Transmission Line **Resiliency**

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Resiliency is a term used more and more by transmission line stakeholders including designers, operators, and owners. Resilience is simply defined as toughness or the capacity to recover quickly from difficulties. It can be used to describe a system, an object or even a person. Dr. Ginsburg, child pediatrician and human development expert, proposes 7 C's that make up being resilient – **competence, confidence, connection, character, contribution, coping and control.** Although some of these words may not be the first choice for describing transmission-line resilience, they surprisingly apply.

Competence is the ability to handle difficult situations effectively. Transmission lines are found in practically every environmental condition and there is an optimum line design for the conditions it must endure. **Confidence** is the belief in the abilities demonstrated from competence. Transmission line stakeholders must have the highest level of confidence in the materials and practices being utilized. **Connection** is the tie to others and a sense of belonging. Extensive work by experts around the world have gone and continue to go into the industry standards by which transmission lines are designed and constructed. **Character** is the strong sense of worth and value. There is no question about the value of a quality transmission line, not only to the stakeholders but to the general public. **Contribution** is making a difference and bringing improvement. New technologies discovered through innovation and R&D efforts are introduced to improve transmission lines. **Coping** is being prepared to effectively overcome challenges. A well designed, constructed and maintained transmission line will hold strong through hazardous conditions and the test of time. **Control** is to monitor, make decisions and take actions. A lack of attention, incorrect decision or avoiding action can take a transmission line out of service or threaten the public.

The 7 C's clearly show that resiliency is achieved through diligence and a concerted effort. There are many physical elements to a transmission line such as the structures, foundations, wires/conductor, hardware, and insulators. Although insulators are typically less than 2 percent of a transmission line's total material cost, owners and operators report that they can represent up to 50% of the maintenance costs. This being the case, considerable attention should be given to the proper selection of insulators to attain a resilient transmission line.

For more than 75 years, toughened glass insulators have proven to be extremely reliable, having the longest life expectancy and being the easiest to maintain. Because glass is a homogenous, amorphous solid, it does not age. Toughened glass is exceedingly strong and therefore ideal for high tension applications. Having a safety-glass behavior, its condition is determined simply by visual inspection, requiring no instruments. Even with an unlikely damaged shell, it maintains electrical and mechanical capability. Quality toughened glass insulators have the built-in **competence** and **character** for resilience.

Pollution or contamination can have a major impact on the performance of an insulator. Coastal salt fog, industrial pollution or other environmentally hazardous conditions typically require special consideration for insulator design. Extensive studies in this area have led to the very important insulator design guide IEC 60815 "Selection and dimensioning of high-voltage insulators intended for use in polluted conditions". This standard defines various pollution levels and provides reference insulator leakage distances. It is a perfect example of how industry experts are in **connection** for the **contribution** to improving insulator performance.

Innovative advancements such as dielectric shell shapes and hydrophobic coatings have expanded the benefits of glass insulators even further for pollution applications. In most cases, the necessary requirements can be attained simply by choosing a non-standard shape or silicone coated glass insulator. A high leakage distance fog-type shaped insulator, shown in photo 1 provides an additional 35% leakage distance compared to a standard shape in photo 2.

Photo 1

Photo 2

This allows for the same insulator string length to be used from a light to a heavy pollution level. An open profile shape insulator, such as shown in Photo 3 & 4 is beneficial for multiple applications including prevention of dust and sand accumulation, ice-bridging avoidance and bird dropping protection.

Photo 3

Photo 4

A silicone coated insulator such as shown in Photos 5 & 6 provides a hydrophobic surface for cases of extreme pollution and eliminates the need for washing.

Photo 5

Photo 6

Taking insulator technology to another level, real-time performance and condition monitoring is now

Photo 7

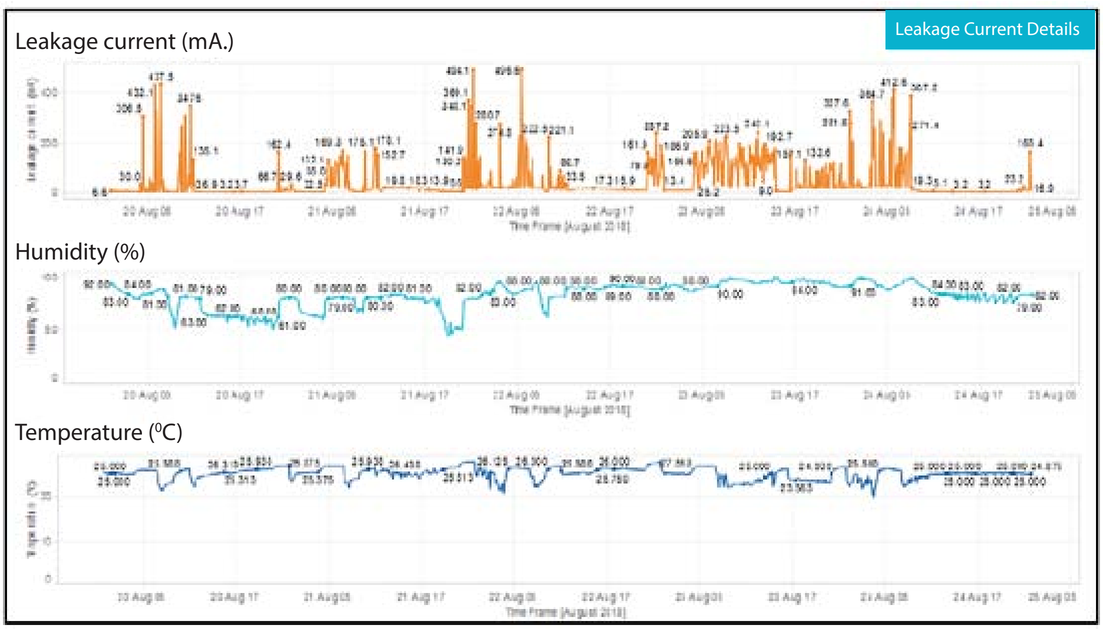
available. As pollution collects on the surface of an insulator, leakage current begins to occur, particularly with the presence of moisture. As the leakage current increases, so does the probability of a flashover interruption. Therefore, monitoring leakage current is an ideal parameter for assessing pollution. A "Smart" insulator (photo 7) is sensing and continuously communicating leakage current, humidity and temperature (photo 8) to a system operations center. Specific algorithms unique to the insulator design are then utilized for diagnostics to determine the operational condition of the insulation. These innovations have made significant **contribution** for **coping** with and **controlling** the challenges of pollution.

Most transmission lines are built for Alternating Current (AC), however especially with the growing demand for renewable energy, Direct Current (DC) line development is on the rise. Two interesting phenomena of DC operation is that it attracts pollution and creates ionic migration within the insulator. Therefore, high resistive dielectric, extra leakage distance, and special corrosion protection to the metal parts are all required to **cope** with DC stresses. Depending on the pollution, silicone coating may also be necessary. Early DC lines built without these insulator elements were not resilient and did not perform very well. DC lines built with **competent** insulators capable of DC operation have proven resiliency for over 40 years and a recent study verified their intact **character** for another 40 years of reliable service.

There are several insulator technologies available with characteristics that may not be advantageous for the application. Operating voltage, mechanical loads, climate conditions, environmental exposure and resiliency expectations for low total ownership cost should all be considered when selecting insulators. It is essential to also note that extreme measures must be taken to **control** the quality of any insulator technology or design. Manufacturing processes, quality assurance procedures and transparency to customers are of the utmost importance. Resiliency is not only achieved by having **confidence** in the right product but also the right manufacturers.

Dr. Ginsburg talks to parents of young children about how raising them to be resilient leads to happiness and success not for today but their entire life. A transmission line designed and built with resiliency as the priority will yield a long lasting, high performing, low maintenance life.

Photo 8



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