

New for PowerKage!

The Kinectrics PowerKage, an **innovative non-electric fence** designed to prevent ground access by squirrels, raccoons, and other animals to power equipment at substations and other facilities has recently been enhanced.



The advancements include a modified “self-closing” gate design to eliminate worry over gates being left open and, a new galvanized powder-coated steel shield to replace the HDPE plastic top. The new shield will not distort, offering improved resistance to climate change, and its true, straight surface is impassable by ground animals. This product upgrade also requires fewer fasteners and will be offered at the same price as the original plastic option.



Kinectrics’ PowerKage has been successfully installed at over 35 utility sites throughout North America, where it has already been **proven highly effective in preventing animal intrusion.**

“There’s no doubt - PowerKage works.”

– Glen Booth, Network Management
Hydro One, Ontario Canada.



Kinectrics Expert Profile

Mark Fenger P. Eng. is a Principal Engineer in Kinectrics’ Transmission & Distribution Technologies group with over 12 years experience in diagnostic testing and cable assessments. His area of expertise is aging of solid insulation materials, particularly partial discharge detection, measurement and interpretation as well as dielectric spectroscopy measurement on solid dielectric cable.



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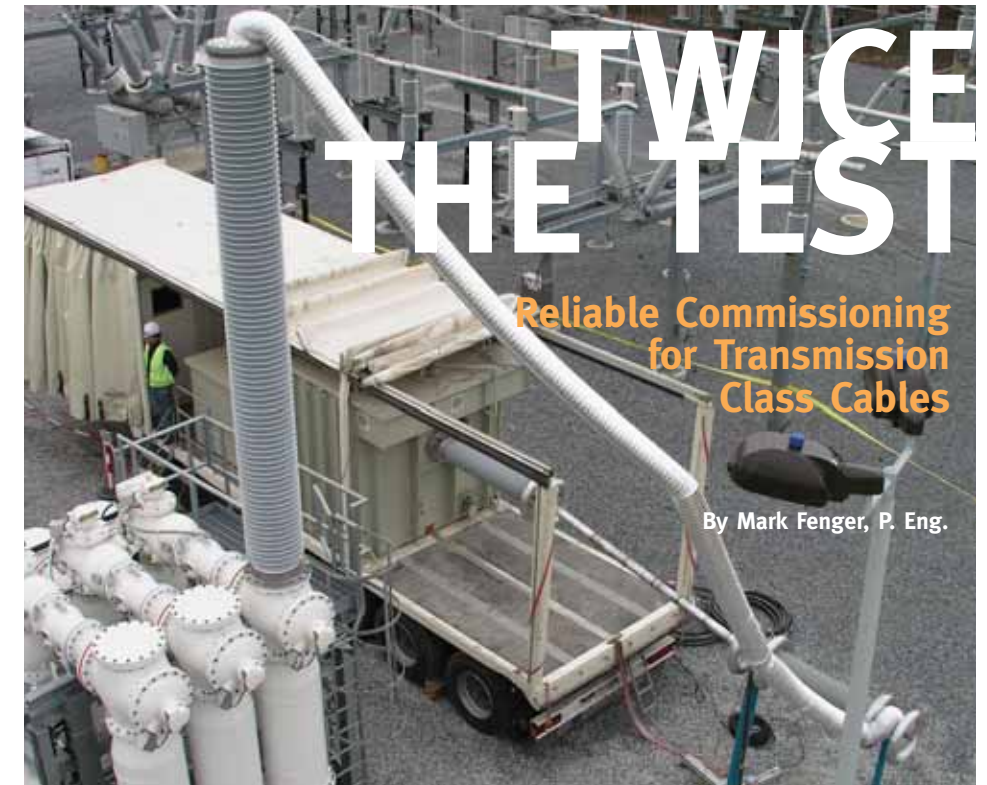
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New for PowerKage

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Mark Fenger**

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TWICE THE TEST

Reliable Commissioning for Transmission Class Cables

By Mark Fenger, P. Eng.

An important qualification

Due to space constraints and public pressure, underground high-voltage cable system installations are becoming more common and several large-scale high voltage underground transmission projects have recently been commissioned in North America. In 2007, a Kinectrics client commissioned a 15 mile long 345 kV XLPE insulated cable system in the Northeastern US. A 24 mile long 345 kV XLPE cable system is also currently under construction in the area.

Although transmission-class cables and cable sections have been subjected to lab qualification testing prior to arriving on site, insulation defects may still have been introduced into the system during transportation or installation. Defects such as dents, cuts, protrusions, impurities and misalignment of cable components can potentially result in catastrophic cable failures, causing damage not only to the faulty component itself but also to adjacent accessories, cables or in some cases, even the general public.

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Prevention pays

Due diligence in taking practical, **preventative** steps to avoid potentially catastrophic system and equipment problems can help boost profits for utilities. This issue of Kinectrics’ ON T&D covers two areas where prevention is key i.e. commissioning testing of HV transmission class cables and, the mitigation of animal intrusion into electrical equipment.

In our feature article “Twice the Test”, senior Kinectrics engineer Mark Fenger reviews the procedures and benefits offered by AC Hi-Pot and Partial Discharge testing as an important step in the field installation of factory-qualified HV transmission class cables. In this area, Kinectrics offers customers reliable commissioning testing of HV cable — in lengths up to 10 km — using its advanced Resonant Test System (RTS). With the Kinectrics RTS, clients gain the advantage of expert testing, managed by experienced engineering specialists from Kinectrics’ TDT group.

To protect electrical equipment from damage and outages caused by animals, Kinectrics has developed the PowerKage, an innovative and economical non-electric fence to protect substations and other areas containing power equipment. Kinectrics’ PowerKage has now been proven effective in over 35 utility installations across North America.

We invite you to discover how Kinectrics’ RTS testing and PowerKage can work for you to prevent potential, costly problems in your electrical systems, equipment and substations.

Cover Story: TWICE THE TEST Reliable Commissioning for Transmission Class Cables

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Of primary concern

Two primary issues are of concern in the commissioning of longer length transmission class cable: (1) The longer the cable system, the higher the number of accessories and, consequently, the higher the risk of experiencing failure (2) The higher the voltage and load ratings, the higher the energy behind an in-service failure and subsequent risk of external damage. Consequently, the issue of after-laying acceptance testing has come to the forefront with the application of high voltage cable systems.

In the past, cable systems have been subjected to a 24 hour soak test (24 hours at rated voltage but with no load). However, experience has shown the soak test to be inefficient in detecting insulation deficiencies prior to applying load to a newly-installed cable. As a result, AC Hi-Potential (Hi-Pot) testing has become common practice during the past 15 – 20 years. AC Hi-Pot withstand testing has been performed for decades as an acceptance test for newly-installed underground cables throughout the world.

Practical field testing

Although the individual components of a cable system are tested at the factory, defects such as impurities, dents, cuts, protrusions and misalignment of cable components can be introduced into a system following shipment. The purpose of an AC withstand test is to apply a sufficiently high voltage for a sufficiently long period of time for a defect to cause insulation failure. An example of an insulation failure (“electrical tree”) is shown in Figure 1.



Figure 1 – An example of electrical “treeing”

Most cable systems are tested according to IEC 60840 and IEC 62067, which stipulate cables rated 30 kV and above should be subjected to an over voltage of 1.7

U_0 where U_0 refers to rated phase-to-ground voltage — continuously for 60 minutes. The waveform applied should be sinusoidal and have a frequency between 20 Hz and 300 Hz. IEC 60840 / IEC 62067 also specify alternate voltage test levels ranging from 1.25 U_0 to 1.92 U_0 depending on the voltage class of the cable.

The issue with AC Hi-Pot testing of longer lengths of transmission class cable relates mainly to the current needed, and consequently, the power needed for energizing a cable at over potential. The longer the cable, the higher the capacitance and test current required. To energize long lengths of cable, a variable frequency resonant test set is needed. Until recently, such test sets were not available on a commercial basis in North America.

Resonant Test System

In 2005, Kinectrics Inc. invested in a 260 kV, 83 Amp variable frequency power supply. Kinectrics Resonant Test System (RTS) power supply (See Figure 2) is capable of energizing up to 10 miles of 138 kV cable, 7 miles of 230 kV cable and 5 miles of 345 kV cable (all figures approximate). For cable systems of longer lengths or higher voltages two or more units can be coupled in parallel or series connection to energize the cable at the desired AC Hi-Pot voltage.

Depending on local site conditions, the test set-up can be erected in half a day. Where site access, clearance or other technical issues exist, one or two days may be required.

Partial Discharge diagnostics

It is common practice to perform a Partial Discharge (PD) test during the AC Hi-Pot test. Unlike the AC Hi-Pot test (a go / no-go test), the Partial Discharge test is a diagnostic test that provides information on the condition

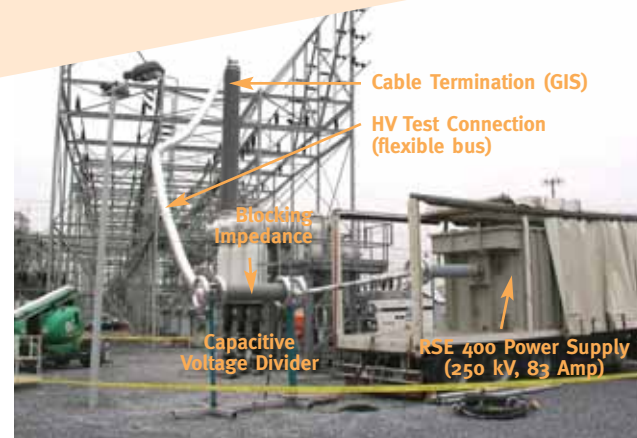


Figure 2 – Field testing with Kinectrics' RTS

of the cable insulation itself. Partial Discharge occurs in or around defects or weak areas of the insulation and causes low magnitude, high-frequency current to be induced on the cable conductor and the cable sheath. By applying a high-frequency sensor such as a coupling capacitor, radio frequency current transformer, or making use of an integrated PD sensor, PD signals can be measured if present.

Due to the attenuation effects of the cable on high-frequency current pulses, such as those induced due to PD activity, PD measurement cannot be performed at the terminal alone. Rather, sensors need to be applied to each joint and termination of the cable system. Typically, non-invasive split-core high-frequency current transformers are placed round the bonding links connecting the individual cable sheath sections to the link box. Coaxial leads are routed up and secured underneath the manhole cover, thus providing easy access to the Partial Discharge sensors once the cable is put under potential.

“ Defects such as dents, cuts... and misalignment of cable components can potentially result in catastrophic failures. ”

“ Partial Discharge testing by Kinectrics has proven to be an effective tool for significantly reducing the risk of catastrophic in-service failures. ”

Traditional calibration, as per IEC 270 cannot be performed for a field-installed cable. IEC 270 refers to a low frequency narrow-band Partial Discharge measurement performed on a lumped capacitance. Each phase of a field-installed cable system constitutes a distributed capacitance.

However, prior to performing a PD test, a meaningful sensitivity assessment is performed by injecting pulses having rise-time, width and fall times of 5 ns and up to 1000 ns into the cable system. The response is measured at the PD sensor, providing a sensitivity assessment as a function of frequency content (See Figure 3). This procedure is typically performed on up to three joints and one termination.

The AC Hi-Pot test takes approximately 60 minutes. Typically, the voltage is ramped up in steps of 0.5 U_0 until the desired test voltage is reached — PD activity is monitored at each step. If the cable withstands the test and no breakdown occurs, the cable will have passed. Furthermore, although no standard exists for PD measurements on

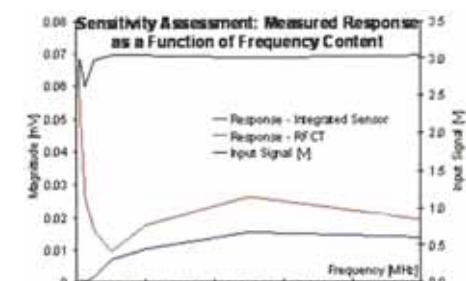


Figure 3 – Sensitivity assessment as a function of frequency content

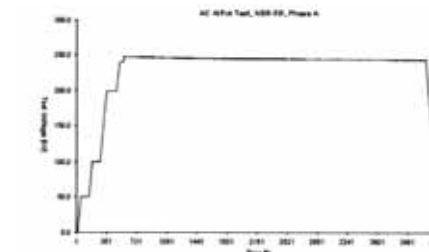


Figure 4 – Successful AC Hi-Pot test example.

installed transmission class cable, the guiding criterion is that the cable system should be free of PD activity at the AC Hi-Pot test level.

A successful AC Hi-Pot test example is provided in Figure 4. An unsuccessful AC Hi-Pot test example is shown in Figure 5.

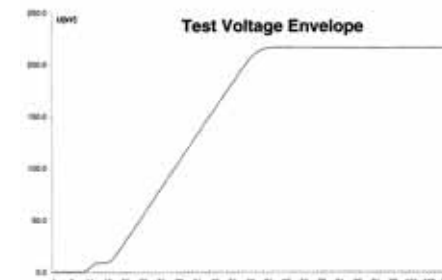


Figure 5 – Unsuccessful AC Hi-Pot test example.

Forensic failure analysis

The failure shown in Figure 1 occurred on a 220 kV XLPE cable 66 seconds into the AC Hi-Pot test. Initial investigations showed the failure to be located in the immediate vicinity of the joint, but not in the joint itself. A forensic analysis showed that the failure had resulted from electrical treeing (Figure 1). The treeing had not resulted from the inclusion of a void or contaminant, but rather from mechanical damage inflicted on the cable during preparation of the cable for splicing. Evidence from the post-failure analysis showed that significant electrical treeing had occurred prior to failure, even in the short time that the cable was at the test voltage.

One advantage of performing an AC Hi-Pot withstand test at resonant frequency is that when a failure occurs, it is manifested as a so-called “soft failure”, preserving even microscopic forensic evidence. In other words,



a failure during an AC Hi-Pot resonant test does not cause large failure currents, which often destroy forensic evidence, limiting the effectiveness of a forensic analysis.

An effective tool

Since December 2005, Kinectrics has tested more than 600 km of XLPE cable rated 230 kV and above. Statistics from these tests show the failure rates as measured per phase to be 4.5%, and as measured per joint to be 0.9%. The combination of AC Hi-Pot and Partial Discharge testing by Kinectrics has proven to be an effective tool for significantly reducing the risk of catastrophic in-service failures, and increasing the reliability of newly-laid cable systems.

