Testing of THERMOLIGN® Suspension Assembly

For

596TW-kcmil 3M™ Composite Conductor

Prepared by:

Robert Whapham
Preformed Line Products, Principal Investigator

Scope

This report will cover the description and results of laboratory testing of PLP's THERMOLIGN® Suspension and 596TW-kcmil 3M™ Brand Composite Conductor (also called ACCR – Aluminum Conductor Composite Reinforced) manufactured by the 3M Company.

The specific tests included in this report are:

- Aeolian Vibration Test
- Galloping Test
- Unbalanced Load Test

The results for each test are reported separately.

Aeolian Vibration

The purpose of this testing is to demonstrate that the conductor accessories will protect the ACCR conductor when it is subjected to dynamic, wind induced bending stresses. It is well understood in the industry that conductors strung under tension will vibrate in standing waves when subjected to laminar wind flows in the range of 2 to 12 miles per hour. Within the span itself, this vibration activity has little or no influence on the conductor. However, at the structures where the conductors are supported or dead-ended, this vibration activity produces bending stresses. The peak-to-peak amplitude of the vibration of the conductor in the span is generally less than the diameter of the conductor itself, but over a number of years, if not properly protected, the conductor can experience fatigue failures. The field failure experience with various conductor accessories on ACSR conductors is well documented. Laboratory aeolian vibration testing at higher levels of activity is commonly used to demonstrate the effectiveness of accessories under controlled and accelerated conditions.

There is no published industry test specification for aeolian vibration testing of conductors in the laboratory. However, a laboratory specification has been established by the IEEE for the vibration testing of Optical Ground Wire (OPGW). This specification is IEEE 1138. The testing of the ACCR conductor will be in accordance with IEEE 1138.

The laboratory test arrangement for the aeolian vibration testing of the 596/TW ACCR Suspension Assembly consisted of a 30 meter span of conductor (Figure 1) with a Dead-End Assembly applied to each end, and a Suspension Assembly applied to the center of the span and secured to a rigid tower. The Suspension Assembly was elevated to simulate a sag angle consistent with standard field spans. During the test, the tension in the conductor was maintained at 25% RBS (5,316 lbs) using a tension beam/weight basket. A vibration shaker was used to initiate and maintain a vibration at a frequency of 33 hertz, with an amplitude of 0.29" peak-to-peak for a period of 100 million cycles (35 days). Visual Observations were made daily of the ACCR conductor and the Dead-End and Suspension Assemblies.

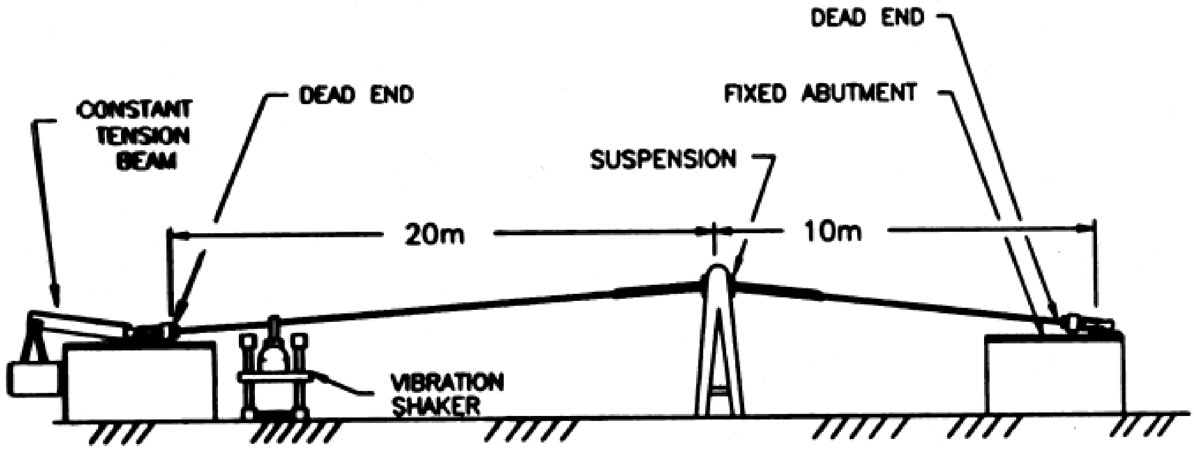

Figure 1 – Aeolian Vibration Test Arrangement

At the completion of the test period the Suspension Assembly was removed and carefully inspected for wear or other damage. The section of the 596/TW ACCR Conductor at the Suspension Assembly was cut out of the span and dissected to determine if any wear or damage had occurred to the Al-Zr outer strands, the aluminum tape or to the composite core.

After 100 million cycles of severe aeolian vibration activity there was no wear or damage observed on the components of the Suspension Assembly or on the components of the ACCR Conductor (See Figures 2 & 3).

Figure 2 – Conductor Strands & Core

Figure 3 – All Elements of Conductor

Simulated Galloping Test

The purpose of this testing is to demonstrate that the Suspension assembly will protect the ACCR conductor when it is subjected to the potentially high bending stresses associated with conductor galloping. Conductor galloping is generally associated with a coating of ice or wet snow on the conductor. This coating usually forms on the windward side of the conductor surface, creating an aerodynamically unstable profile. Moderate to high winds blowing across the iced conductor can cause the conductor to lift. As the conductor lifts, it rotates slightly, changing the aerodynamic profile, allowing the conductor to fall. This lift/fall action generally "locks" into the fundamental (single loop) natural frequency of the span or into one of the first few natural frequencies (double or triple loop). The resulting motion can be at very large amplitudes, which can produce damaging bending stresses at the conductor support locations.

Galloping is a very random occurrence in the field, and therefore must be simulated in the laboratory. However, as with aeolian vibration, there have been no industry test specifications established for conductors. The IEEE has however, established a laboratory galloping test for Optical Ground Wire (OPGW) as part of IEEE 1138, which will be used for the ACCR.

The laboratory test arrangement consisted of a 30 meter span of 596/TW ACCR conductor, terminated at each end with a PLP Dead-End Assembly (Figure 4). The Suspension Assembly was installed on the span near the 1/3rd-point, and secured to a laboratory tower. The Suspension Assembly was elevated to simulate a sag angle consistent with standard field spans. During the test, the tension was maintained at 8% RBS (1,700 lbs) using a tension beam/weight basket. An offset crank mechanism (Figure 5) was attached to the conductor to drive the longer span into its fundamental (single loop) natural frequency (1.8 hertz, in this case). A peak-to-peak amplitude of 39" was maintained for a period of 100,000 cycles (15.4 hours).

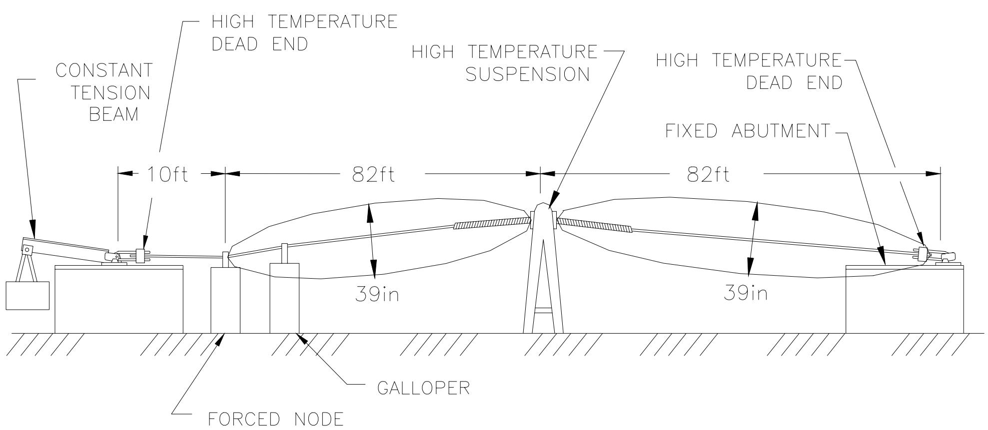

Figure 4 - Galloping Test Configuration

Figure 5 - Offset Crank Mechanism

At the completion of the test period the Suspension Assembly and the section of the conductor within the Suspension Assembly were dissected to determine their condition. After 100,000 cycles of galloping activity there was no wear or damage to the components of the Suspension Assembly or to the components of the ACCR conductor.

This sample will be tensile tested to demonstrate that the severe galloping activity will not result in any reduction in strength of the conductor at the Suspension Assembly location.

Unbalanced Load Test

The purpose of this testing is to demonstrate that the Suspension Assembly will protect the ACCR conductor at a support location which is subjected to unbalanced tension loading. By using roller type stringing blocks, the horizontal tension component of the conductor on both sides of a suspension tower are equal when the Suspension Assembly is installed. However, if ice or wet snow builds-up on the conductors and falls off of one span before the other, a substantial unbalance of the tensions on either side of the suspension can occur. The Suspension Assembly will rotate from its vertical position towards the higher tension. A similar condition will exist at the suspension towers adjacent (in both directions) to a broken conductor.

To simulate the effects of unbalanced loading in the laboratory, a 30 ft. span of 596/TW ACCR was terminated at one end with a PLP Dead-End Assembly and attached to the hydraulic ram of the 55K Tensile Equipment. The Suspension Assembly was installed near the far end of the span in an inverted position, and secured to a short tower on the tensile equipment test frame.

The unbalanced load is applied to the conductor in increments of 5% of the RBS (1,063 lbs), until a continuous slip at the Suspension assembly occurs. Each load increment is held for 5 minutes. As the unbalanced load increases, the angle of rotation of the Suspension Assembly on the attachment plate also increases.

The Suspension Assembly held up to 25% RBS before slipping, and after dissecting the conductor, no damage was observed.

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