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Digital Solution for Transmission Line Risk Management

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Airborne dust or coastal salt contamination of overhead line insulators can seriously compromise the performance of a transmission line, either AC or DC, generating potential heavy financial losses and additional maintenance costs.

Classical evaluation and mitigation of contamination requires usually an outage during which either samples are taken down to measure the pollution level and decide future action plans, or preventive line washing at predefined intervals is performed. Ideally information on the condition of the string of insulators should be more useful if provided on a real time basis without disturbing the system. This would allow maintenance actions at the proper time without any risk of facing a flashover or the other way around unnecessary premature spending resulting from making a wrong guess on the actual condition of the line.

Innovative techniques for real time evaluation of the condition of a string of insulators are now possible thanks to smart insulators capable to communicate in real time their pollution condition. This paper will describe various aspects of this IoT technology where the insulator itself produces a diagnostic. Instead of measuring the level of contaminants through physical sampling on a string, this development will concentrate directly on the impact of the environment on the performance of the string by measuring the actual leakage current. Using wireless communication technologies, the data is transferred to a dedicated server where the information will be analysed and presented to the end user with a diagnostic of the actual risk of having a pollution related flashover. Such processes imply a detailed knowledge of the signature of each type of insulator in terms of leakage current since threshold values depend upon shape and profile.

1. Classical pollution evaluation and monitoring methods

Pollution severity and evaluation methods are based on IEC 60815 describing and classifying pollution levels through ESDD and NSDD levels as described in figure 1. In order to assess these levels of pollution experts will use direct measurements from sampling contaminants from actual insulators. Based on the findings the positioning on the graph shown in figure 1 will help determine either the optimum leakage distance and shape of insulators (figure 2) or the use of a hydrophobic surface which from experience is less and less a polymer insulator but more often now a silicone coated glass or porcelain insulator (figure 3).

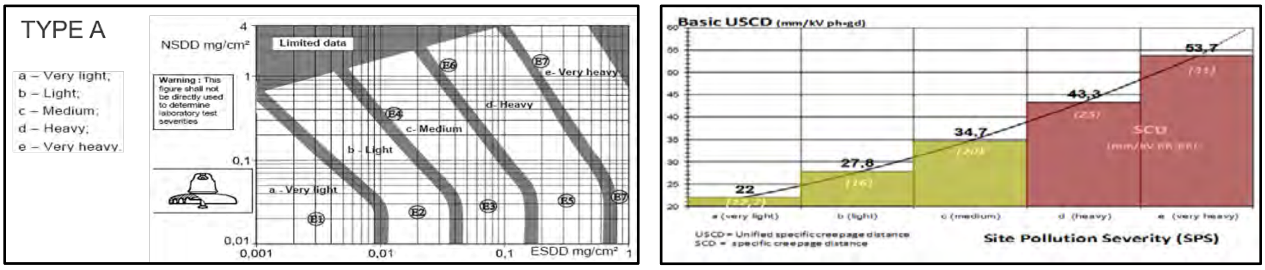


Figure 1: IEC 60815 pollution severity and recommendations for optimum leakage distance.

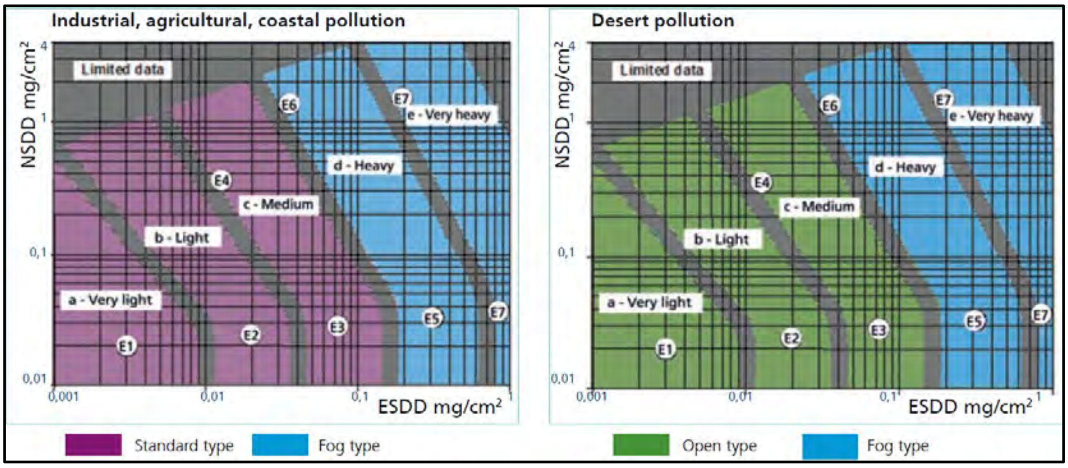


Figure 2: Recommendation of optimum shape of insulator based on pollution conditions (Sediver catalog)

Figure 3: Silicone coated glass insulators
(220kV transmission line Sri Lanka USCD = 31,5mm/kV)

While removing insulators from actual lines is not always possible another method described in IEC 60815 is the use of DDDG, dust collectors which are usually installed on the ground in the vicinity of the area under investigation (figure 4). Good and bad results have been obtained with these instruments, often because of the difference in airborned dust pattern between the elevation of the dust collectors and the actual position of the insulators. Alternatively, some utilities will prefer to install dummy insulators inside the tower at the height of the conductors making it easier to take units down with no need of an outage.

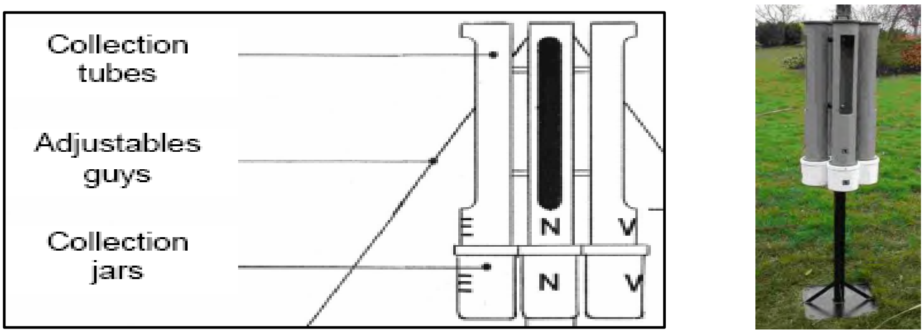


Figure 4: DDDG for collection of contaminants separately from an actual transmission line.

2. Leakage currents

In the end what matters is the impact of the pollutants on the insulation more than the pollution itself. Measuring directly the current produced by the existence of the contaminants can provide a piece of information which can be used direclty for flashover prediction (figure 5) provided there is a clear knowledge of the critical values of leakage currents for the insulator under consideration. It is well established that the critical maximum sustainable current of an insulator is a function of its shape. The example in figure 6 demonstrate clearly this point from tests performed on strings with approximately the same leakage distance but not the same shape.

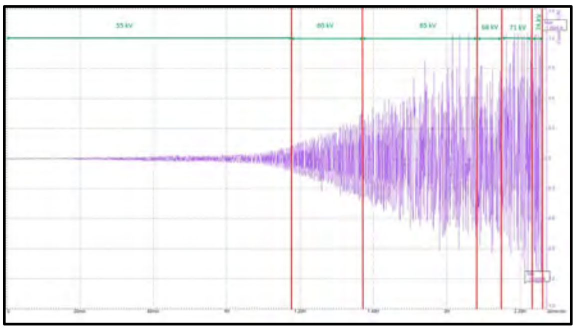


Figure 5: Example of leakage current measured during a flashover process

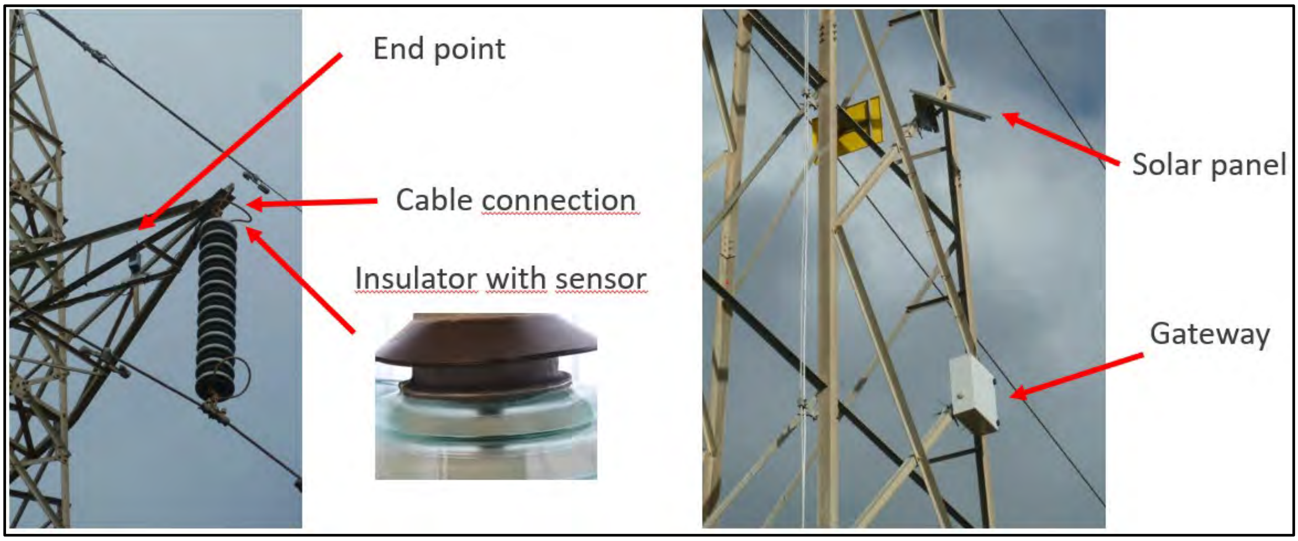
Type 1	Salt fog test 80g/l	Type 2
2725	Leakage distance (mm)	2750
80,6	Max withstand voltage (kV)	53,2
283	Leakage current (mA)	127

<u>Figure 6</u>: Example of max withstand currents for insulator string having the same leakage distance but with different shapes.

3. <u>Smart insulators</u>

Sediver introduced approximately 2 years ago an innovative solution (currently patented in more than 40 countries) where an actual insulator (on the tower side) will not only provide its normal insulation performance but measure the actual leakage current of the string. While leakage current sensors have existed for a number of years, the particularity of this device is the fact that the sensor is built in the actual insulator and the data transferred to a server which will analyze the information and produce a diagnostic tailored for the actual application under consideration. This risk estimation is based on actual field and test data gathered over decades by Sediver.

The technology is based on capturing the leakage current, making initial calculations in a microprocessor installed in an end point which will process the leakage current and send it over either directly in a LoRa environment or in GSM format through a gateway itself capable to manage the information collected in a radius of approximately 7 miles (figure 7).



<u>Figure 7:</u> Sediver 3S IoT technology

The end user, once connected can see the combined relevant parameters such as leakage current, humidity and temperature as time goes (figure 8). Likewise a more detailed examination of the activity on the insulator string is made possible thanks to a display classifying the current intensities in bins (figure 9). The frequency of events for any particular range of currents can be shown anytime.

Figure 8: Example of screen display for the end user

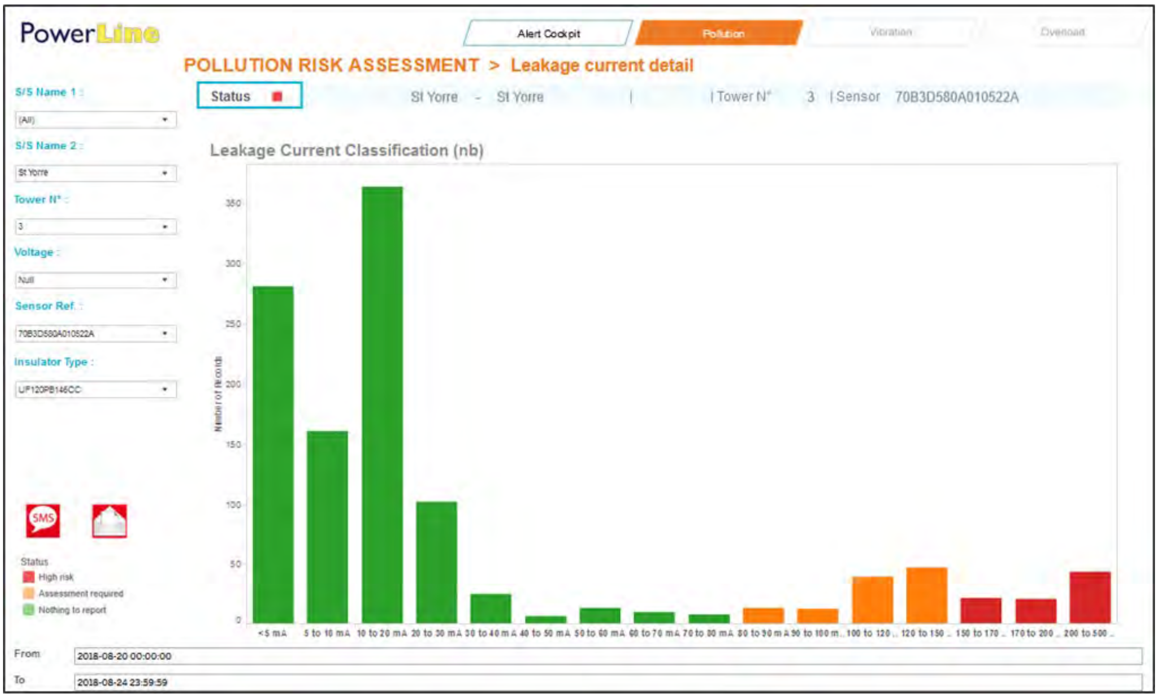


Figure 9: more detailed display of frequency of events as a function of currents classified by intensity.

4. Field experience and evolutions

This IoT system is currently installed in Latin America, Europe, Middle East and Asia and is interesting more and more utilities either for monitoring their lines which need washing (determination of the optimum washing cycle), helping the selection of the most appropriate type of insulators, or define a dynamic pollution map of their system (figure 10 shows a few examples of applications).

The challenges in this technology are multiple. Being totally autonomous once installed there is a need to balance available power (supplied by solar panels and batteries) and the consumption of energy required to capture, process and send the data. A new generation is currently being installed where such considerations have been optimized mainly around the process used to monitor the relevant currents and the appropriate moment for recording processing and forwarding the information. The first results are positively answering these needs.

Figure 10: examples of some applications deployed worldwide.