

ANSI C119.4 Testing of TS Conductor "Ruddy" with AFL Connectors

Electrical Test Results

NEETRAC Project: 22-132

Final Report

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Research, and Applications Center

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Connector and Conductor Testing of TS Conductor “Ruddy” with AFL Connectors - Electrical Test Results

NEETRAC Project 22-132

1.0 SUMMARY

Jeff Phillips from TVA requested modified mechanical and electrical testing per ANSI C119.4-2016 on eight (8) AFL B135010-Y-TS connectors (deadends) and four (4) B4684-Y-TS connectors (compression joints) installed on TS conductor, “Ruddy,” M3 8.5. This report covers the electrical testing. The modifications included a tension scheme and a high temperature limit of $180\text{ }^{\circ}\text{C} \pm 3^{\circ}\text{C}$. The tension scheme consisted of applying an initial 10% of the conductor’s RBS load to the conductor-connector samples at room temperature and resetting the tension to 10% of the conductor’s RBS while the samples were at room temperature every 25 cycles. The modified ANSI C119.4-2022 current cycling testing had four pass / fail criteria:

1. No connector may have a maximum temperature that exceeds the temperature of the control conductor. As shown in Figure 6, all connectors met this requirement.
2. All connectors must not have a stability factor exceed $\pm 10^{\circ}\text{C}$ for each connector temperature measurement recorded at the test intervals specified in Table 9 of ANSI C119.0. As shown in Figure 7, all connectors met this requirement.
3. For each connector, all DC resistance measurements recorded at the test intervals specified in Table 9 of ANSI C119.0 must be within $\pm 5\%$ of the average DC resistance. As shown in Figure 8, all connector met this requirement.
4. Each connector must not experience slippage. Throughout the test, all connectors met this requirement as no slippage occurred.

In summary, all connectors passed the modified ANSI C119.4-2022 current cycling testing requirements.

2.0 INTRODUCTION

Jeff Phillips from TVA requested modified mechanical and electrical testing per ANSI C119.4-2016 on AFL connectors B135010-Y-TS (deadends) and B4684-Y-TS (compression joints) installed on TS conductor, “Ruddy,” M3 8.5. This report covers results for the modified 500 cycle current cycle testing (CCT). The modifications included a tension scheme and a high temperature limit of 180 °C. The tension scheme consisted of applying an initial 10% of the conductor’s RBS load to the conductor-conductor samples at room temperature and resetting the tension while the samples were at room temperature to 10% of the conductor’s RBS every 25 cycles.

3.0 TEST SAMPLES

The test samples consisted of AFL connectors B135010-Y-TS (dead-ends) and B4684-Y-TS (compression joints) installed on TS conductor, “Ruddy,” M3 8.5. A sample assembly consisted of deadend-conductor-compression joint-conductor-deadend. The assembly lengths were approximately 40 ft. A general diagram of the sample assembly and loading method can be seen in Figure 1. As received condition of materials can be seen in Figure 2, Figure 3, and Figure 4.

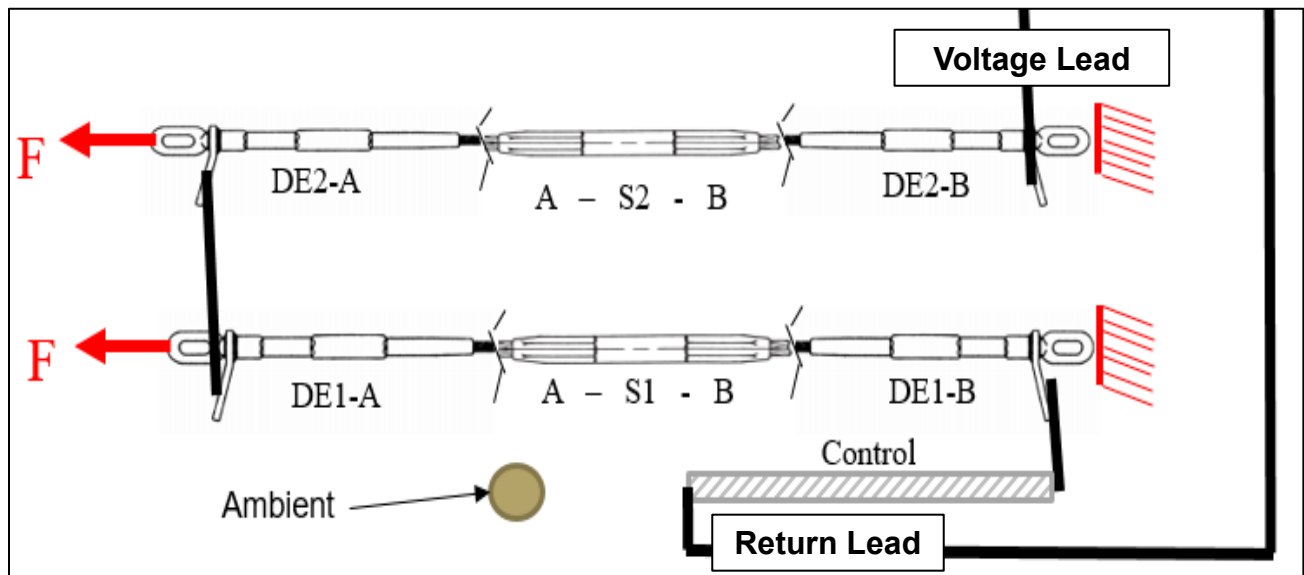


Figure 1: Loading Method and Generalized Diagram of Sample Assembly

- Figure displays two sample assemblies (deadend-conductor-compression joint-conductor-deadend). Four assemblies were tested in the series configuration shown.



Figure 2: Typical as Received Condition of AFL Compression Joints, B4684-Y-TS



Figure 3: Typical as Received Condition of AFL Deadends, B135010-Y-TS



Figure 4: As Received Condition of TS Conductor

4.0 PROCEDURE

4.1 Sample Preparation

All deadends were installed on TS conductor per AFL Installation Instructions INS-ACA126. All compression joints were installed on TS conductor per AFL Installation Instructions INS-ACA127. Per instruction from the customer and manufacturer, the inhibitor used for all installations was HiTemp AFL Universal Compound (HiTUC).

4.2 Testing

A 500-cycle current cycle test was performed per ANSI C119.4-2016, with the following additions/modifications:

- Four sample assemblies were tested. Each sample assembly consisted of deadend – conductor – compression joint – conductor – deadend. In total, eight (8) deadends and four (4) compression joints were tested.
- The samples were placed under an initial mechanical load (tension) of 10% of the conductor's RBS while the samples were at room temperature, and then reset at room temperature to 10% RBS every 25 cycles.
- The max control temperature was not allowed to exceed 183 °C.
- The time for the "on" portion (current on) of the test cycles was set to 3 hours and 50 minutes to enable samples to sit at the high temperature for approximately 2 hours. The "off" portion of a cycle was set for 2 hours and 40 minutes.
- Per customer's instruction, fans (forced convection) were used throughout the cool down periods.
- DC resistance was measured using a four-wire method at 100 amps.
- In addition to the ANSI C119.4 test requirements (maximum temperature, temperature stability, and resistance stability), the pass criteria for the test stated, that no slippage may occur during the test.
- For resistance measurements on deadends, equalizer plates were used on the eye side of the connector and metal wire-ties were used on the other side. For compression joints, wire-ties were used on both sides. All resistance measurements were made using a micro-ohmmeter.

A photo of the test cell can be seen in Figure 5. Thermocouples were placed in holes that were drilled inside of the connector barrel. Deadends had one thermocouple. All compression joints had two thermocouples installed, one installed on each barrel. To measure the tension across the sample assemblies, a 10-kip Honeywell model 3124-10k was used in each span. When setting the tension to 10% of the conductor's RBS, the tension was adjusted manually.

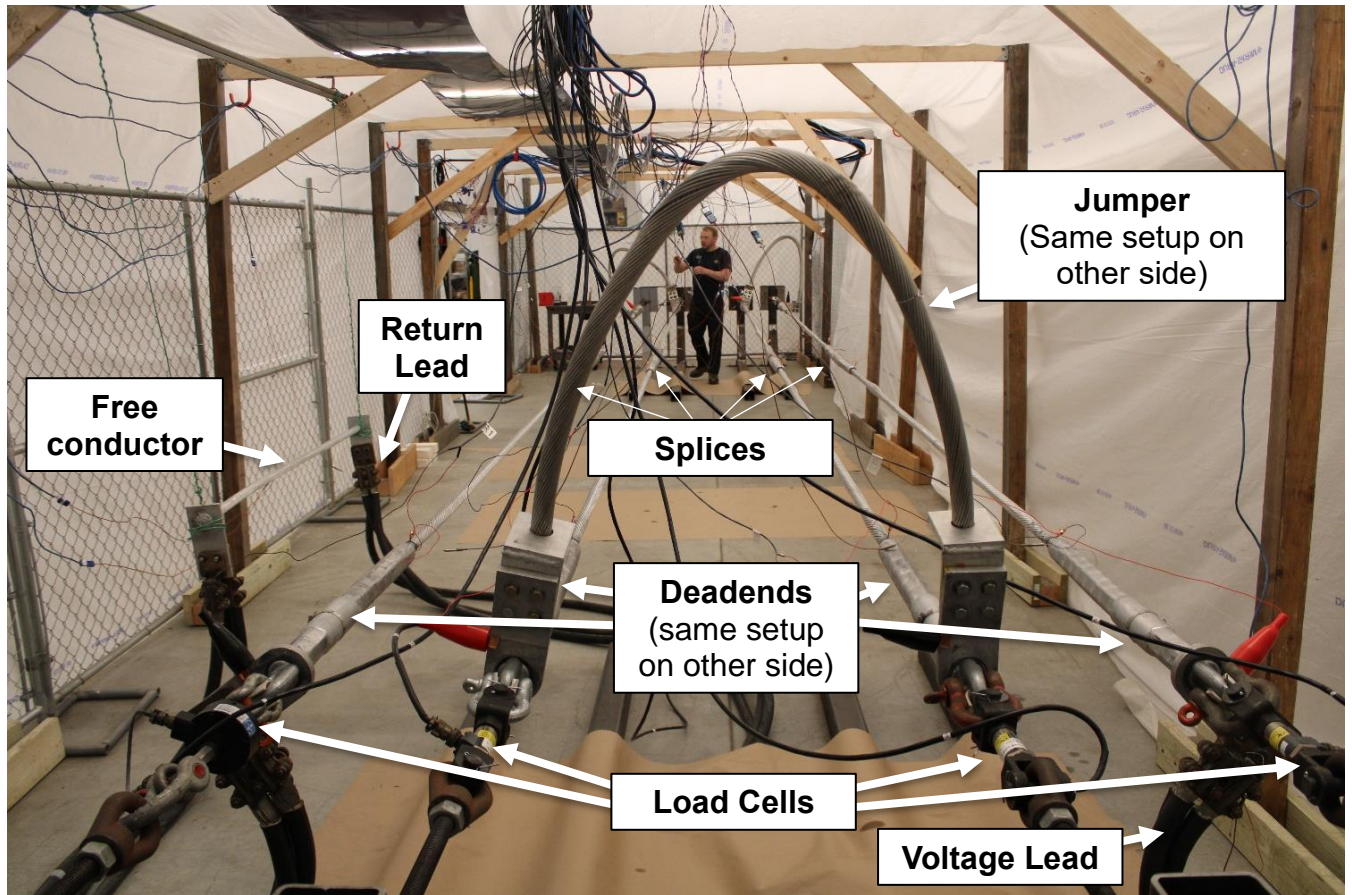


Figure 5: Photo of Test Cell – Series Loop

4.2.1 Test Event - Filler Port Pins

Inside the initial 25 cycles, the filler port plugs of 2 connectors ejected out of the aluminum body. The plugs were unable to be found; however, holes in the shielding plastic encapsulating the test were found; additionally, inhibitor was found on the ceiling of the lab located ~20 ft above the samples. As NEETRAC personnel were working around the test cell, immediate preventative measures were taken once the samples cooled to ambient temperature. 1/16" holes were drilled in the uncrimped zone of the aluminum bodies for each connector to act as pressure relief "vents" as the ejected pins could not be found. Prior to resuming the test and after discussing the event with the customer, the following actions were taken: the 1/16" holes were filled with aluminum screws and the filler port holes for the two connectors that ejected plugs were plugged with new plugs. Afterwards, hose clamps were fastened around the filler port plugs on all connectors.

5.0 RESULTS

The modified ANSI C119.4-2022 current cycling testing had four pass / fail criteria:

1. No connector may have a maximum temperature that exceeds the temperature of the control conductor. As shown in Figure 6, all connectors met this requirement.
2. All connectors must not have a temperature stability factor exceed ± 10 °C for each connector temperature measurement recorded at the test intervals specified in Table 9 of ANSI C119.0. As shown in Figure 7, all samples passed met this requirement.
3. For each connector, all DC resistance measurements recorded at the test intervals specified in Table 9 of ANSI C119.0 must be within $\pm 5\%$ of the average DC resistance. As shown in Figure 8, all connectors met this requirement.
4. Each connector must not experience slippage. Throughout the test, all connectors met this requirement as no slippage occurred.

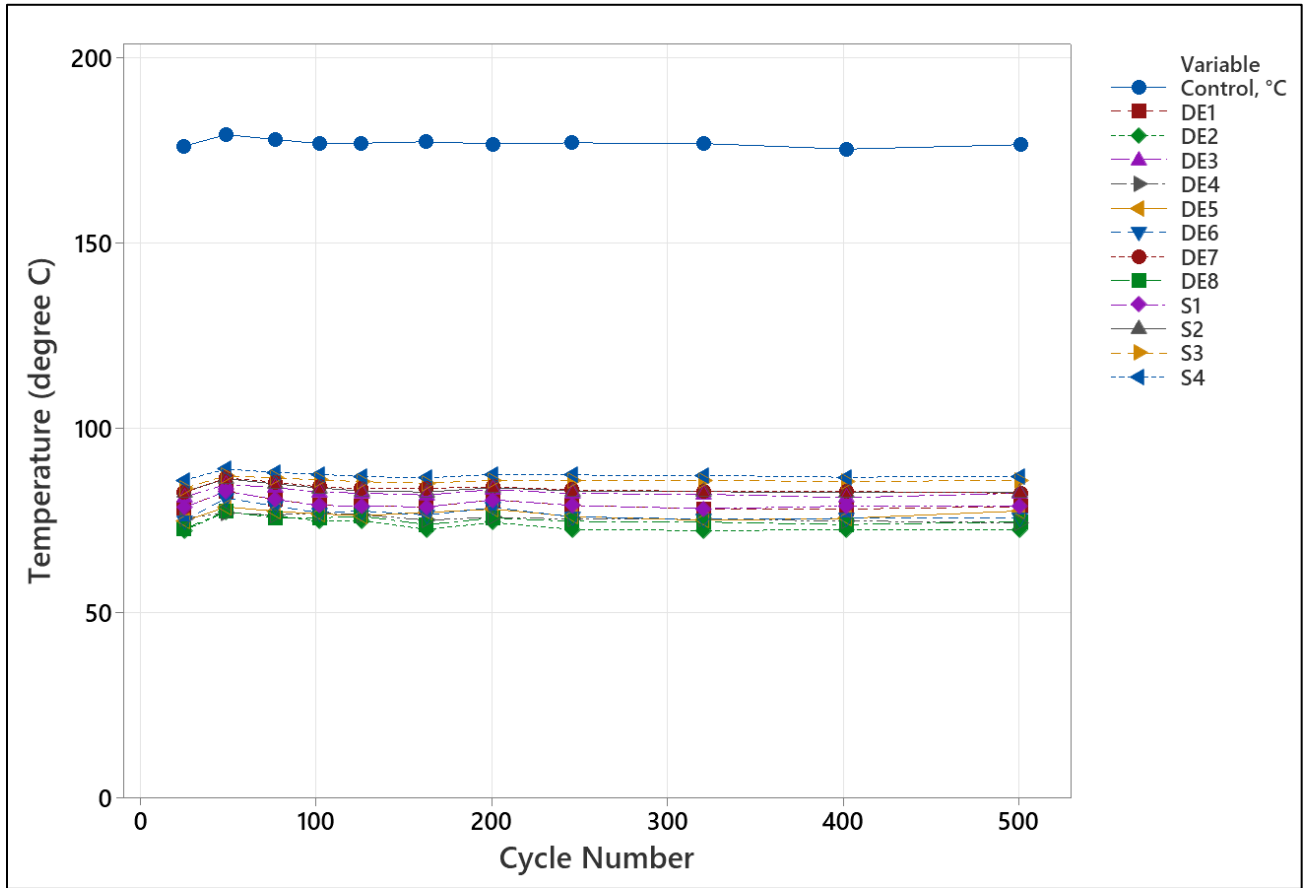


Figure 6: Max Temperature vs Cycle Number

- Per test requirements, a connector could not exceed the control conductor temperature. All connectors passed.

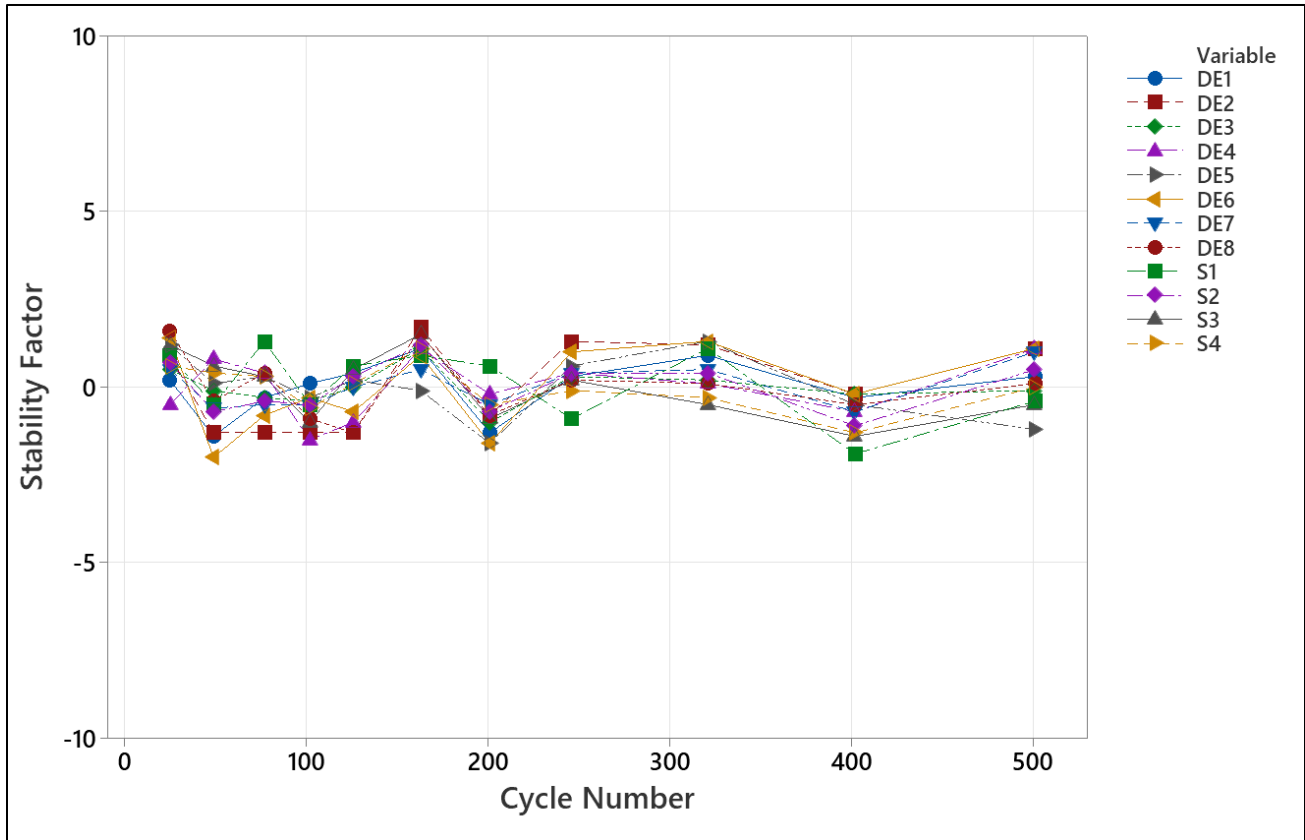


Figure 7: Temperature Stability Factor vs Cycle Number

- Per test requirements, the maximum allowable stability factor value was ± 10 . All connectors passed.

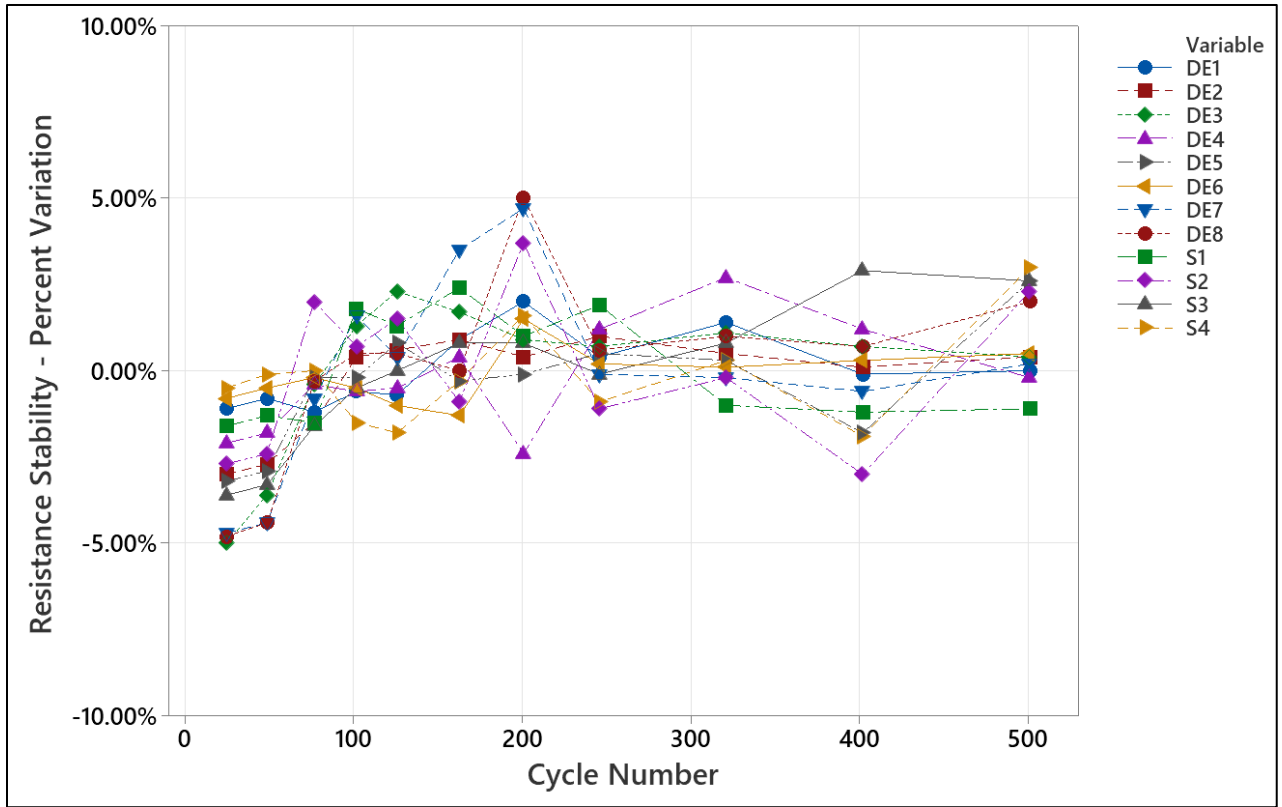


Figure 8: Resistance Stability vs Cycle Number

- Per test requirements, the maximum allowable percent variation was $\pm 5\%$. All connectors passed

6.0 CONCLUSION

Modified electrical testing per ANSI C119.4-2016 was performed on eight (8) AFL deadends (B135010-Y-TS) and four (4) compression joints (B4684-Y-T) installed on TS conductor, “Ruddy,” M3 8.5. The modifications included a tension scheme and a high temperature limit of 180 °C. The tension scheme consisted of applying an initial 10% of the conductor’s RBS load to the sample assemblies and resetting the tension to 10% of the conductor’s RBS at approximately every 25 cycles. Based on the requirements defined in the Results Section, all samples passed the test requirements.

7.0 ANSI C119.4 REQUIRED DECLARATIONS

- a. Test dates
 - 04/08/2024 to 11/05/2024
- b. ANSI C119.4-2016 standard used
- c. Facility and personnel
 - Test performed at NEETRAC's mechanical test facility located at 22 Kennedy Dr., Forest Park, GA 30297.
 - Personnel
 - Engineer in responsible charge: Joseph Goldenburg, P.E., Principal Research Engineer
 - Other engineering staff:
 - Engineer executing project under supervision: Tristen Cline, E.I.T, Research Engineer I
 - Test Technicians:
 - Oscar Rodriguez, Test Technician III
 - Ian Brown, Test Technician III
 - Kevin Garner, Test Technician IV
- d. For equipment used refer to Equipment Section.
- e. Connectors: AFL connector part numbers B135010-Y-TS (dead-end), B4684-Y-TS (compression joint), and HiTemp AFL Universal Compound
- f. Electrical Class: Class A
- g. Report is for electrical testing only
- h. Description of conductor: TS Conductor "Ruddy"; RBS = 42,510 lb & overall diameter of conductor = 1.131 in
- i. Installed per manufacturer's instructions, AFL Installation Instructions INS-ACA126 and AFL Installation Instructions INS-ACA127
- j. After 25 cycles, current on period used a setpoint of 1470 amps. Test would stop if a deviation of 10 amps was experienced.

- k. Connectors pass test requirements
- l. Test method: augmented version of CCT (high temperature limit of 180°C and tension scheme applied)
- m. Thermocouple locations were drilled into connectors, equalizer plates and wire ties were used for deadends, wire ties were used for compression joints.
- n. Details in report
- o. Details in report
- p. N/A

8.0 EQUIPMENT

CN7810 - Connector Test Cell DAQ and Control System

CN7788 - Honeywell 10 kip load cell

CN7789 - Honeywell 10 kip load cell

CN7790 - Honeywell 10 kip load cell

CN7814 - Morehouse 10 kip load cell

CQ6791 – DMO600 Micro-ohmmeter

9.0 STANDARDS

ANSI C119.4 American National Standard for Electric Connectors - Connectors for Use between Aluminum-to-Aluminum and Aluminum-to-Copper Conductors Designed for Normal Operation at or Below 93°C and Copper-to-Copper Conductors Designed for Normal Operation at or Below 100°C