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Creep Testing for 995.0 kcmil ACCS/TW/C7 Overhead Conductor

NEETRAC Project: 24-151

Final Report

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NEETRAC
National Electric Energy Testing,
Research, and Applications Center

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1.0 BACKGROUND

Owners of overhead lines must maintain safe electrical clearances to the ground and other nearby objects. The design method for assuring long-term safe clearance under all weather conditions was developed by Alcoa and the Bonneville Power Administration during the 1920s. Data for the elastic and creep properties was superimposed graphically on the catenary curves for sag and tension. Nomographs (paper charts) were used to map the condition of the conductor. Through the 1970s, most transmission lines in North America were designed using nomographs. In 1964, Alcoa computerized the process in SAGTEN, a FORTRAN program for mainframe computers. Alcoa later published DOS and Windows versions for desktop PCs. PLS-CADD® software introduced in 1985 merged the graphical model with a drafting engine to automate the generation of plan and profile drawings for overhead lines. The method developed in the 1920s remains in use, and has migrated worldwide simply because a more reliable method has not been found.

This project covers two creep tests performed to determine creep coefficients for overhead line design programs. Stress-strain data by EPRI was obtained and used to generate the complete conductor model and provide the conductor coefficients in the format used by the line design programs.

2.0 TEST SAMPLES

Two test samples were removed from a reel provided by INL circa January 2025. The designation on the reel identified the conductor as 995.0 kcmil ACCS/TW/C7.

3.0 PROCEDURE AND TEST APPARATUS

Samples were cut from the reel only after bolted clamps were applied to the conductor to lock in the manufacturing prestress. This ensures the load distribution among the strands and between the aluminum and composite core properly reflect as-installed conductor. Cast-resin terminations were installed on each end of the two samples. The bolted clamps were removed after the resin cured.

A conductor creep test machine is similar to a conductor stress-strain machine, in that both apply tension and measure strain. Creep test machines require several special features to ensure continuity of the test and the data during power interruptions. The test has to run uninterrupted for over 1000 hours.

Tension is applied by a motor-driven linear actuator that is self-locking in the event of a power interruption. Springs at the opposite end of the machine buffer (soften) the effect of actuator movement, and provide stable tension during power interruptions.

Creep is measured by suspending an aluminum gage rod at two balance points using a roller slide, springs and a turnbuckle for fine adjustment. By careful adjustment of turnbuckles and roller slides, the gage rod is positioned to float in space within a millimeter of its desired position. The fixed end of the gage rod is then bolted to a gage block that is bolted around the conductor. The floating end of the gage rod contacts the sample only at the spring-loaded plunger of a dial indicator. The digital resolution of the dial indicator is 0.0001 in. With the 216 in gage section, the strain resolution is 0.00004630% (0.4630 ppm). Figure 1 through Figure 4 show detailed views of the system.

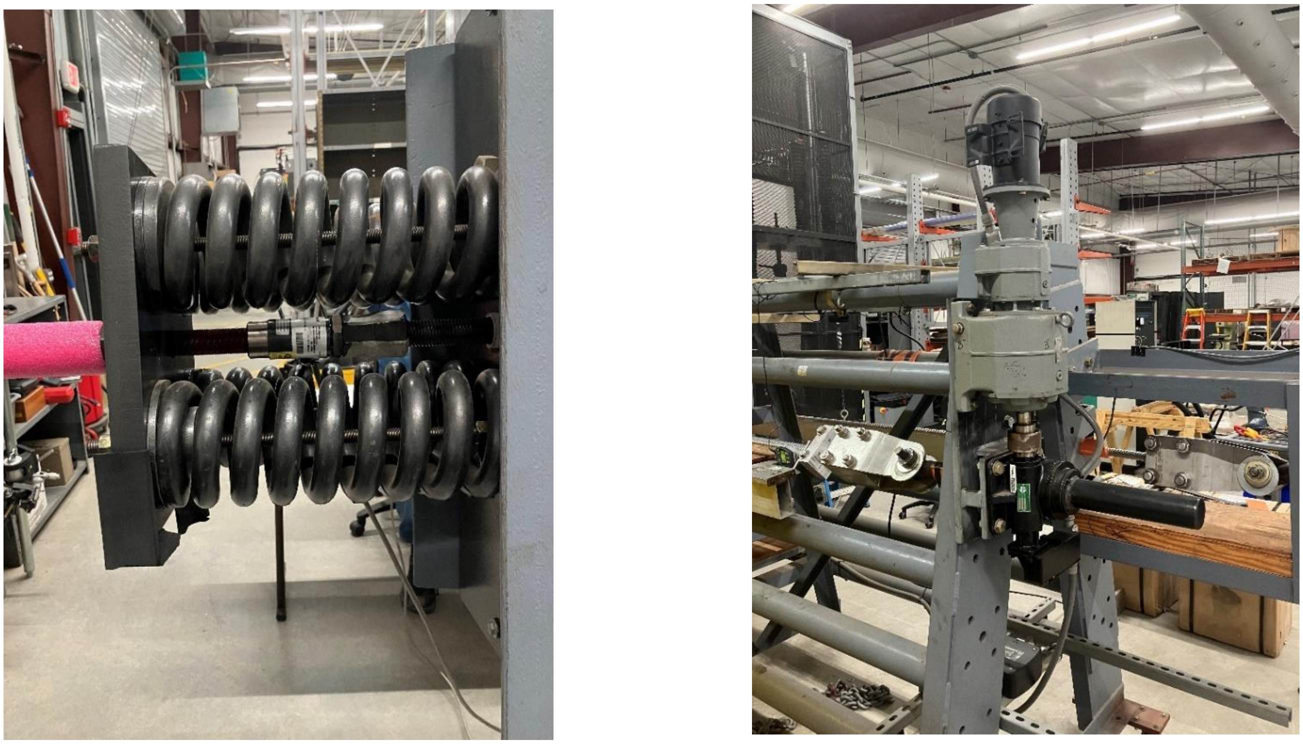

Figure 1: Buffer Springs and Load Cell (Left), Motor-Driven Actuator (Right)

Figure 2: Dial Indicator at Floating End of Gage Rod

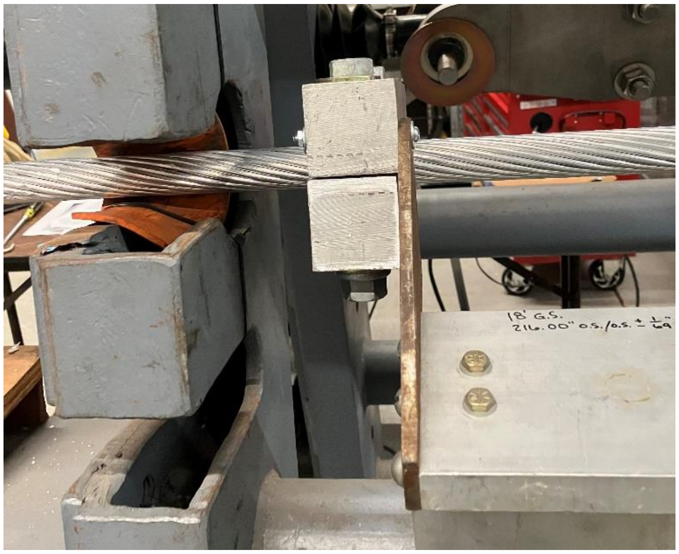

Figure 3: Fixed End of Gage Rod Bolted to Gage Block

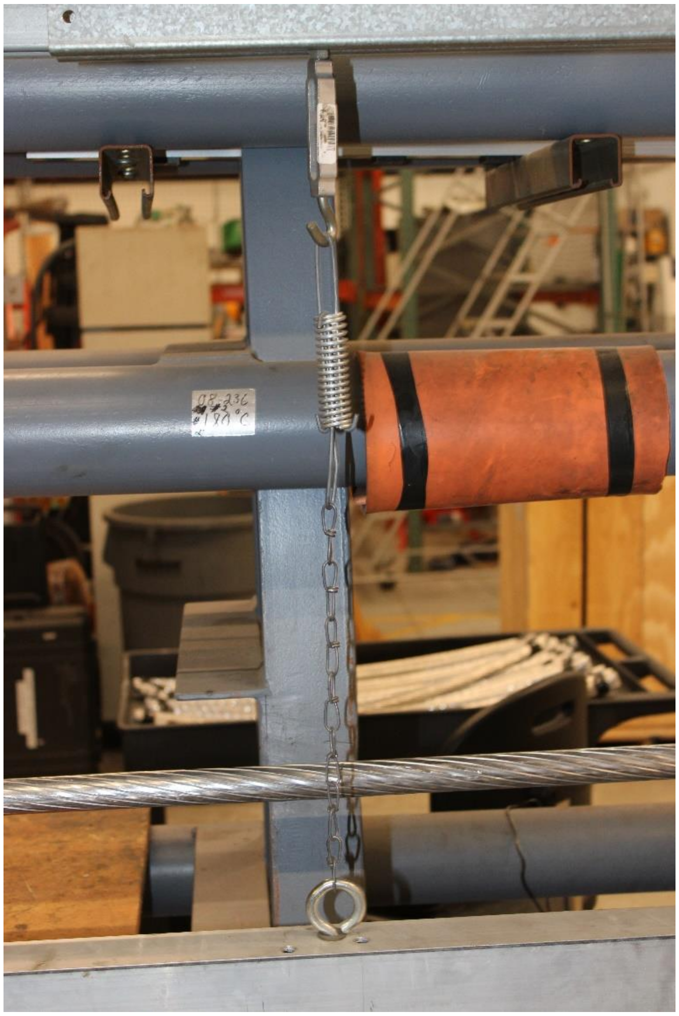

Figure 4: Spring/Turnbuckle Suspension for Gage Rod, Typical Two Places

The sample and all test equipment are in conditioned lab space to ensure thermal stability. A type T thermocouple was taped to the gage rod surface to provide the ambient temperature. Conductor temperature was not measured, but in the conditioned space it tracks the ambient.

4.0 RESULTS

Creep benches typically have an actuator speed that is too slow to load the sample rapidly enough to properly measure the rapid creep that occurs in the early minutes of the creep test. By industry convention, the first hour of creep is measured using the more capable equipment designed for stress-strain testing. The data from the first hour of the 1000 hour creep test is discarded, and the one-hour creep from the stress-strain test is used as the starting point.

The one-hour creep from the stress-strain test was determined as shown in Figure 5 and Figure 6. The one-hour creep at 15% RBS measured as 0.0865%. At 25% RBS, the one-hour creep measured as 0.1641%.

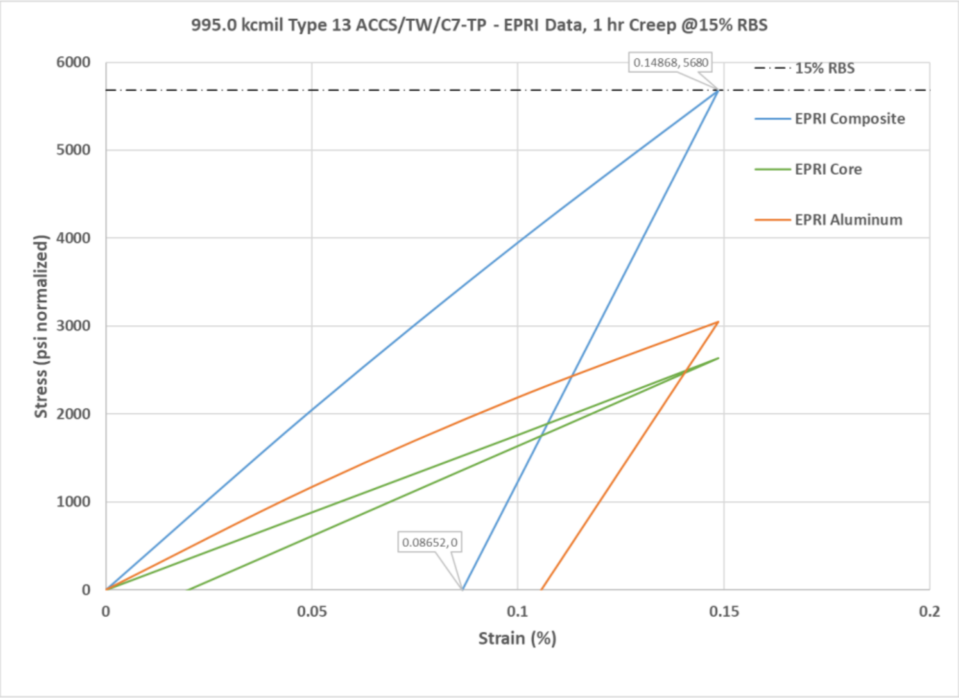

Figure 5: Derivation of One-Hour Creep at 15% RBS

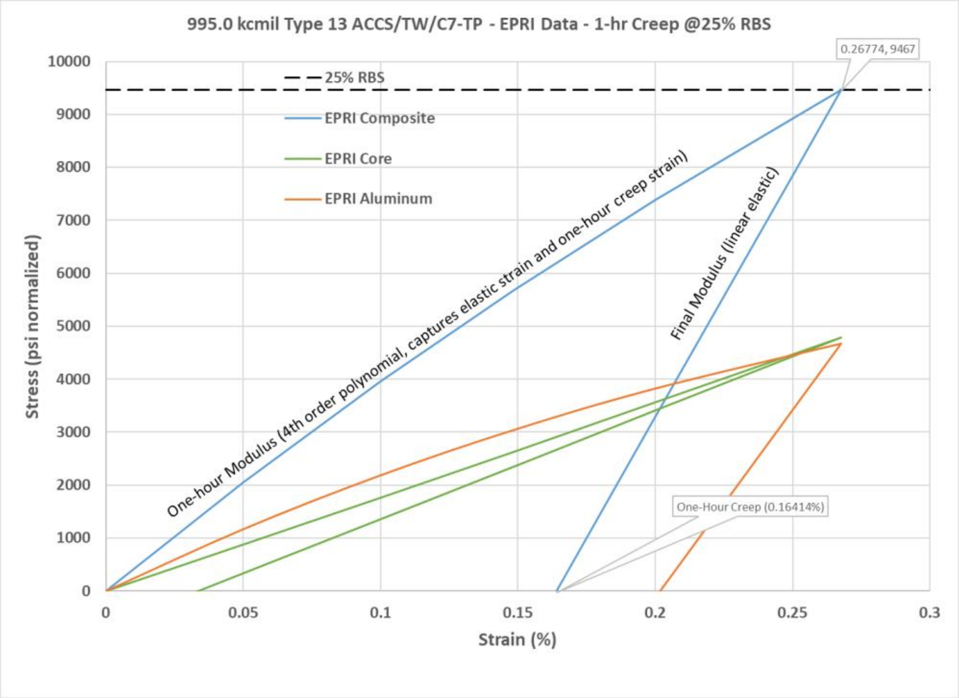

Figure 6: Derivation of One-Hour Creep at 25% RBS

The creep data in the industry-standard format is shown in Figure 7. Creep data was combined with stress-strain data from EPRI to create the complete conductor model shown in Figure 8. The conductor coefficients are provided in Table 1.

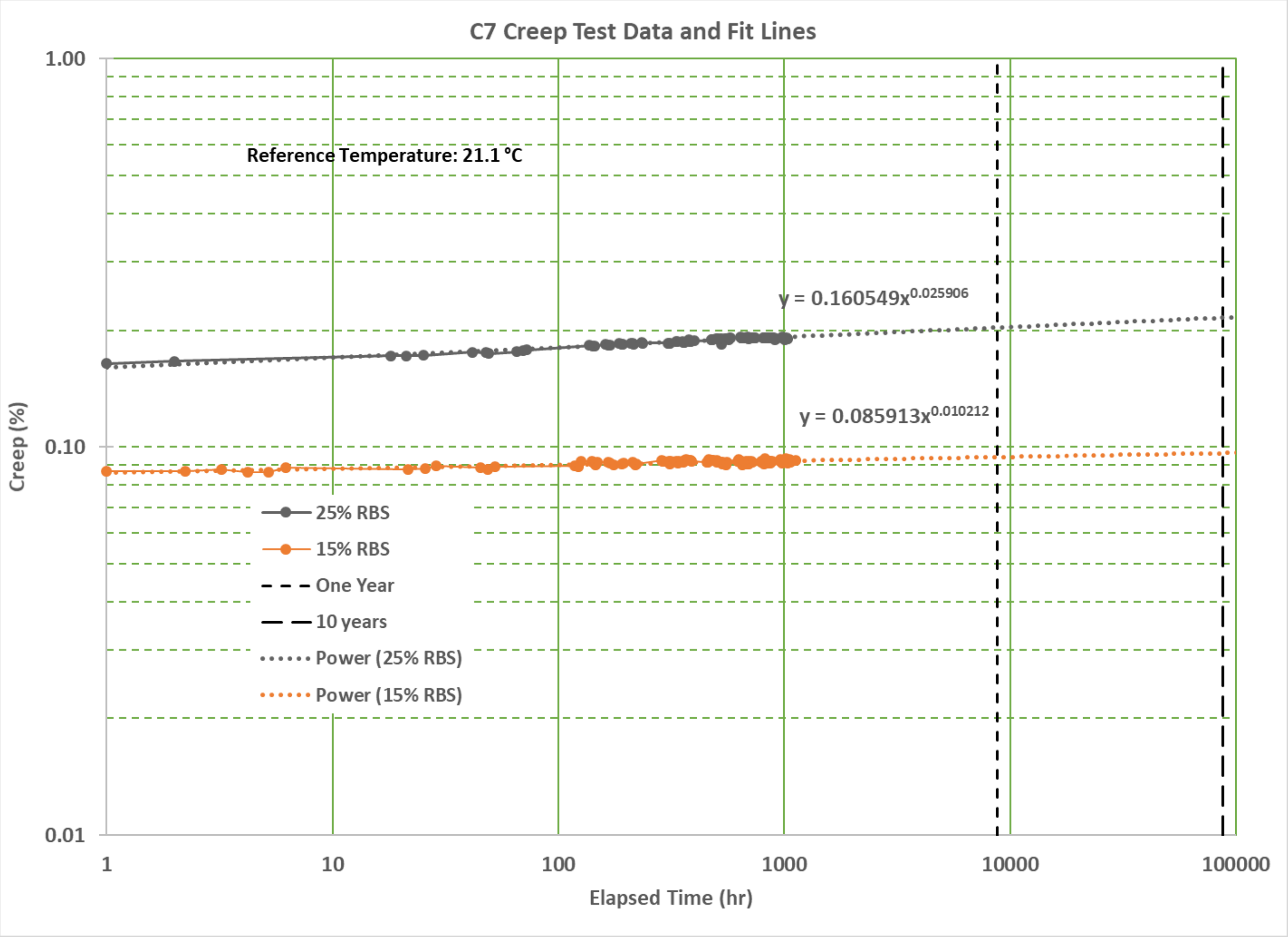

Figure 7: Creep Data and Fit Curves for 15% RBS and 25% RBS

Equations for creep are:

15% RBS: Strain(%) = $0.08591*(\text{hours})^{0.01021}$
25% RBS: Strain(%) = $0.16055*(\text{hours})^{0.02591}$

Values for 1-hour creep are:

15% RBS: 0.0865 %
25% RBS: 0.1641 %

Values for 10-year creep are:

15% RBS: 0.0965 %
25% RBS: 0.2156 %

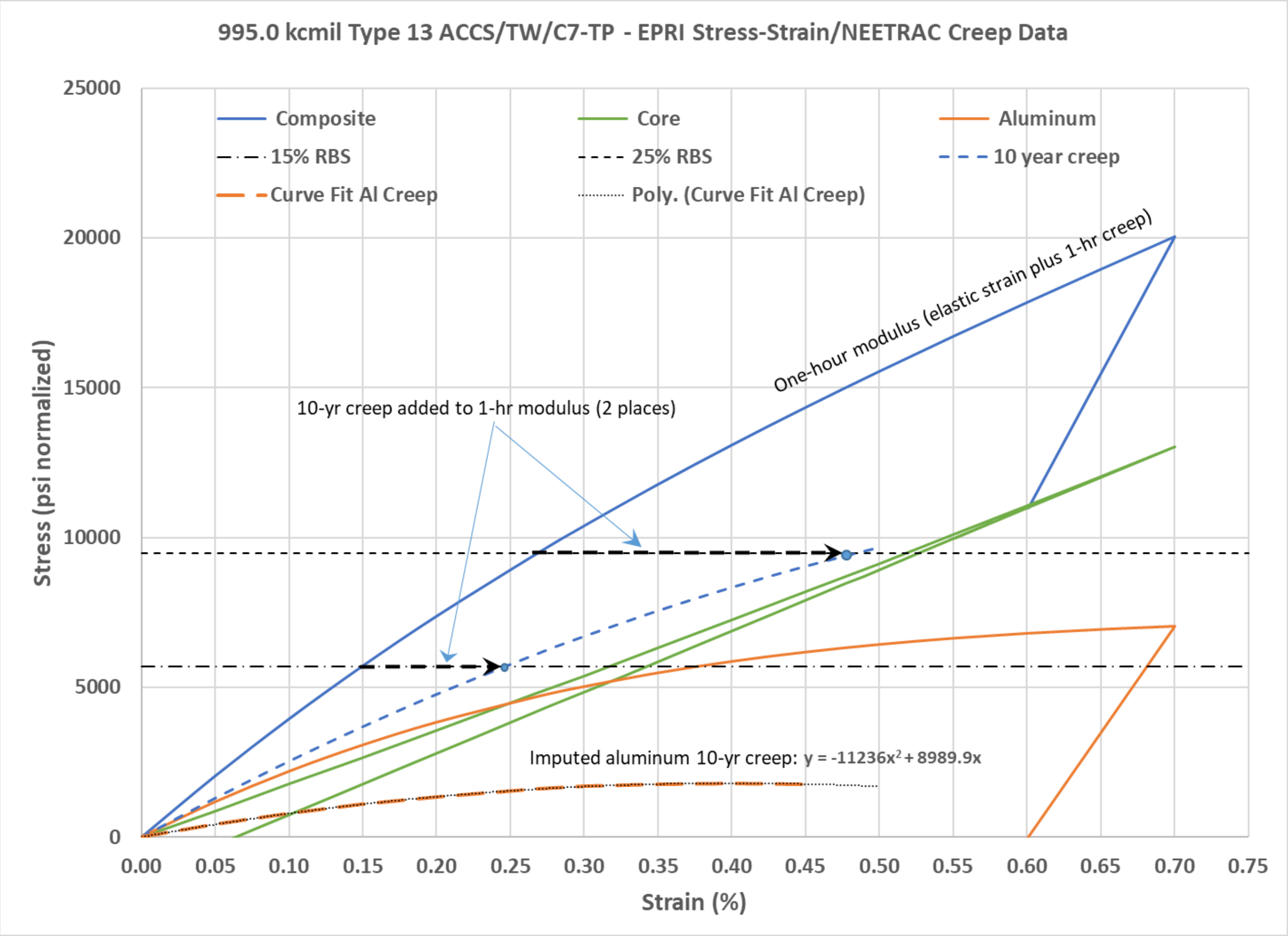

Figure 8: Complete Stress-Strain and Creep Model

Conductor coefficients are used to transmit the laboratory data to a computer model. Line design software is typically proprietary, but all programs use common conductor coefficients obtained from stress-strain tests per ASTM B1008, and ASTM Creep Standard Draft WK62464. Both ASTM Standards are harmonized with IEC (European) and prior guides published by the Aluminum Association.

Table 1 shows the coefficients derived from the stress-strain test at EPRI, and the creep tests performed at NEETRAC.

Table 1: Coefficients for 995.0 kcmil ACCS/TW/C7 Conductor, Imperial Units

	K0	K1	K2	K3	K4	73.8	Ref. Temperature (°F)
Al. initial	0	24980	-33040	19600	-4130	70900	Al linear modulus (normalized)
Al. creep	0	0	-11236	8990	0	0.00128	Al thermal modulus (%/°F)
Core initial	0	17510	1310	640	-380	20480	Core linear modulus (normalized)
Core creep	0	17510	1310	640	-380	0.0001	Core thermal modulus (%/°F)

5.0 DISCUSSION / CONCLUSIONS

The goal of conductor testing is to model and predict conductor behavior during its service life. The complete model is shown graphically as Figure 8 with coefficients provided in Table 1. Computer design software uses this information for line design and demonstration of compliance with statutory requirements for safe ground clearance and other electrical clearances.

6.0 EQUIPMENT

NEETRAC two-span creep bench

Mitutoyo dial indicator, Span A, Calibration Control # CN-7837

Mitutoyo dial indicator, Span B, Calibration Control # CN-6813

Lebow 25,000 lb rod load cell, Span A, Calibration Control # CN-7839

Lebow 25,000 lb rod load cell, Span B, Calibration Control # CN-7838

National Instruments LabView data acquisition software

Omega HH378 Thermocouple Reader, Calibration Control # CQ-6766

Omega HH147 Thermocouple Reader, Calibration Control # CQ-3081