Powerline Conductor Accelerated Testing Facility (PCAT)

Overview:

The Powerline Conductor Accelerated Testing facility (PCAT) at Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee is a unique outdoor test facility for conducting both thermal stress and age characterization of advanced power line conductors. The facility includes a 2MW DC power supply which can vary the loading of the conductor under test up to 600 Vdc and 5000 Adc. The low voltage nature of the facility permits extensive instrumentation of the test conductor's surface and core temperatures by means of thermocouples as well as simultaneous measuring of conductor tension, sag, and environmental conditions (e.g., wind, solar, ambient). The facility consists of five 161kV-rated steel transmission poles, which have extensive support to ensure mechanical stability, with two poles at each of the two dead ends and one in the center with a crossarm. The test line forms the load for the power supply by making a loop connecting the plus side of the power supply to the conductor with the returning end connected to the minus side of the power supply. Currently, the facility permits testing of 1200 ft (one span out and back) to 2400 ft (two spans out and back) ft of conductor length at one time.

Description:

The Powerline Conductor Accelerated Testing facility (PCAT), which was commissioned and dedicated in March 2003, supports the urgent need to address issues associated with electricity transmission reliability and security in the US. Figures 1 and 2 show a view of the PCAT site and its design. It is the first of four operational facilities that comprise the Department of Energy's (DOE) National Transmission Technology Research Center (NTTRC). PCAT is part of DOE's effort to address the growing demands for electric power at a time when the amount of electricity that can be currently transmitted over power lines is dropping. PCAT provides a facility to test and evaluate advanced power transmission technologies with the potential to increase the capacity and reliability of the U.S. T&D network. Technologies to be characterized include new composite and improved conventional conductors, advanced sensors and controls, and power electronics.

The PCAT facility, which was constructed in late 2002 and became operational in early 2003, is located within a mile of the main ORNL campus. It consists of a closed-loop of 2400 ft of advanced composite conductor mounted on 161kV steel transmission poles. The advanced conductor and line accessories are being tested for thermo-cycling and high-current situations as well as conductor characterization (e.g., sag, tension, conductor temperature) at rated and emergency loading. A 2-MW dc power supply fed by a 13.5kV/4160V transformer provides power for the site. TVA designed the PCAT structures and installed poles, hardware, conductor and accessories at the site.

The highly instrumented PCAT yields important data about the performance of advanced conductors and their line accessories under high temperatures and high current, varying current loads, and naturally varying environmental conditions. The tests provide both the manufacturer and utilities with conductor performance data under accelerated field-like operating conditions. These tests short-circuit the need for utilities to conduct long-term and controlled demonstration

tests of advanced conductors. With the PCAT tests showing that new conductors perform as designed under extreme conditions, electric utilities will take greater interest in replacing their existing lines with the advanced conductors. Widespread usage of advanced transmission line conductor has the potential to increase the efficiency of energy transmission and provide one way of solving the problems of growing energy demand and transmission bottlenecks.

Figure 1. Aerial view of PCAT including its power supply and instrumentation trailers, transmission line structures and current conductor under test.

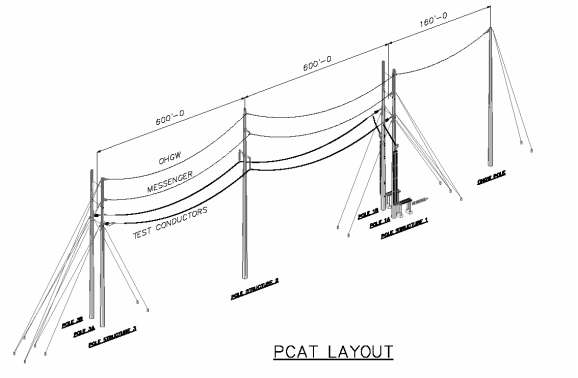

Figure 2. PCAT design layout showing the pole structures and supports.

PCAT Tests:

The first technology being tested at PCAT is an aluminum conductor composite-reinforced (ACCR) cable, which is an advanced conductor developed by 3M Corporation. Testing on this first conductor and its associated accessories began in March of 2003 and will be completed in the Fall. The conductor's associated high-performance accessories and splices are manufactured by Alcoa Fujikora and Preformed Line Products. The accessories are being tested in conjunction with the 3M conductor. ACCR, which is a promising replacement for conventional conductors, addresses the issues of transmission line capacity and reliability. High current loads produce heat, which cause transmission lines to sag and prematurely age and could degrade their performance if the design operating temperature is exceeded for extended periods. ACCR uses 3M's Nextel 650 ceramic fibers, embedded in an aluminum matrix, to make a composite wire which is lighter, more conductive, and with less stretch when heated by current flow as do conventional conductors. The addition of zirconium to the aluminum wire surrounding the composite core of the conductor makes the conductor more resistant to deformation or annealing at higher temperatures.

ACCR wire operates at temperatures of up to 240°C (464°F) under emergency conditions and 210°C (410°F) under normal conditions with no degradation of its properties, while conventional aluminum-conductor steel-reinforced wires can operate only at 100°C (212°F) or below. The higher operating temperature allows ACCR to transmit two to three times more power than Aluminum Conductor Steel Reinforced (ACSR) cable. Thus, ACCR can replace traditional wires on existing transmission towers and rights-of way (ROWs), avoiding the cost and environmental impact of building new towers and acquiring new ROWs.

ORNL researchers are testing 3M's small-, medium-, and large-diameter conductor cables successively. The tests are evaluating the overall performance of the conductor to verify

predictions of computer models by looking at sag and tension data, such as stress/strain curve and knee point. Each test is consisting of multiple cycles (up to 500) of simulated thermo-cycling and is being run from five to six months. During each cycle, the conductor is being subjected to its peak load and then returning it to normal load—the equivalent of 30 years of peak loads.

Long-Term Tests:

Long-term plans for the PCAT facility include performance characterization of other advanced conductors and existing conductors (e.g., ACSS). PCAT provides the first step in conductor testing by providing a highly instrumented test facility operating at low voltage but high current. The next step is high-voltage testing of the conductor at the Powerline Conductor Operational Testing Facility (PCOT). PCOT, a DOE high-voltage transmission test facility under development, will be operated jointly by TVA and ORNL. It provides a controlled high-voltage operating environment where the conductors/cables under test can be operated in various loading modes, heavily instrumented, and accessible for joint government and industry testing.

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