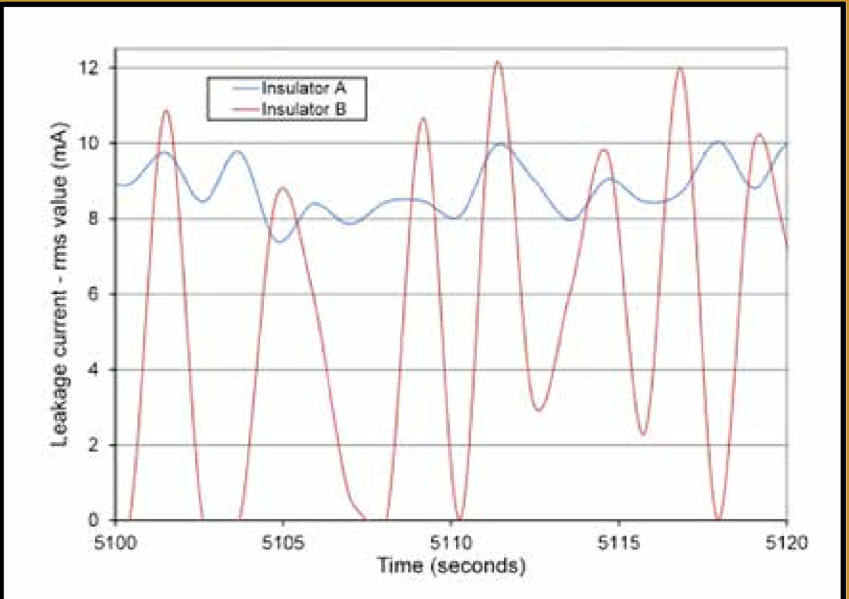

Fig. 1: Leakage current measurements of naturally aged insulators.

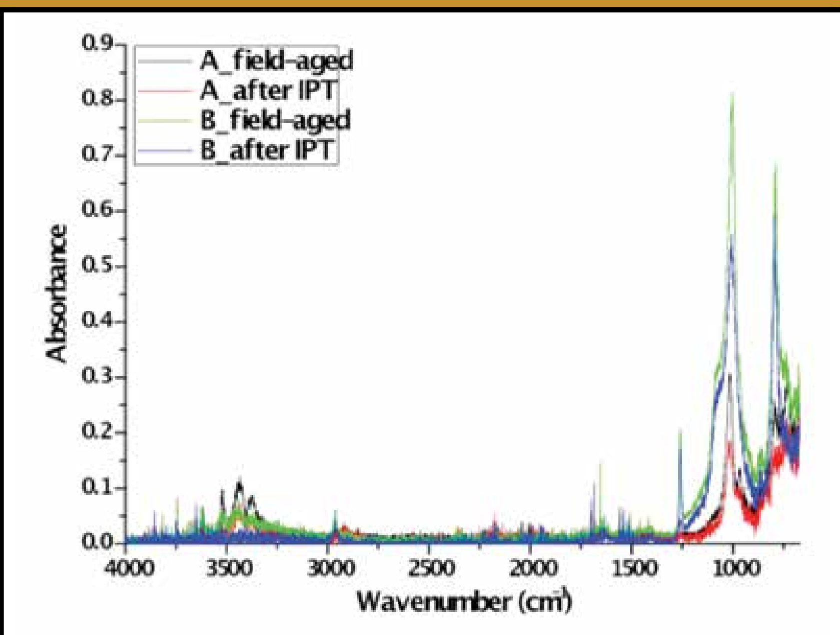

Fig. 2: Comparison of composite insulators prior to and after IPT tests.

also being performed on these naturally aged insulator specimens and showed HC classification in the range of Class 2 to Class 4, according to IEC 62073. Prior to these tests, all cut samples were cleaned with distilled water followed by an additional ultrasonic cleaner to fully remove any pollution residue from the test field.

PhD candidate, Nikos Mavrikakis, is closely involved in this research and has performed many of the inclined plane tests (IPT) based on IEC 60587, as now recommended for assessing new polymeric materials. He states that its application to naturally aged insulators, such as in this case, can provide valuable additional information on resistance to tracking and erosion as well as expected remaining service life.

An example of findings from the leakage current monitoring of one sample (A) cut from a field-aged composite insulator, showed that the highest average RMS value fell in the range of 45.6 mA (see Table 1). Figure 1 depicts continuous leakage current activity registered for samples A and B and associated with partial discharge activity.

Consultant Dionisios Pylarinos explains the process by which lines workers at HEDNO identify target insulator specimens to be removed from lines and transferred to TEI for in-depth evaluation. Says Pylarinos, "crews have conducted close field inspection as well as hydrophobicity measurements of insulators. Based on this, they have already taken down 21 specimens from 7 different towers along the 150 kV network. According to defined selection criteria such as location, number of years in service and localized pollution severity, one of each different design of composite insulator was sent for electrical testing. The remaining 14 units were subsequently installed at the Talos test station, to be taken down at prescribed intervals for complementary analysis and diagnostics."

Apart from the electrical analyses performed at TEI's HV laboratory, Siderakis notes that various

"Knowing the ageing mechanisms affecting composite insulators in our system allows us to better predict their life expectancy and plan for suitable countermeasures. It also helps us identify the most suitable inspection tools for insulators to recommend to transmission lines maintenance staff."

complementary tests have also been performed. These included stability of hydrophobicity (i.e. using the dynamic drop test), resistance to corona discharges and hydrophobicity transfer and recovery of the polymeric housing – all in accordance with guidelines established by CIGRE WGs D1.14 and B2.21. "The main goal," he says, "was to provide a reliable assessment of all key electrical properties of these sample insulators."

Moreover, Siderakis adds that to complete the picture, various physical analysis techniques of the insulator housings were also conducted to better assess their properties after ageing. These techniques were performed at TEI's Center of Materials Technology & Photonics under the supervision of two of its professors, Emmanuel Koudoumas and Nikos Katsarakis. One of the most common methodologies to detect integrity of the structural bonding of a polymeric material is Fourier Transform Infrared Analysis (FTIR) spectroscopy. Fig. 2 shows data that compares the FTIR radiation absorbance spectrum of two naturally aged composite insulators against a new insulator used as reference.

Siderakis believes that the collaboration involved in all these many tests has contributed to a better understanding of the ageing mechanisms that could affect polymeric insulators on Crete's transmission network. As example, he points to the FTIR spectrum and remarks that the marked reduction in absorbance of chemical bonds in the housing material of certain field aged units is indicative of premature ageing since more degraded insulators tend to show lower absorbance. He says that other physical properties of housings can also be examined including hardness, roughness, tear strength, hydrolysis and resistance to degradation, water immersion, UV and flammability.

HEDNO Assistant Director of the Islands Network Operation Department, Emmanuel Thalassinakis, help put this co-operative research into context. Says Thalassinakis, "the aim of combining field testing and outdoor test site research on the one hand with laboratory electrical and physical testing on the other is not only to detect possible degradation of insulator samples. It also provides more information regarding ageing mechanisms of polymeric materials in our type of environment as well as the residual performance we can expect of our insulators. Knowing this allows us to better predict their life expectancy and plan for suitable countermeasures. It also helps us identify the most suitable inspection tools for insulators to recommend to transmission lines maintenance staff. In the end, the maintenance strategy for the Cretan power system can be adjusted to meet the new needs linked to our decision to use silicone insulators on all our transmission lines."

Examples of degraded insulators hung at Talos Test Station.