# Long-Term Accelerated Aging Tests of the CTC Global Aluminum Conductor Composite Core Dublin Conductor

*Final Results*

**3002009962**

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Technical Update, March 2017

EPRI Project Manager

G. Sibilant

ELECTRIC POWER RESEARCH INSTITUTE
3420 Hillview Avenue, Palo Alto, California 94304-1338 ▪ PO Box 10412, Palo Alto, California 94303-0813 ▪ USA
800.313.3774 ▪ 650.855.2121 ▪ askepri@epri.com ▪ www.epri.com

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Principal Investigator
G. Sibilant

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# ABSTRACT

This report details the hardware, test setup, test parameters, and results of accelerated thermal mechanical aging tests as well as the results of the post-aging tests conducted on an aluminum conductor composite core (ACCC) conductor and associated connectors. These tests were performed as a follow-up to the long-term aging tests previously conducted by EPRI and described in report 3002007503, *Accelerated Aging Tests of High-Temperature, Low-Sag (HTLS) Conductor Systems: Test Results*.

In the earlier set of tests, the ACCC conductor exhibited anomalous performance, which was suspected of being an artifact of the relatively short test span employed in the EPRI testing. For the current report, tests were conducted on two test spans, each approximately 90 ft (27 m) in length. All of the connectors that formed the various conductor test setups were installed by CTC Global staff in the EPRI laboratory.

**Keywords**
ACCC conductor
AFL connectors
Burndy connectors
Post-thermal cycling tests
Thermal mechanical aging

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# 1
# INTRODUCTION AND BACKGROUND

The CTC Global aluminum conductor composite core (ACCC) conductor was tested at the EPRI facility in Charlotte, North Carolina. These tests were done as a follow-up to the long-term aging tests previously conducted by EPRI and described in report 3002007503, *Accelerated Aging Tests of High-Temperature, Low-Sag (HTLS) Conductor Systems: Test Results.*

In the earlier set of tests, the ACCC conductor exhibited anomalous performance, which was suspected of being an artifact of the relatively short test span employed in the EPRI testing. For the current report, tests were conducted on two test spans, each approximately 90 ft (27 m) in length. All of the connectors that formed the various conductor test setups were installed by CTC Global staff in the EPRI laboratory.

## Conductor Test Setup

Four conductor test configurations were set up as follows:

1. Initial setup
   a. Test span (splices and dead-ends)
   b. Return span with no splices
2. Long-term setup
   a. Second test span (splices and dead-ends)
   b. Return span: line with no splices; same as used in initial setup
3. Modified long-term setup
   a. Second test span: left from Test Setup 2
   b. Return span removed; a new span with splices and dead-ends installed
4. Final long-term setup
   a. Both test spans from the modified long-term setup removed
   b. Test Span 1: Burndy splices and dead-ends
   c. Test Span 2: AFL splices and dead-ends

All test spans were approximately 90 ft (27 m) in length, and the connectors were installed as recommended by the manufacturer unless otherwise noted.

## Initial Setup

One test span was made up of two dead-ends and two splices; the second test span (the return span) was made up of two dead-ends only. The splices and dead-ends in both spans were installed according to the manufacturer’s instructions.

Thermal analysis was undertaken before and after pre-stressing the test conductor span. This was done to determine whether the pre-stressing would have an effect on the initial thermal and mechanical performance of the conductor and connectors in the test.

The thermal analysis consisted of subjecting the conductor to a series of controlled power levels while measuring temperature at several points on the hardware fittings as well as several points along the conductor. The test line was tensioned to 25% of the conductor's rated breaking strength (RBS).

At the completion of the initial thermal analysis, the test line was tensioned to 18,000 lbf (80,068 newton) or 44% of the conductor's RBS and left overnight at this tension. The return line (line without splices) was not pre-tensioned.

The next day, the tension was lowered to the test tension of 25% of the conductor's RBS, and another set of thermal analysis test cycles was performed on the conductor. The thermal and tension profiles measured before and after pre-stressing were compared to one another. The test line was then removed from the test setup; the return line was left in the test setup.

### Long-Term Test Setup

For the long-term setup, the return span (no splices) was left in the test frame. A new test span was installed and consisted of two dead-ends and two splices. The test span was not pre-stressed; it was tensioned to 25% of the conductor's RBS.

### Modified Long-Term Test Setup

For the modified long-term setup, the test span was kept in the test frame, but a spliced return span was installed—this test span replaced the return span with no splices. The test span consisted of two dead-ends and two splices. The test span was pre-stressed to 44% of the conductor's RBS and left overnight. The next day, the tension was reduced to 25% of the conductor's RBS.

### Final Long-Term Test Setup

For the final long-term setup, both test spans that formed part of the modified long-term setup were removed. Two new test spans were installed: one had Burndy splices and dead-ends installed; the other had AFL splices and dead-ends installed. The Burndy connectors were installed using a modified procedure, while the AFL connectors were installed according to the manufacturer's instructions.

The Burndy mechanical connectors were installed with a modified pressing procedure. The unpressed connector's pressing section lengths are 14 in. (356 mm) on each side of the splice. The connectors were forward pressed from 10 in. (254 mm) from the mouth, and the remaining 4 in. (102 mm) were reversed pressed. The modified pressing procedure was followed to replicate the strand behavior of the AFL hardware and extrude an equal amount of outer aluminum strands into the test span.

# 2

# CONDUCTOR AND CONNECTORS TESTED

The test conductor and connectors that formed part of the tests are described in this section.

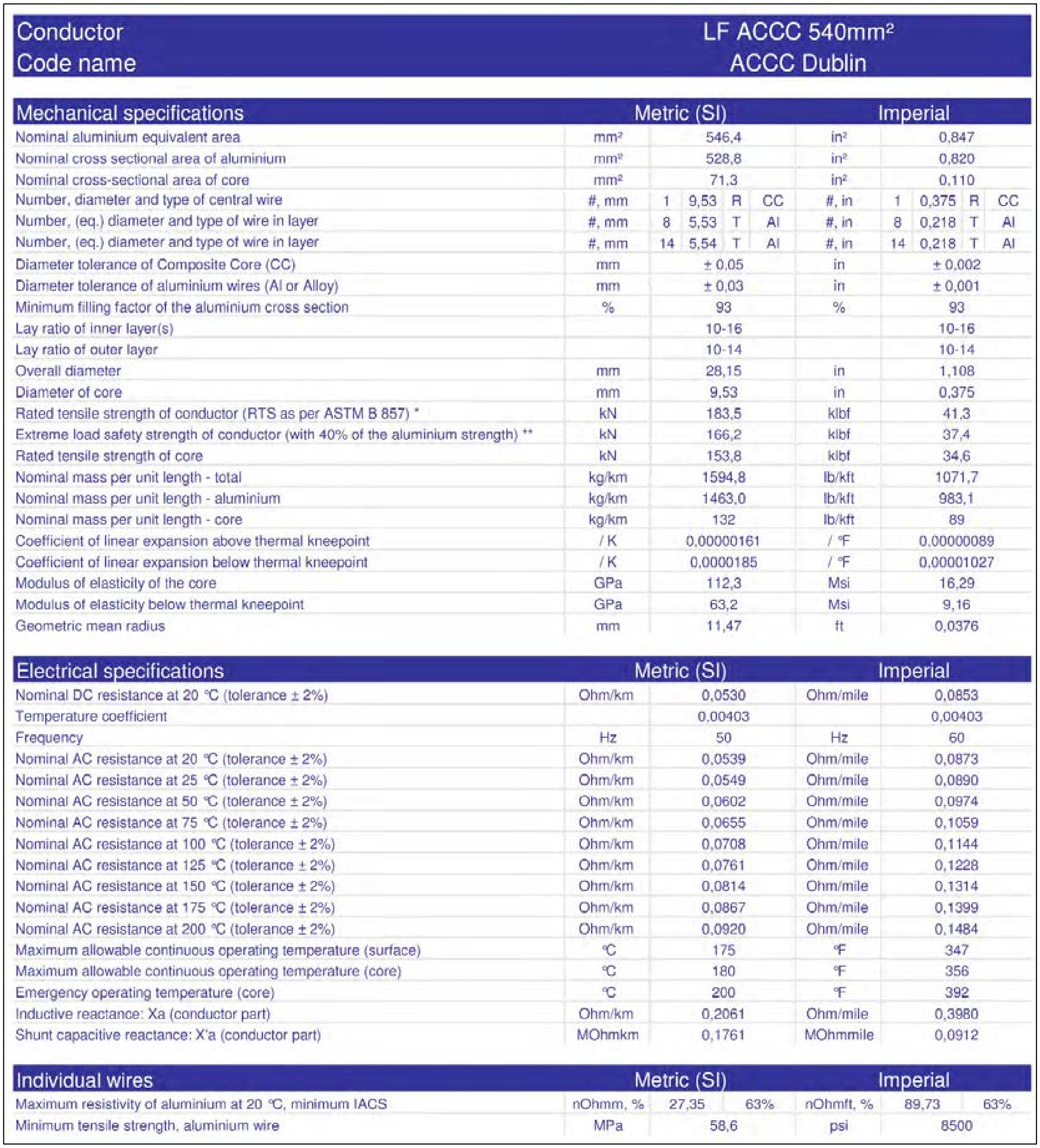
## Test Conductor

The conductor used in the tests was the ACCC Dublin conductor, which was stranded by Lamifil in Europe. The conductor's outer diameter is similar to that of the Drake aluminum conductor steel-reinforced (ACSR) diameter; however, the equivalent aluminum area of the ACCC conductor is larger. Information on the conductor used in the tests is shown in Table 2-1, and the conductor specifications are listed in Table 2-2.

**Table 2-1**
**Conductor used in the tests**

| Company | Conductor Name | Description |
|---|---|---|
| CTC | Aluminum conductor composite core (ACCC): Dublin | 1350: Fully annealed aluminum outer strands; composite carbon core |
|  | | |

**Table 2-2**
**Conductor specifications**



| Conductor | LF ACCC 540mm$^2$ |
|---|---|
| Code name | ACCC Dublin |

| Mechanical specifications | Metric (SI) | | | | | Imperial | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Nominal aluminium equivalent area | mm$^2$ | 546,4 | | | | in$^2$ | 0,847 | | | |
| Nominal cross sectional area of aluminium | mm$^2$ | 528,8 | | | | in$^2$ | 0,820 | | | |
| Nominal cross-sectional area of core | mm$^2$ | 71,3 | | | | in$^2$ | 0,110 | | | |
| Number, diameter and type of central wire | #, mm | 1 | 9,53 | R | CC | #, in | 1 | 0,375 | R | CC |
| Number, (eq.) diameter and type of wire in layer | #, mm | 8 | 5,53 | T | Al | #, in | 8 | 0,218 | T | Al |
| Number, (eq.) diameter and type of wire in layer | #, mm | 14 | 5,54 | T | Al | #, in | 14 | 0,218 | T | Al |
| Diameter tolerance of Composite Core (CC) | mm | ± 0,05 | | | | in | ± 0,002 | | | |
| Diameter tolerance of aluminium wires (Al or Alloy) | mm | ± 0,03 | | | | in | ± 0,001 | | | |
| Minimum filling factor of the aluminium cross section | % | 93 | | | | % | 93 | | | |
| Lay ratio of inner layer(s) | | 10-16 | | | | | 10-16 | | | |
| Lay ratio of outer layer | | 10-14 | | | | | 10-14 | | | |
| Overall diameter | mm | 28,15 | | | | in | 1,108 | | | |
| Diameter of core | mm | 9,53 | | | | in | 0,375 | | | |
| Rated tensile strength of conductor (RTS as per ASTM B 857) * | kN | 183,5 | | | | klbf | 41,3 | | | |
| Extreme load safety strength of conductor (with 40% of the aluminium strength) ** | kN | 166,2 | | | | klbf | 37,4 | | | |
| Rated tensile strength of core | kN | 153,8 | | | | klbf | 34,6 | | | |
| Nominal mass per unit length - total | kg/km | 1594,8 | | | | lb/kft | 1071,7 | | | |
| Nominal mass per unit length - aluminium | kg/km | 1463,0 | | | | lb/kft | 983,1 | | | |
| Nominal mass per unit length - core | kg/km | 132 | | | | lb/kft | 89 | | | |
| Coefficient of linear expansion above thermal kneepoint | / K | 0,00000161 | | | | / °F | 0,00000089 | | | |
| Coefficient of linear expansion below thermal kneepoint | / K | 0,0000185 | | | | / °F | 0,00001027 | | | |
| Modulus of elasticity of the core | GPa | 112,3 | | | | Msi | 16,29 | | | |
| Modulus of elasticity below thermal kneepoint | GPa | 63,2 | | | | Msi | 9,16 | | | |
| Geometric mean radius | mm | 11,47 | | | | ft | 0,0376 | | | |

| Electrical specifications | Metric (SI) | | Imperial | |
|---|---|---|---|---|
| Nominal DC resistance at 20 °C (tolerance ± 2%) | Ohm/km | 0,0530 | Ohm/mile | 0,0853 |
| Temperature coefficient | | 0,00403 | | 0,00403 |
| Frequency | Hz | 50 | Hz | 60 |
| Nominal AC resistance at 20 °C (tolerance ± 2%) | Ohm/km | 0,0539 | Ohm/mile | 0,0873 |
| Nominal AC resistance at 25 °C (tolerance ± 2%) | Ohm/km | 0,0549 | Ohm/mile | 0,0890 |
| Nominal AC resistance at 50 °C (tolerance ± 2%) | Ohm/km | 0,0602 | Ohm/mile | 0,0974 |
| Nominal AC resistance at 75 °C (tolerance ± 2%) | Ohm/km | 0,0655 | Ohm/mile | 0,1059 |
| Nominal AC resistance at 100 °C (tolerance ± 2%) | Ohm/km | 0,0708 | Ohm/mile | 0,1144 |
| Nominal AC resistance at 125 °C (tolerance ± 2%) | Ohm/km | 0,0761 | Ohm/mile | 0,1228 |
| Nominal AC resistance at 150 °C (tolerance ± 2%) | Ohm/km | 0,0814 | Ohm/mile | 0,1314 |
| Nominal AC resistance at 175 °C (tolerance ± 2%) | Ohm/km | 0,0867 | Ohm/mile | 0,1399 |
| Nominal AC resistance at 200 °C (tolerance ± 2%) | Ohm/km | 0,0920 | Ohm/mile | 0,1484 |
| Maximum allowable continuous operating temperature (surface) | °C | 175 | °F | 347 |
| Maximum allowable continuous operating temperature (core) | °C | 180 | °F | 356 |
| Emergency operating temperature (core) | °C | 200 | °F | 392 |
| Inductive reactance: Xa (conductor part) | Ohm/km | 0,2061 | Ohm/mile | 0,3980 |
| Shunt capacitive reactance: X'a (conductor part) | MOhmkm | 0,1761 | MOhmmile | 0,0912 |

| Individual wires | Metric (SI) | | | Imperial | | |
|---|---|---|---|---|---|---|
| Maximum resistivity of aluminium at 20 °C, minimum IACS | nOhmm, % | 27,35 | 63% | nOhmft, % | 89,73 | 63% |
| Minimum tensile strength, aluminium wire | MPa | 58,6 | | psi | 8500 | |

## Test Connectors

Two different connectors were used in these tests. One set of connectors was manufactured by Burndy; information on these connectors is listed in Table 2-3. The second set of connectors was manufactured by AFL Global; information on these is given in Table 2-4.

**Table 2-3**
**Burndy connectors used in the tests**

| Conductor | Connector Manufacturer | Connector Description |
|---|---|---|
| ACCC<br>(CTC) | Burndy | The connectors use a collet gripping system to mechanically connect to the core of the conductor. No compression grip is used on the core.<br>A sleeve is inserted between the conductor aluminum strands and the outer aluminum housing, and then the outer housing is compressed onto the conductor. |
|  | | |

**Table 2-4**
**AFL connectors used in the tests**

<table>
<tr><th>Conductor</th><th>Connector Manufacturer</th><th>Connector Description</th></tr>
<tr><td>ACCC (CTC)</td><td>AFL Global</td><td>Two-stage compression connector. An extra sheath is placed on the core section inside the connector before the core grip piece is crimped onto the conductor core.</td></tr>
<tr><td colspan="3"></td></tr>
</table>

# 3
# MEASUREMENTS

Temperature and tension measurements were monitored continuously during the tests. Resistance measurements were taken periodically, initially every 100–150 cycles and later at 50-cycle intervals.

## Temperature Measurements

All temperature measurements were made using K-type temperature probes (thermocouples). Measurements were made by drilling a hole in the surface to be measured (connector or conductor) and then placing the temperature-sensitive thermocouple tip inside the drilled hole. Once the thermocouple tip was inserted into the hole, the hole was peened closed. An example of the thermocouple inserted into a connector is shown in Figure 3-1.

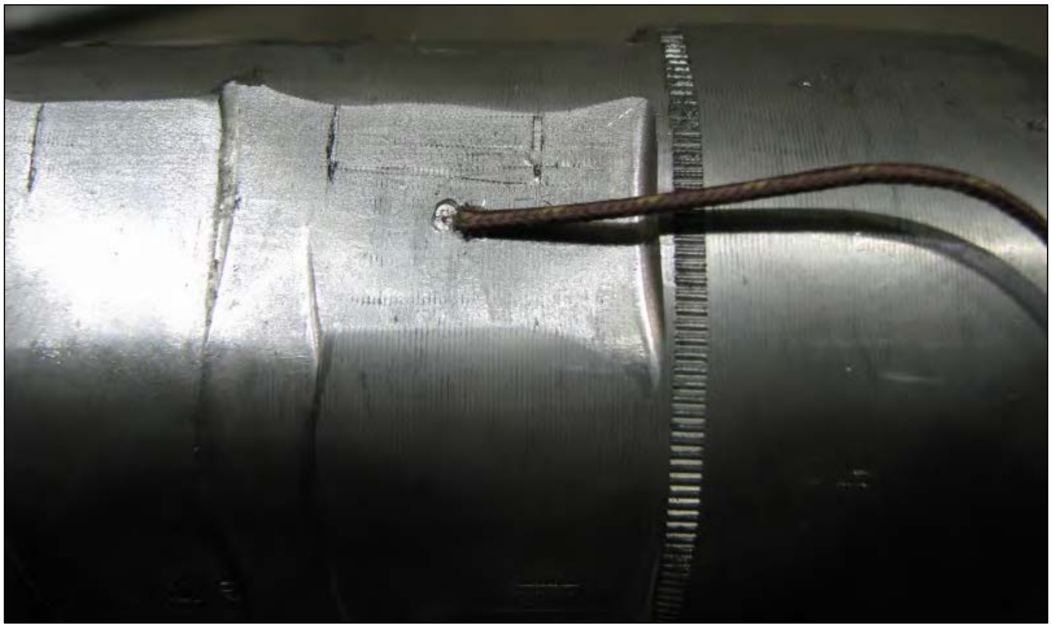


**Figure 3-1**
**Thermocouple in drilled hole**

Thermocouples were placed on all connectors included in the tests. Temperature measurements were also made at the conductor/connector interface. Temperature measurements were taken every 5 minutes and stored in the control and data acquisition computer system.

All of the connectors had more than one thermocouple measurement point, and data were collected from all of these thermocouples. An example of the thermocouple placement on one connector can be seen in Figure 3-2.

Figure 3-2
Example of the thermocouple placement

A connector in a healthy condition should have a temperature profile that is well below that of the conductor's temperature profile. In these tests, a connector would be classified as having failed the test if its temperature exceeds that of the conductor.

## Tension Measurements

Each conductor was connected mechanically to the test frame by an insulator bell to provide electrical isolation. A calibrated load cell was connected in series between the insulator and the test frame; the configuration is shown in Figure 3-3.

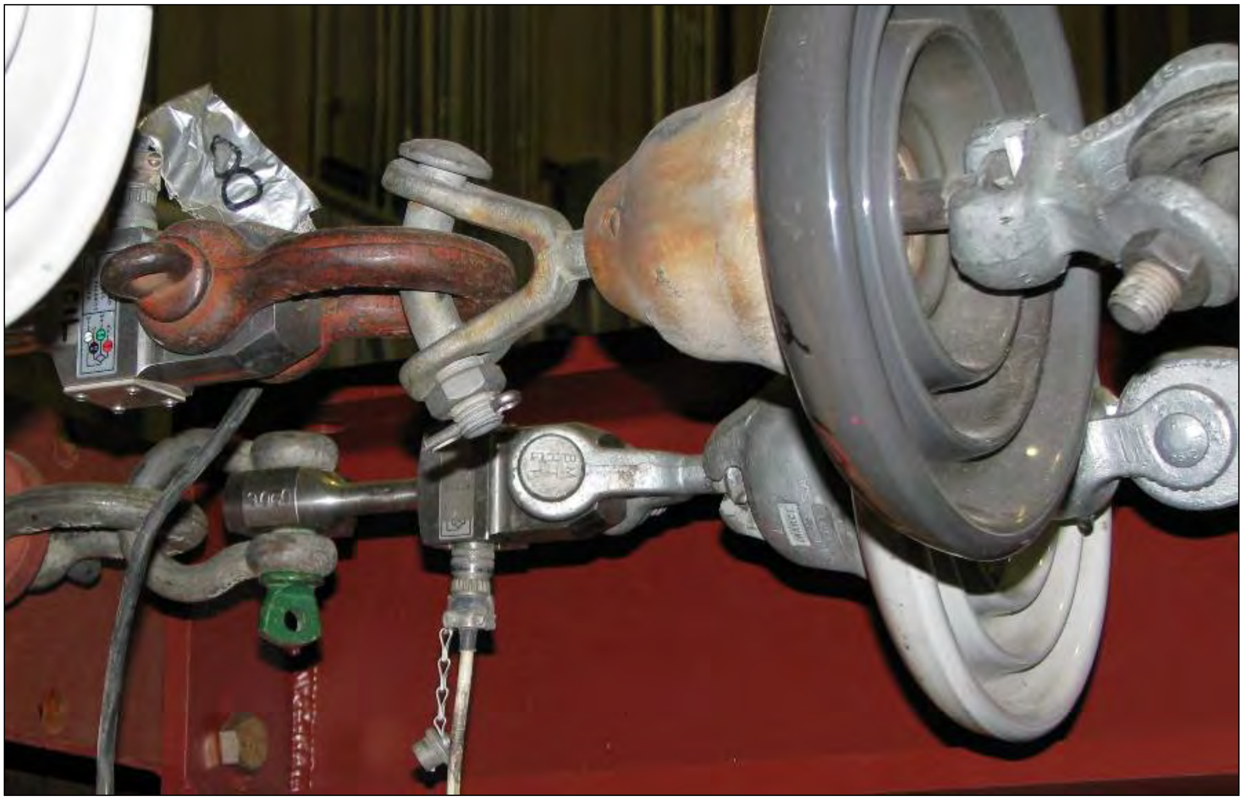


Figure 3-3
In-line load cells

The conductors were tensioned to 25% of their RBS as specified by the manufacturers. The change in tension during the thermal tests was recorded every 5 minutes and stored in the data acquisition system.

### Resistance Measurements

Resistance measurements were taken at regular intervals. An initial baseline measurement was made before the tests started. The first few resistance measurements were done in 150–200 cycle intervals.

A properly made, new connector would have a resistance value lower than that of the same length conductor. A connector would fail these tests if the resistance of the connector exceeded that of the conductor.

### Radiography

All connectors were radiographed before the thermal cycling tests began and again after the 1500 cycles had been completed.

# 4
# THERMAL MECHANICAL RESULTS OVERVIEW

## Test Protocol

The CTC Global ACCC conductor was tested at the EPRI facility in Charlotte. Two spans, each approximately 90 ft (27 m) in length, were tested. Each span had two dead-ends and two splices with about 30 ft (9 m) of separation between each connector in series. One test span had AFL compression connectors installed; the other had Burndy (collet-type) connectors installed.

The test plan called for the completion of 1500 thermal mechanical cycles. Each cycle lasted for approximately 5 hours and consisted of a heating period, a period of constant temperature, and a cooldown period.

The test control temperature was set to the maximum continuous operating temperature on the surface of the conductor: 180°C. Surface temperature profiles for the two spans for three thermal cycles are shown in Figure 4-1.

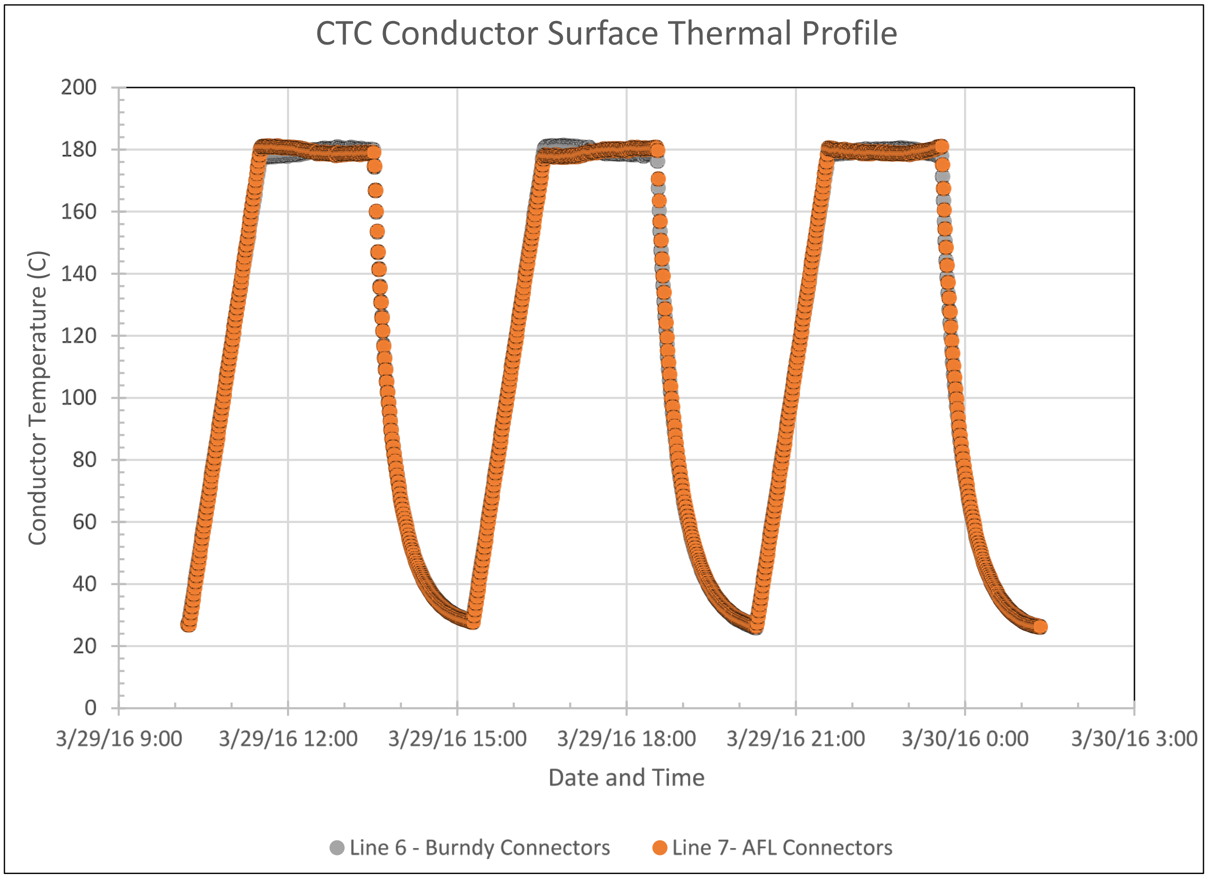


**Figure 4-1**
**Conductor surface thermal profiles for three thermal cycles**

The conductor was initially tensioned at 25% of its RBS. The tension was not held constant but was allowed to vary as the conductor heated up and cooled down during each cycle. The test lines were re-tensioned if the tension measured at the end of the cooling period was lower than 20% of the conductor's RBS. Tension profiles for both test lines are shown in Figure 4-2.

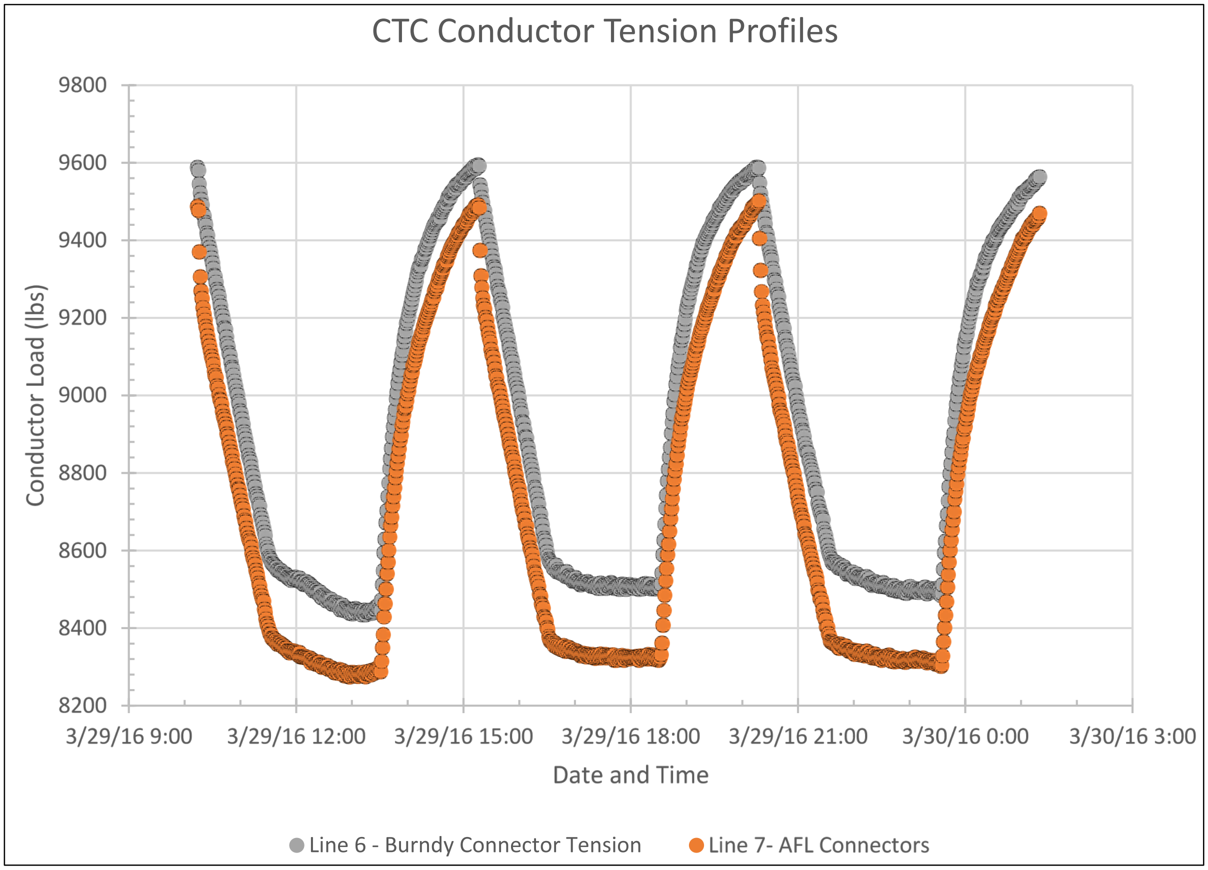


**Figure 4-2**
**Conductor tension profiles for three thermal cycles**

The 1500 thermal mechanical cycles testing was completed at 4:04 pm on November 13, 2016.

## Thermal and Tension Profiles

The 1500-cycle thermal and tension profiles for the two test lines are shown in Figures 4-3 and 4-4.

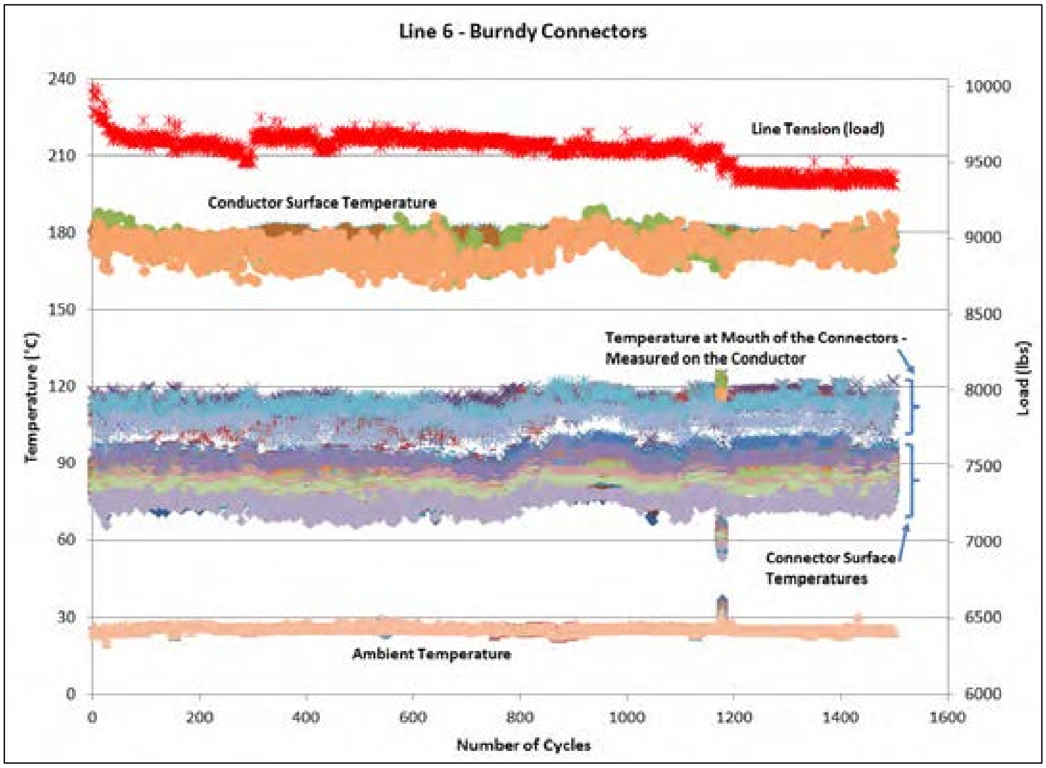


**Figure 4-3**
**Line 6 thermal profiles and tension: Burndy connectors**

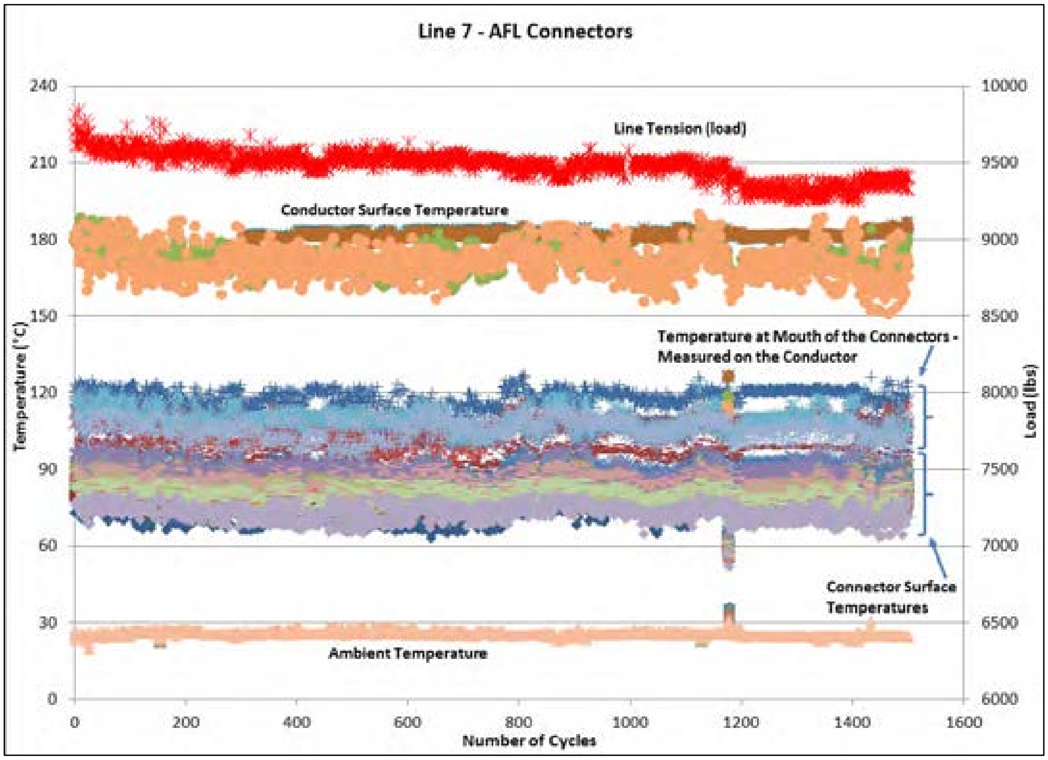


**Figure 4-4**
**Line 7 thermal profiles and tension: AFL connectors**

The initial line temperature control was linked to the green thermocouple data set; however, it was later changed to a more accurate thermocouple arrangement, which is shown in the brown data set. A similar change was made on Line 7, where the more accurate brown data points are more visible.

The line tension for Line 6 has dropped from the initial tension of 10,325 lb (4683 kg) (25% RBS) down to 9357 lb (4244 kg). This lower value is approximately 22.8% of the conductor's RBS. The conductor span was not re-tensioned during the 1500 test cycles.

The connector temperatures were generally below 100°C. The splice surface temperatures were found to be higher than the dead-end surface temperatures.

The initial line temperature control was linked to the green thermocouple data set; however, it was later changed to a more accurate thermocouple arrangement, which is shown in the brown data set.

The line tension for Line 7 has dropped from the initial tension of 10,325 lb (4683 kg) (25% RBS) down to 9324 lb (4229 kg). This lower value is approximately 22.7% of the conductor's RBS. The conductor span was not re-tensioned during the 1500 test cycles.

The connector temperatures were generally below 105°C. The splice surface temperatures were found to be higher than the dead-end surface temperatures.

### Resistance Profiles

The 1500-cycle thermal and tension profiles for the two test lines are shown in Figures 4-5 and 4-6. From these figures, it can be seen that the resistance values for the connectors were stable. The resistance values did not increase much during the thermal cycles for almost all of the connectors in the test. The one exception was Line 6: DE1, a Burndy dead-end. This connector experienced a 10 μΩ increase in its resistance value (that is, a 43.5% increase).

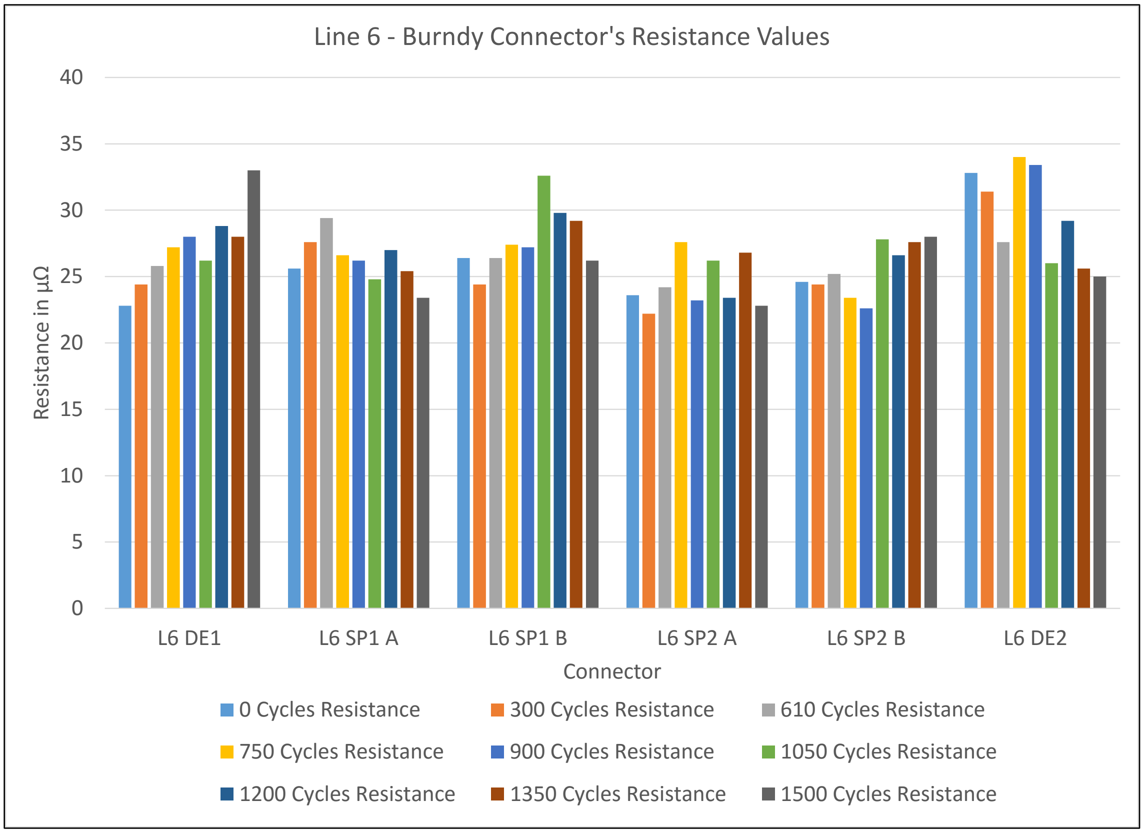


**Figure 4-5**
**Line 6 resistance profiles**

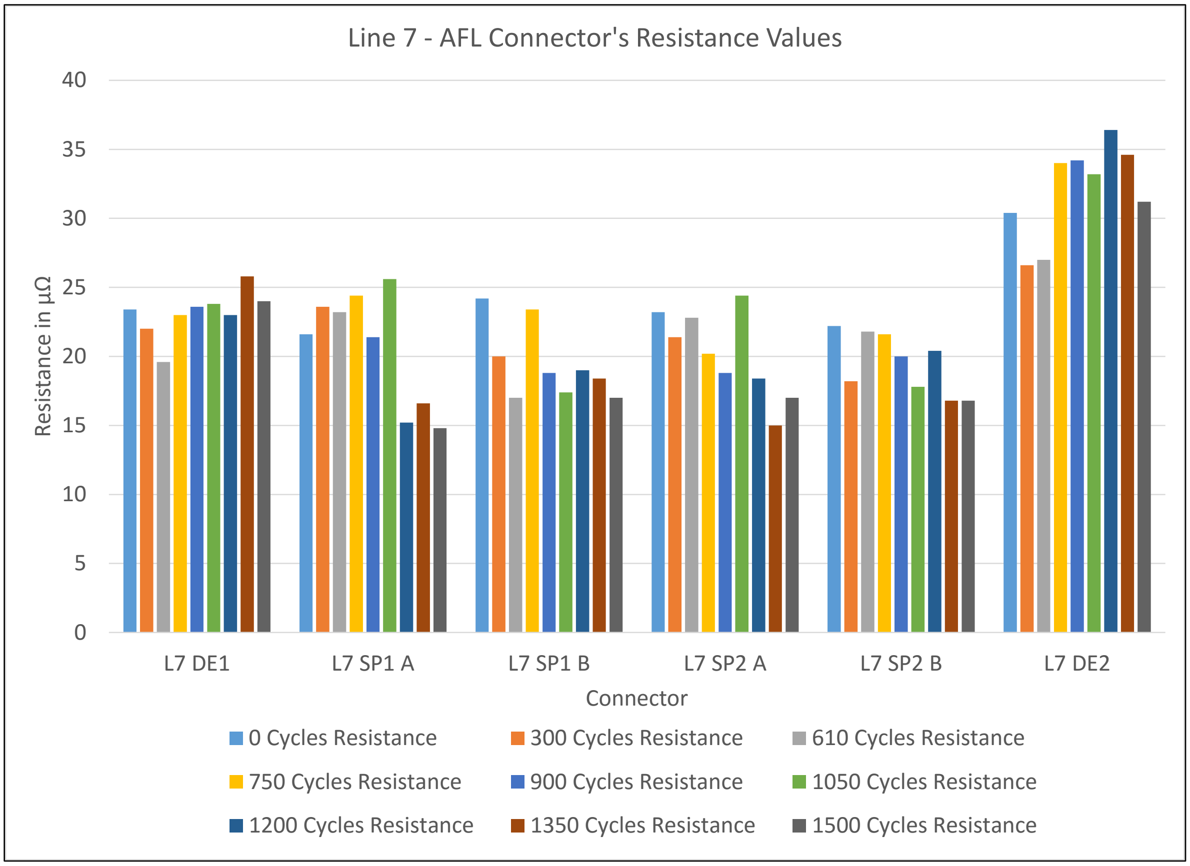


**Figure 4-6**
**Line 7 resistance profiles**

# 5

# POST-THERMAL CYCLING TESTS AND RESULTS

## Tests Undertaken

At the end of the 1500 thermal mechanical test cycles the test spans were cut into pieces and sent to the CTC facility for testing, the following tests were done:

1. Conductor Tensile Tests
2. Connector Tensile Tests
3. Glass Temperature Transition
4. Core Shear Strength
5. Core Tensile Tests

All post thermal cycling tests were done at the CTC facility in Irvine California. An EPRI representative witnessed the testing.

## Conductor Tensile Tests

An aged section of the conductor was tensile tested to determine the residual strength left after thermal-mechanical aging. A new conductor sample was also tested, this was done to get a baseline strength which the aged sample strength could be compared against. The manufacturers rated breaking strength was given as 41,200 lbs. The aged conductors and connectors tested had to equal or exceed 95% (39140 lbs) of the manufacturer's rated breaking strength for a new conductor. The results of the tests are shown in Table 5-1:

**Table 5-1**
**Conductor Tensile Strength**

| Sample | Breaking Load in lbs | % RBS |
|---|---|---|
| Unaged Conductor | 42367 | 102.8 |
| Aged Conductor | 48763 | 118.4 |

From the results in Table 3-1 it can be seen that both the aged and unaged conductor sample broke at loads above the RBS. Similar tests done on other HTLS conductors have shown a similar trend, i.e. the aged sample breaks at a higher load than the unaged sample. A photograph showing a conductor sample in the tensile test bed is shown in Figure 5-1.

**Figure 5-1**
**Conductor sample in tensile test bed**

## Connector Tensile Tests

All the connectors which formed part of the tests were tensile tested to determine the residual strength left after thermal-mechanical aging. New connector samples were also tested, this was done to get a baseline strength which the aged samples strengths could be compared against. Connector strength is rated at 95% of the conductors RBS.

The results of the AFL Connector tensile tests are shown in Table 5-2:

**Table 5-2**
**AFL Connector Tensile Strength**

| Sample | Breaking Load in lbs | % RBS | Notes |
|---|---|---|---|
| New AFL Splice | 39977 | 97.0 | Conductor pulled out of Epoxy Grip |
| Aged AFL Splice 1 | 47758 | 115.9 | Splice Pullout |
| Aged AFL Splice 2 | 47921 | 116.3 | Conductor Break |
| New AFL Dead-end | 37746 | 91.6 | Conductor pulled out of Epoxy Grip |
| Aged AFL Dead-end 1 | 47488 | 115.3 | Conductor Break |
| Aged AFL Dead-end 2 | 48385 | 117.4 | DE Pullout |

From Table 5-2 it can be noted that the New Splice and Dead-end samples pulled out of the epoxy resin end fittings below the 100% rated strength. The conductor did not break, nor did the conductor slip out of the splice or dead-end. The AFL epoxy resin end fittings for the new samples were the first to be cured. It is believed that the curing was not completed properly which led to the lower slip epoxy slip out values. All the aged fittings exceeded 115% of the conductors rated breaking strength. Images of the AFL samples tested are shown in Figure 5-1 to Figure 5-7.

**Figure 5-2**
**Conductor pullout from the Epoxy Fitting – AFL new splice**

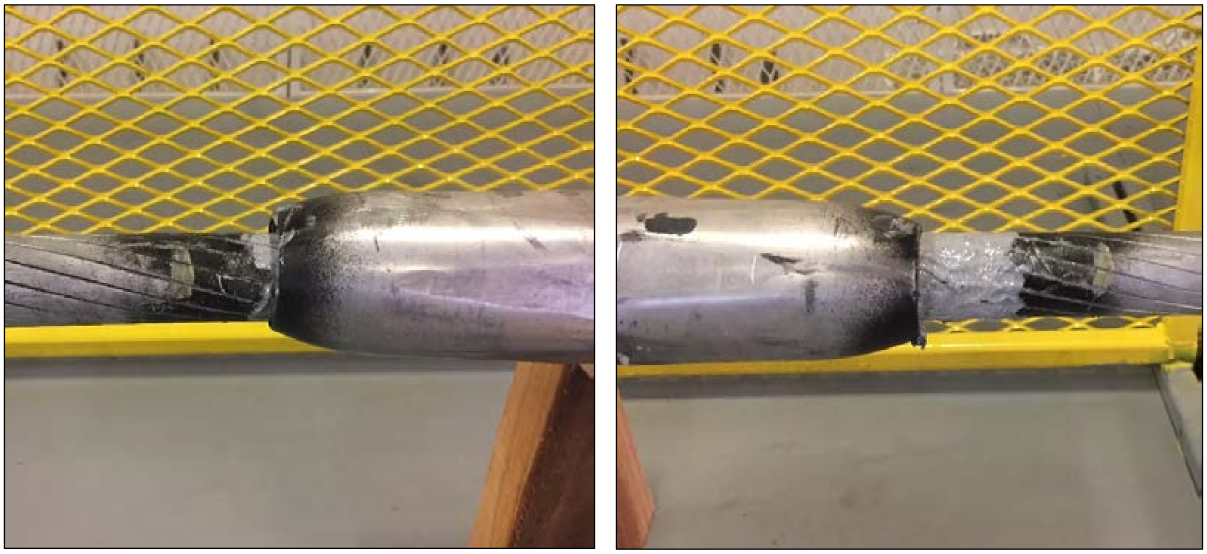


**Figure 5-3**
**Conductor pullout on left hand side of splice – AFL splice 1**

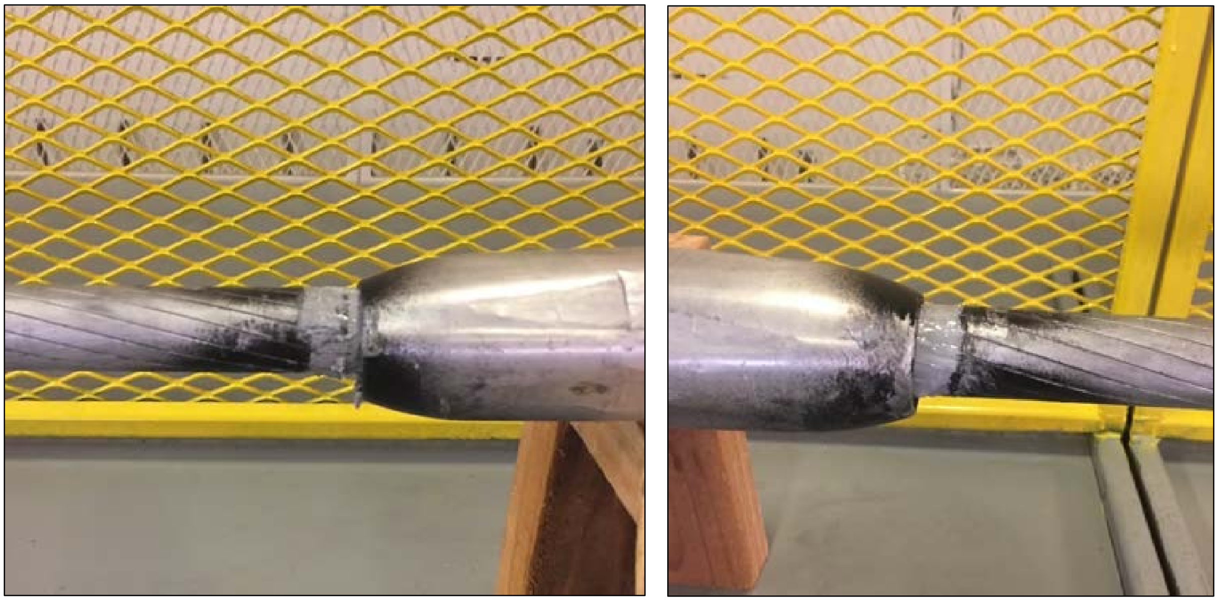


**Figure 5-4**
**Conductor pullout on both sides of splice – AFL splice 2**

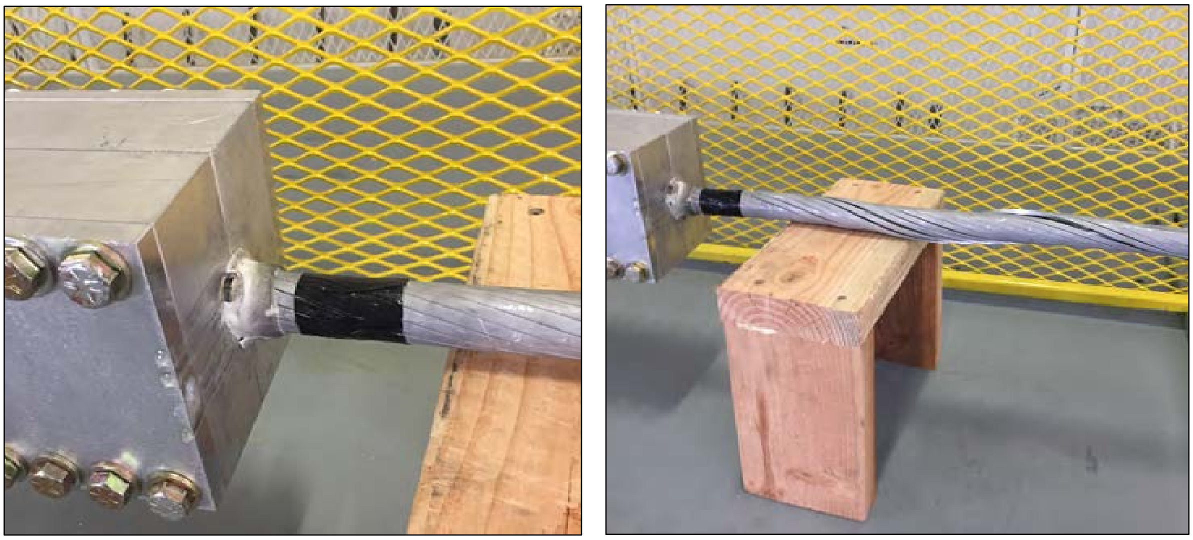


**Figure 5-5**
**Epoxy conductor slippage – AFL new dead-end**

**Figure 5-6**
**Conductor break – AFL dead-end 1**

**Figure 5-7**
**Conductor pulled out of dead-end – AFL dead-end 2**

The results of the Burndy Connector tensile tests are shown in Table 5-3:

**Table 5-3**
**Burndy Connector Tensile Strength**

| Sample | Breaking Load in lbs | % RBS | Notes |
|---|---|---|---|
| New Burndy Splice | 43703 | 106.1 | Conductor broke in Epoxy fitting |
| Aged Burndy Splice 1 | 45761 | 111.1 | Conductor slipped out of fitting |
| Aged Burndy Splice 2 | 45785 | 111.1 | Conductor broke |
| New Burndy Dead-end | 43064 | 104.5 | Conductor broke just out of epoxy fitting |
| Aged Burndy Dead-end 1 | 46591 | 113.1 | Conductor broke |
| Aged Burndy Dead-end 2 | 45623 | 110.7 | Conductor broke |

From Table 5-3 it can be noted that all the Burndy unaged and aged fittings exceeded 100% of the conductors rated breaking strength. It is interesting to note that the aged fittings had higher breaking strengths than the unaged samples. Images of the Burndy samples being tested are shown in Figure 5-8 to Figure 5-13.

**Figure 5-8**
**Conductor break in epoxy fitting – Burndy new splice**

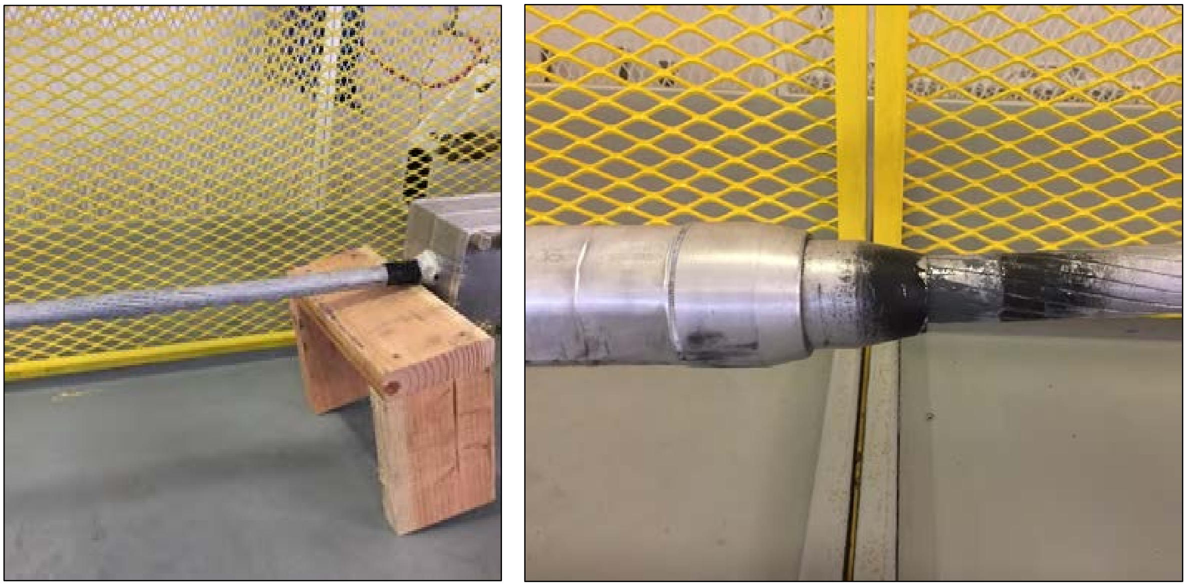


**Figure 5-9**
**Conductor pulled out of splice – Burndy splice 1**

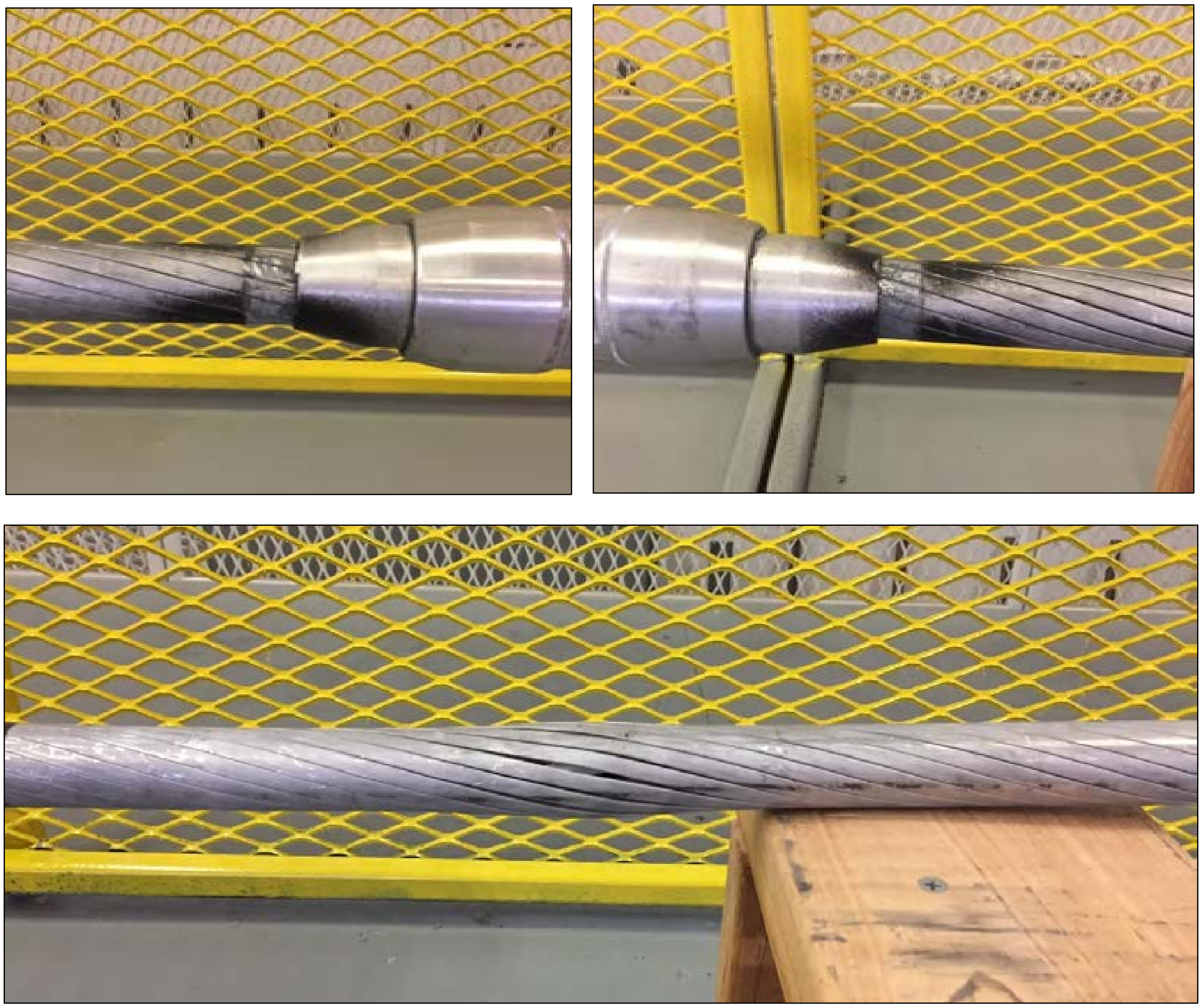


**Figure 5-10**
**Conductor break – Burndy splice 2**

**Figure 5-11**
**Conductor broke just out of epoxy fitting and seating in fitting – Burndy new dead-end**

**Figure 5-12**
**Conductor break – Burndy dead-end 1**

**Figure 5-13**
**Conductor break – Burndy dead-end 2**

The breaking loads for the conductor and AFL and Burndy connectors are represented graphically in Figure 5-14.

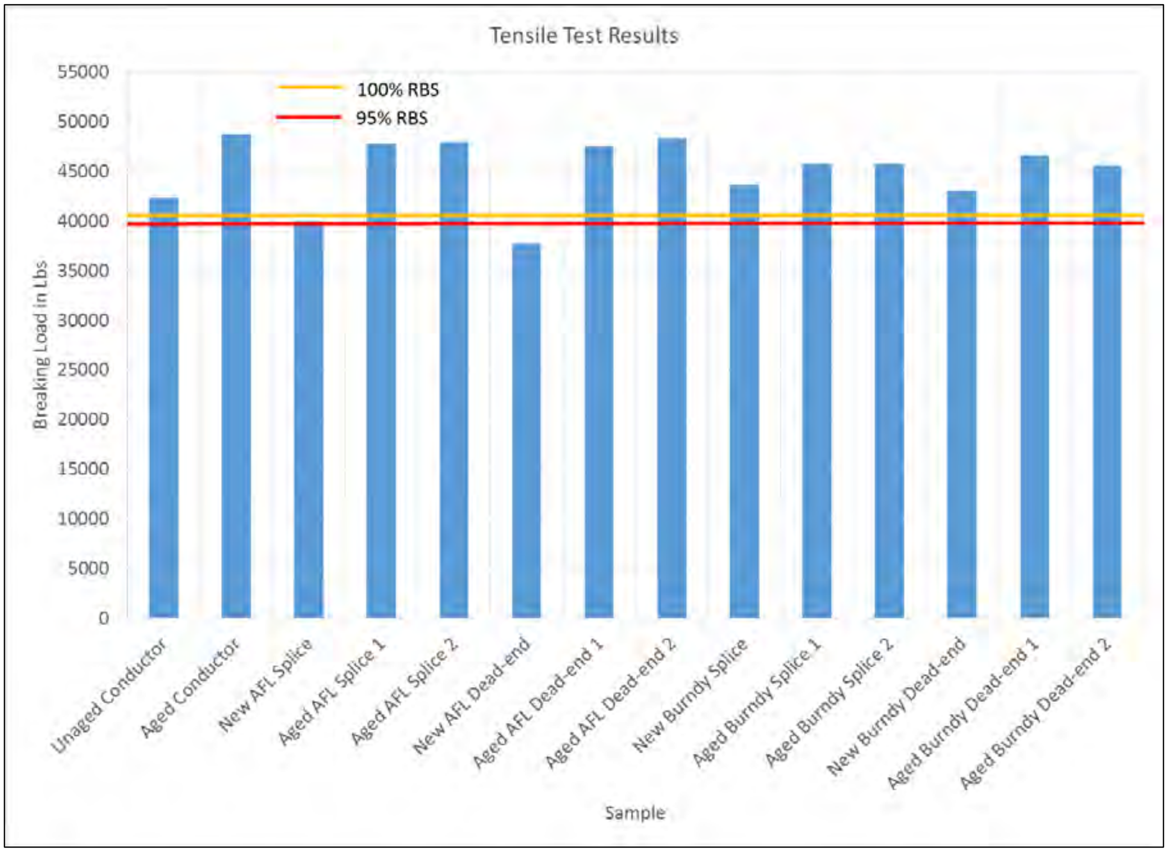


**Figure 5-14**
**Breaking loads**

## Glass Temperature ($T_g$) Transition Tests

This test determines the temperature at which the properties of the composite core materials of the conductor change. It provides an indication of the maximum allowable operating temperature of the conductor. The test uses dynamic mechanical analysis (DMA) to determine the glass transition temperature (Tg) of the composite materials. The test follows, as closely as possible, the procedure described in ASTM D7028-07 [3] and IEC 1006 [4] standards. Figure 5-15 shows an example of a DMA scan. The Tg is taken to be the temperature of the maximum loss modulus (E'') – indicated by the arrow in Figure 5-15. The initial and final Tg temperatures were measured using the same test method.

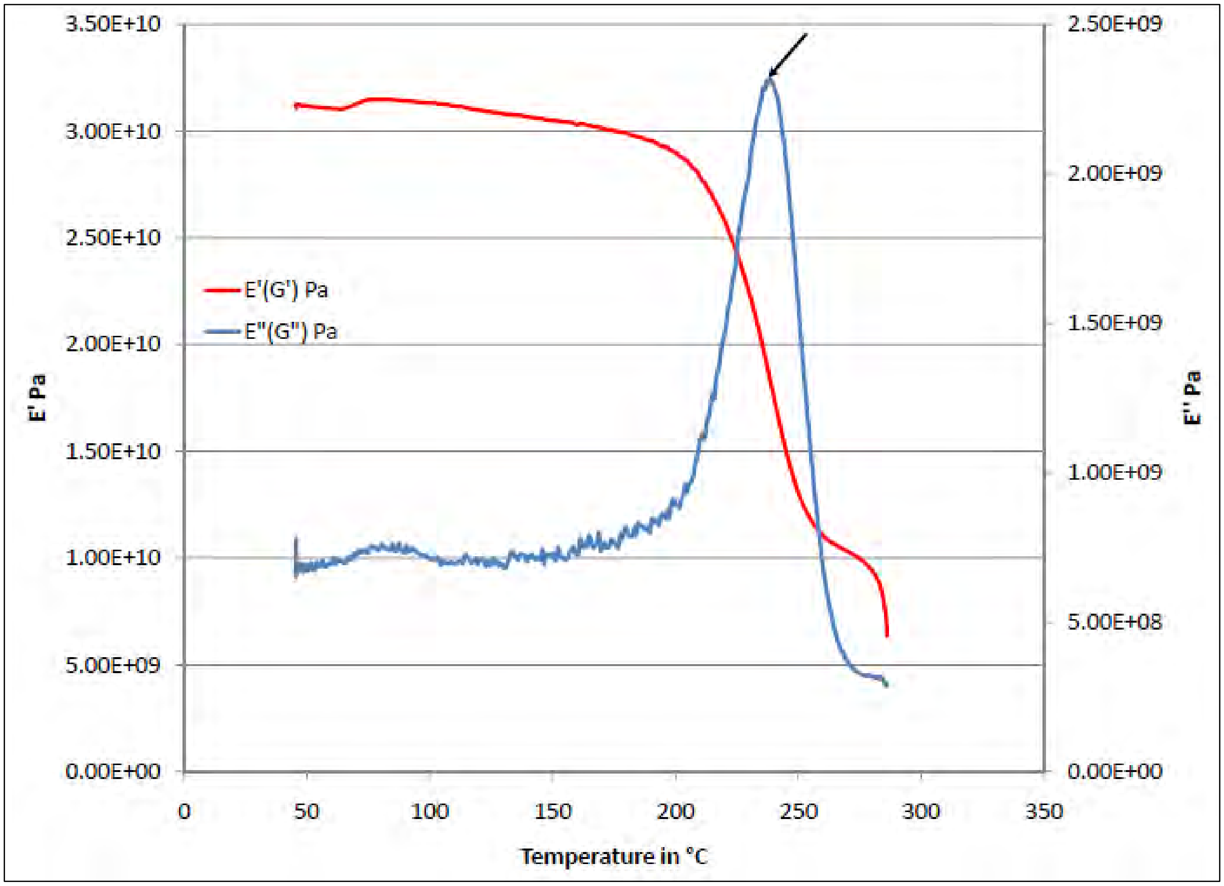


**Figure 5-15**
**DMA scan (arrow indicates the Maximum Loss Modulus [E"])**

Typically $T_g$ values for new samples are above the maximum operating temperature of the conductor. The $T_g$ test results are shown in Table 5-4:

**Table 5-4**
**Core $T_g$ Values**

| Sample | $T_g$ in °C | Delta T from New $T_g$ in °C |
|---|---|---|
| Line 6 | 212.5 | 16.2 |
| Line 7 | 212.6 | 16.1 |
| New | 228.7 | - |

## Core Shear Tests

This test determines a secondary mechanical characteristic of the conductor core. The cores are characterized by a three-point bending test that induces a shear failure. The initial and final mechanical characteristics were assessed with the same protocol.

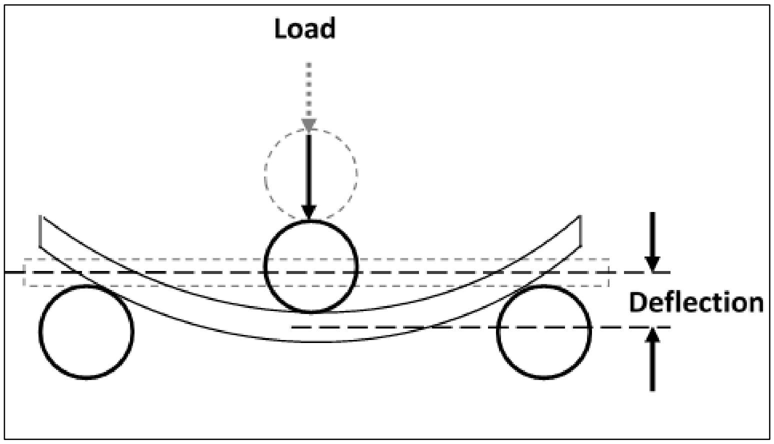


**Figure 5-16**
**Physical representation of three-point bending test**

The results of the shear tests are shown in Table 5-5. e.

**Table 5-5**
**Core Shear Strength**

| Sample | Line 6 - Burndy | Line 7 - AFL | New - Control |
|---|---|---|---|
| 1 | 37.20 | 32.11 | 45.37 |
| 2 | 35.82 | 39.95 | 45.86 |
| 3 | 38.51 | 34.03 | 46.32 |
| 4 | 39.28 | 35.54 | 39.71 |
| 5 | 39.14 | 32.22 | 40.62 |
| **Average** | 37.99 | 34.77 | 43.58 |
| **Standard Deviation** | 1.47 | 3.22 | 3.15 |
| **% Difference from Control sample** | 12.8 | 20.2 | - |

## Core Tensile Tests

An aged section of the conductor core was tensile tested to determine the residual strength left after thermal-mechanical aging. A new conductor core sample was also tested, this was done to get a baseline strength which the aged sample strength could be compared against. The results of the core tensile tests are shown in Table 5-6.

**Table 5-6**
**Core Tensile Strength**

| Sample | Tensile Strength (Ksi) | Tensile Strength (Mpa) |
|---|---|---|
| Line 6 | 319.66 | 2,206.04 |
| Line 7 | 325.68 | 2,245.45 |
| New | 328.96 | 2268.13 |

# 6

# CONDUCTOR AND CONNECTORS

The physical condition of the conductor and connectors has not changed significantly from when they were installed. There has been no loosening of the aluminum strands, nor has there been and slippage of the conductor in the connectors. Images of the two conductor spans and some connectors are shown in Figure 6-1, Figure 6-2, and Figure 6-3.

**Figure 6-1**
**Two ACCC conductors after 1500 cycles (the two conductors on the right hand side)**

**Figure 6-2**
**Burndy and AFL dead-ends (in the foreground) after 1500 cycles**

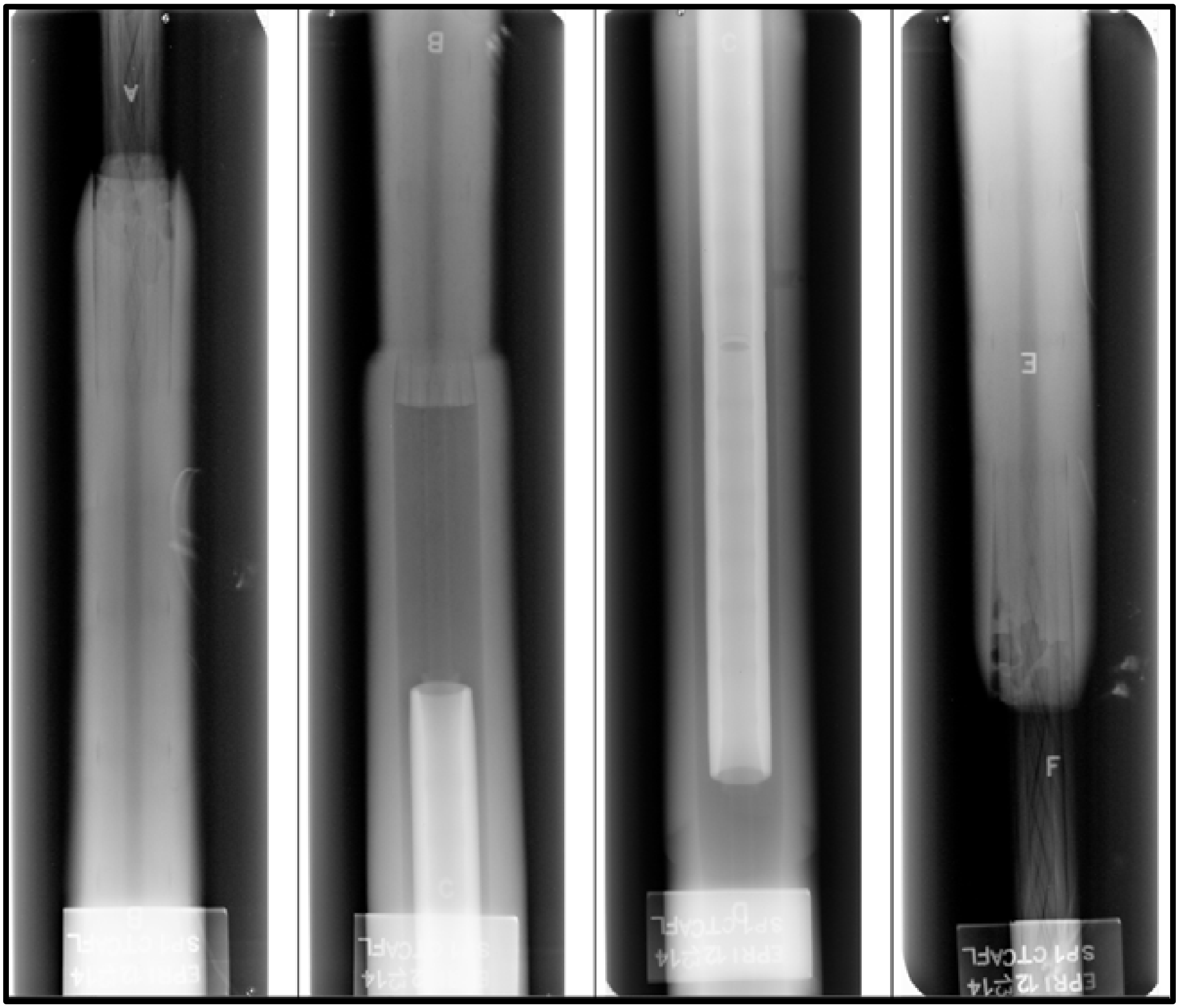
**Figure 6-3**
**Burndy and AFL splices (in the foreground) after 1500 cycles**

# A

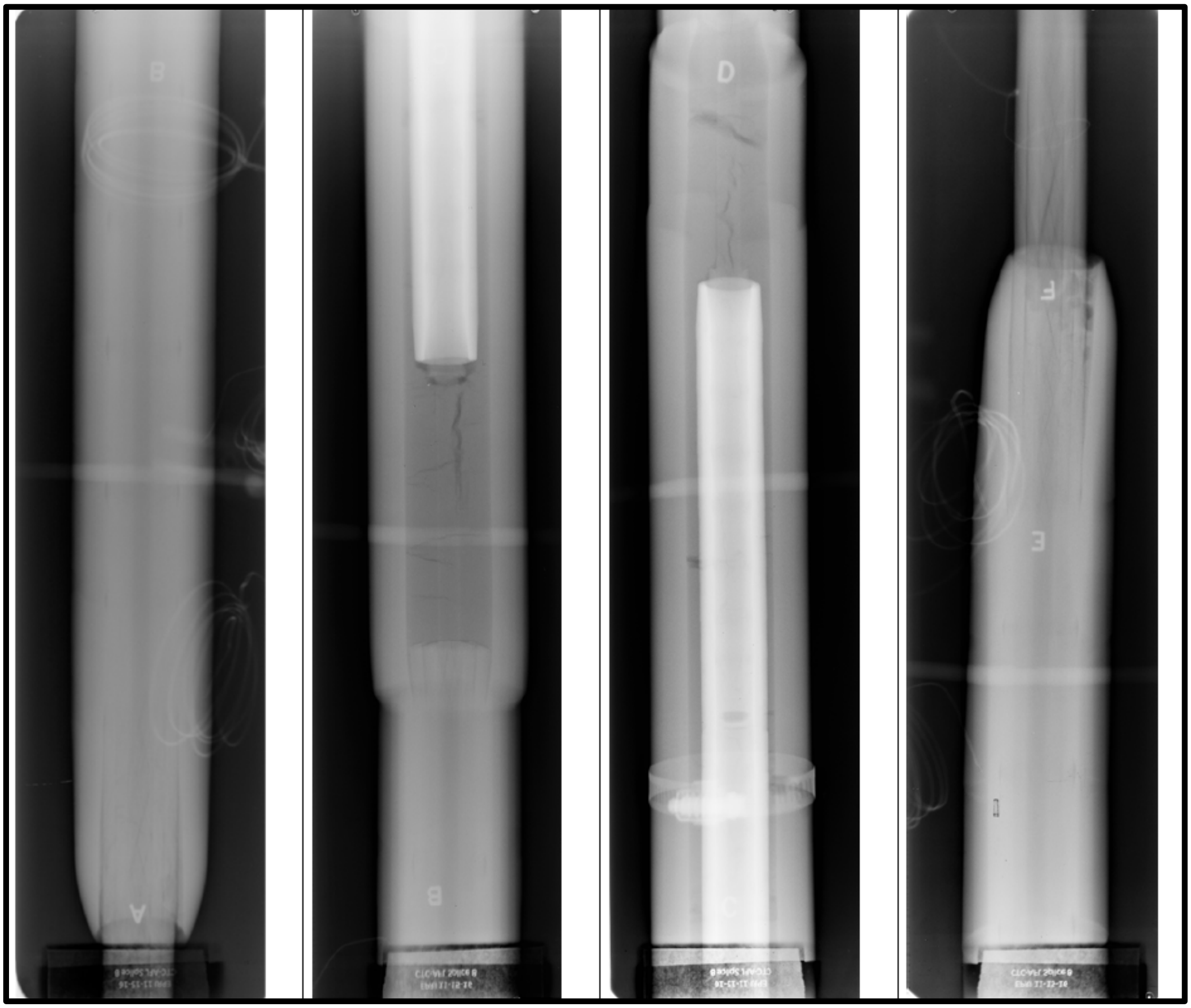
# RADIOGRAPHS OF AFL SPLICES

The physical condition of the conductor and connectors has not changed significantly from when they were installed.

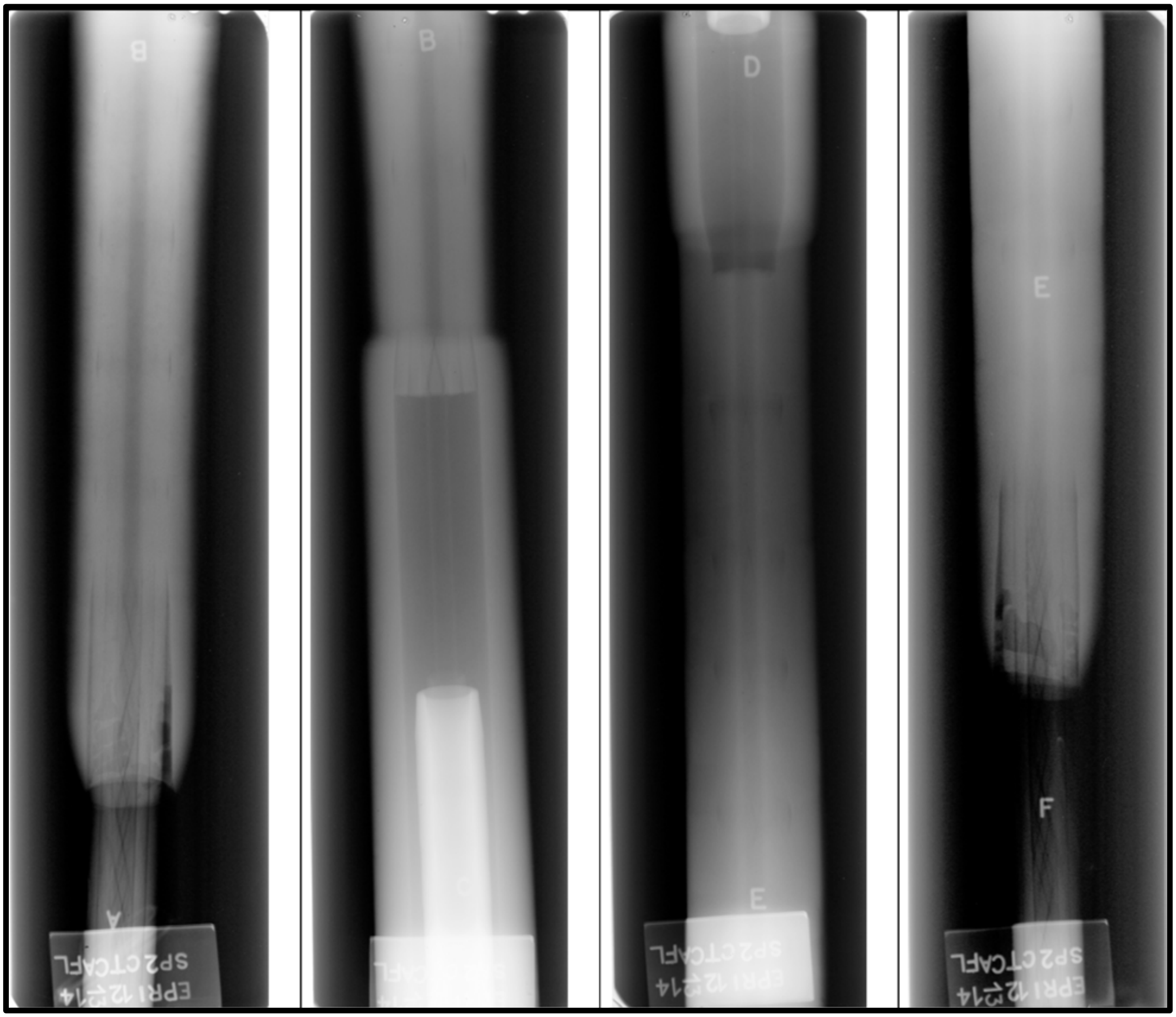
### Splice 1 – 0 Cycles



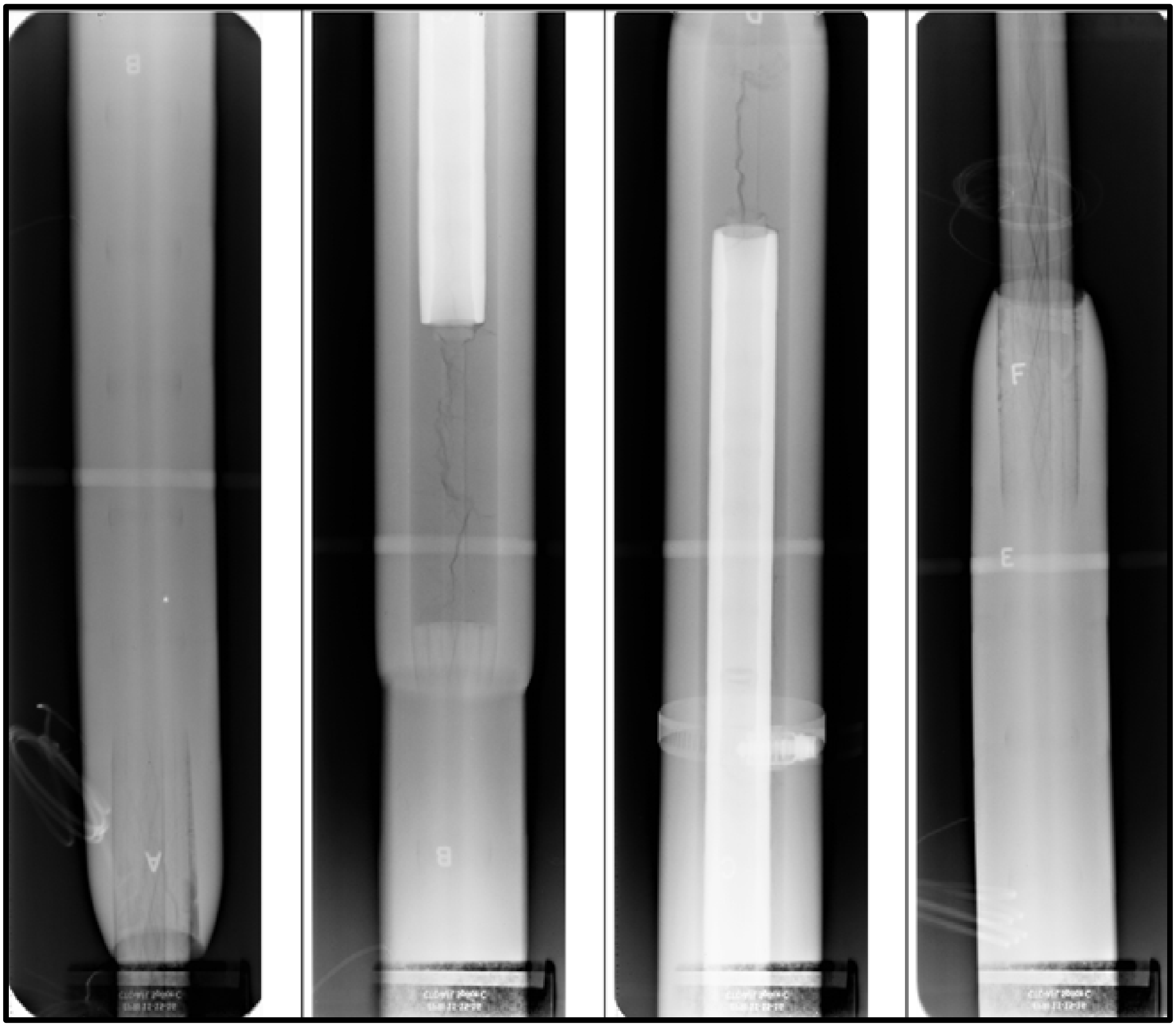
## Splice 1 – 1500 Cycles



## Splice 2 – 0 Cycles



## Splice 2 – 1500 Cycles

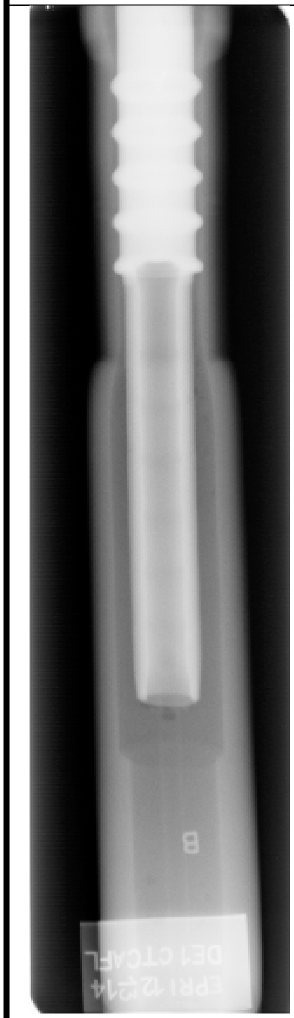
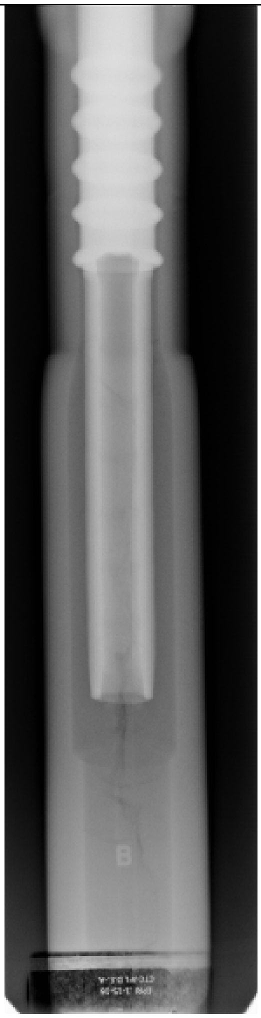
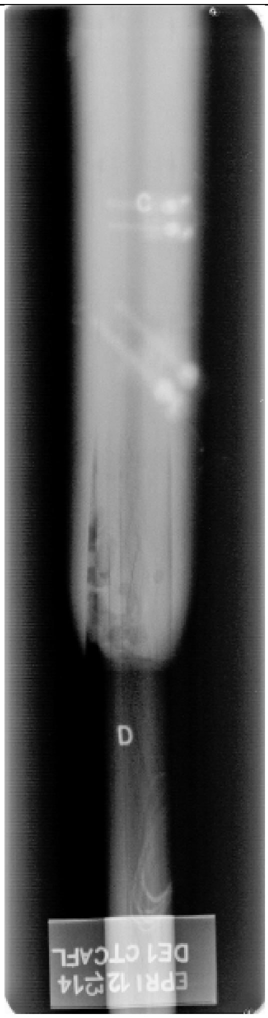
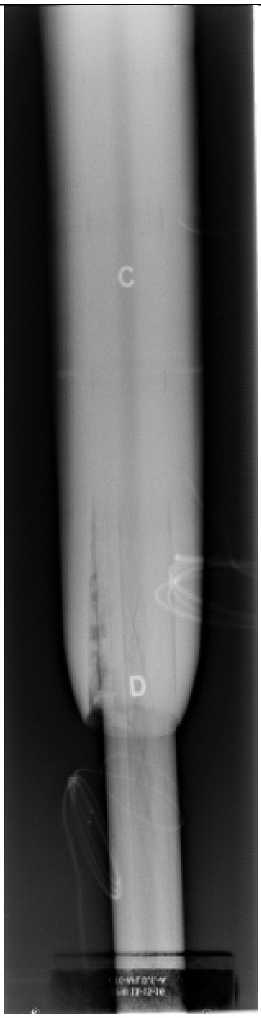


# B

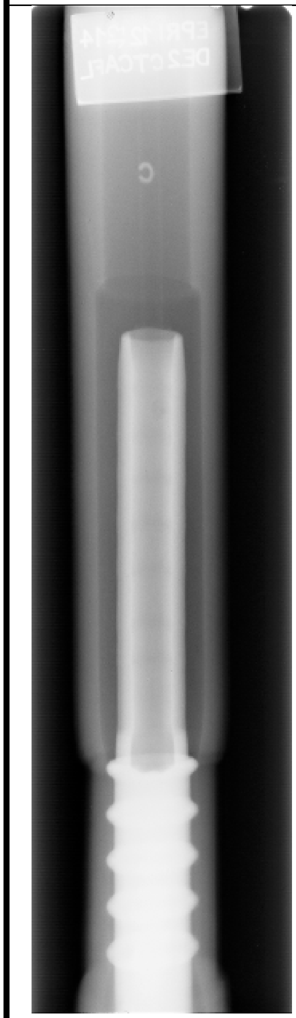
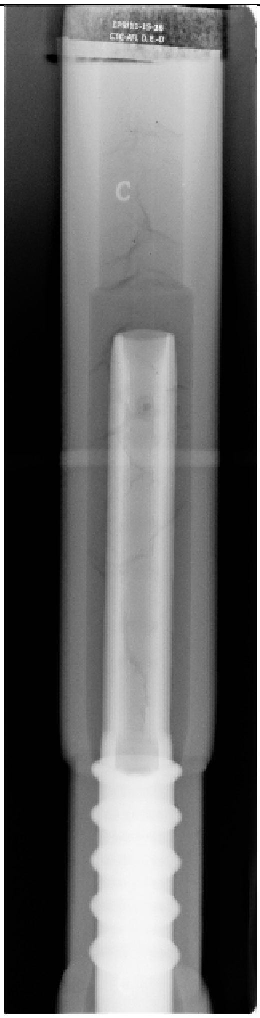
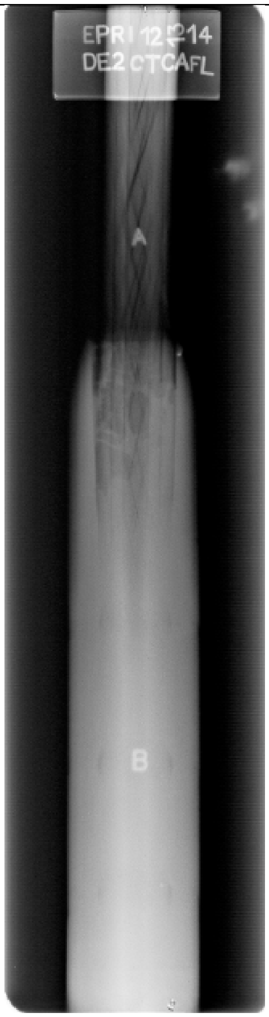
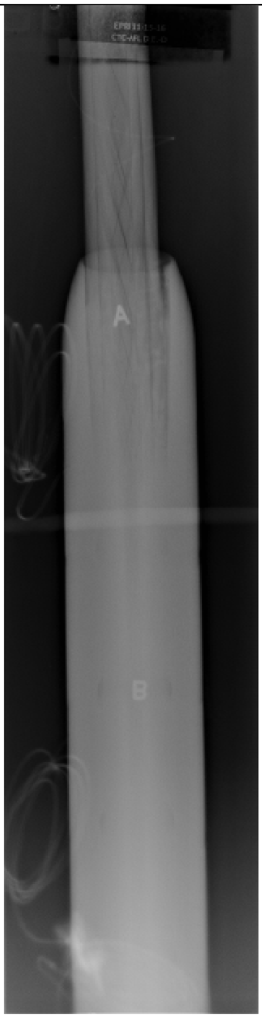
# RADIOGRAPHS OF AFL DEAD-ENDS

The physical condition of the conductor and connectors has not changed significantly from when they were installed.

## Dead-end 1

| 0 cycles | 1500 Cycles | 0 Cycles | 1500 Cycles |
|---|---|---|---|
|  |  |  |  |

## Dead-end 2

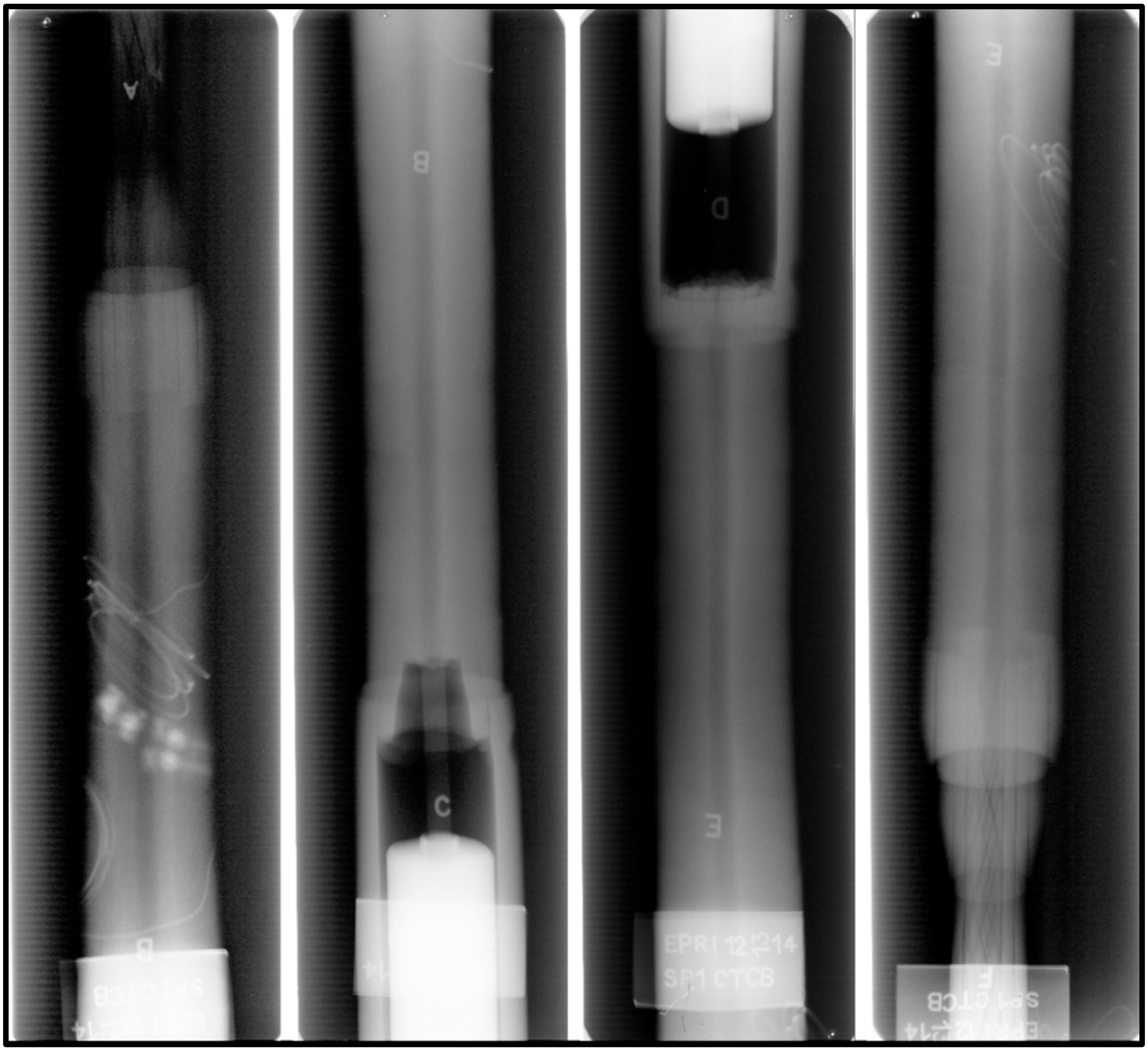
| 0 cycles | 1500 Cycles | 0 Cycles | 1500 Cycles |
|---|---|---|---|
|  |  |  |  |

# C

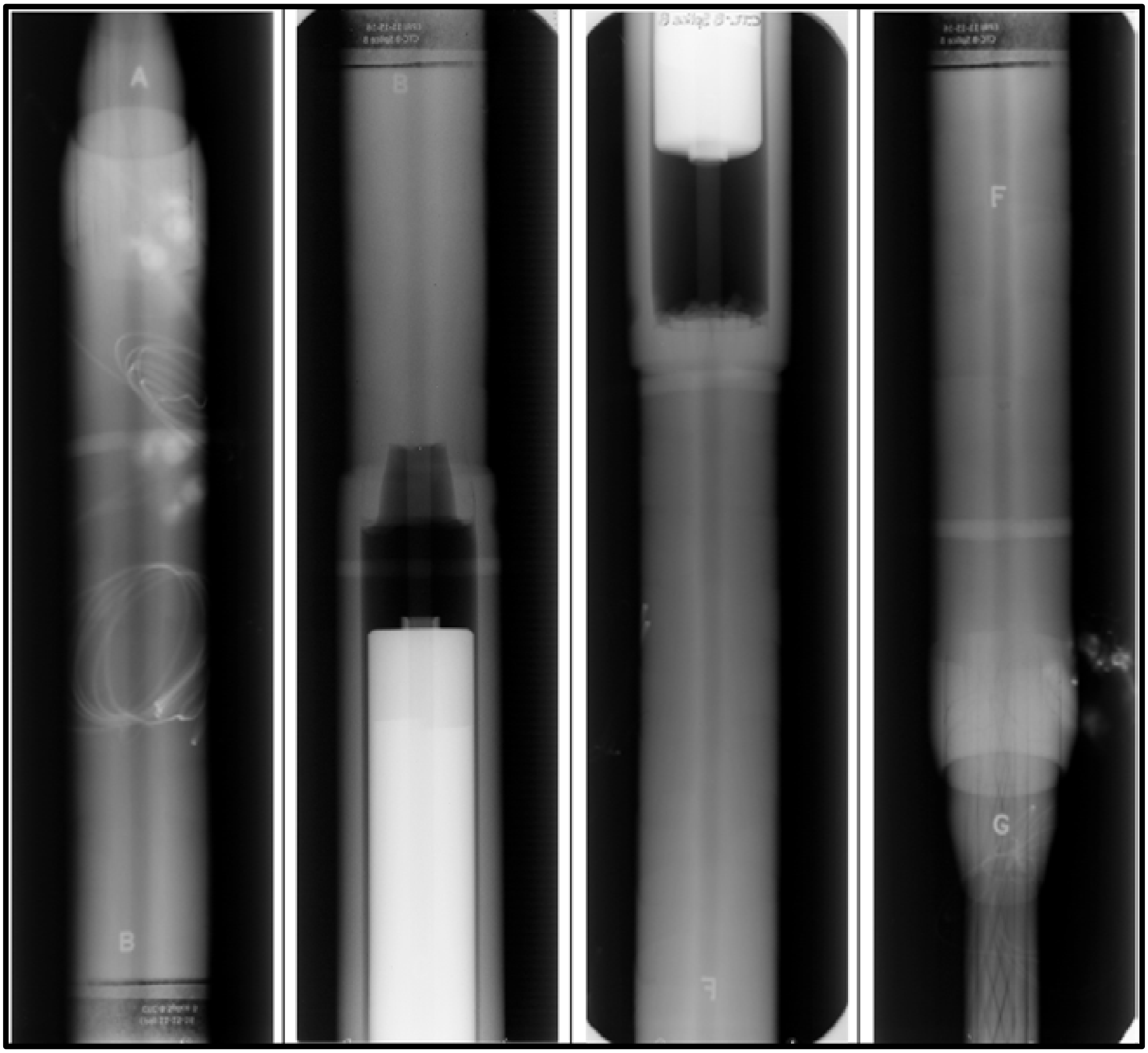
# RADIOGRAPHS OF BURNDY SPLICES

The physical condition of the conductor and connectors has not changed significantly from when they were installed.

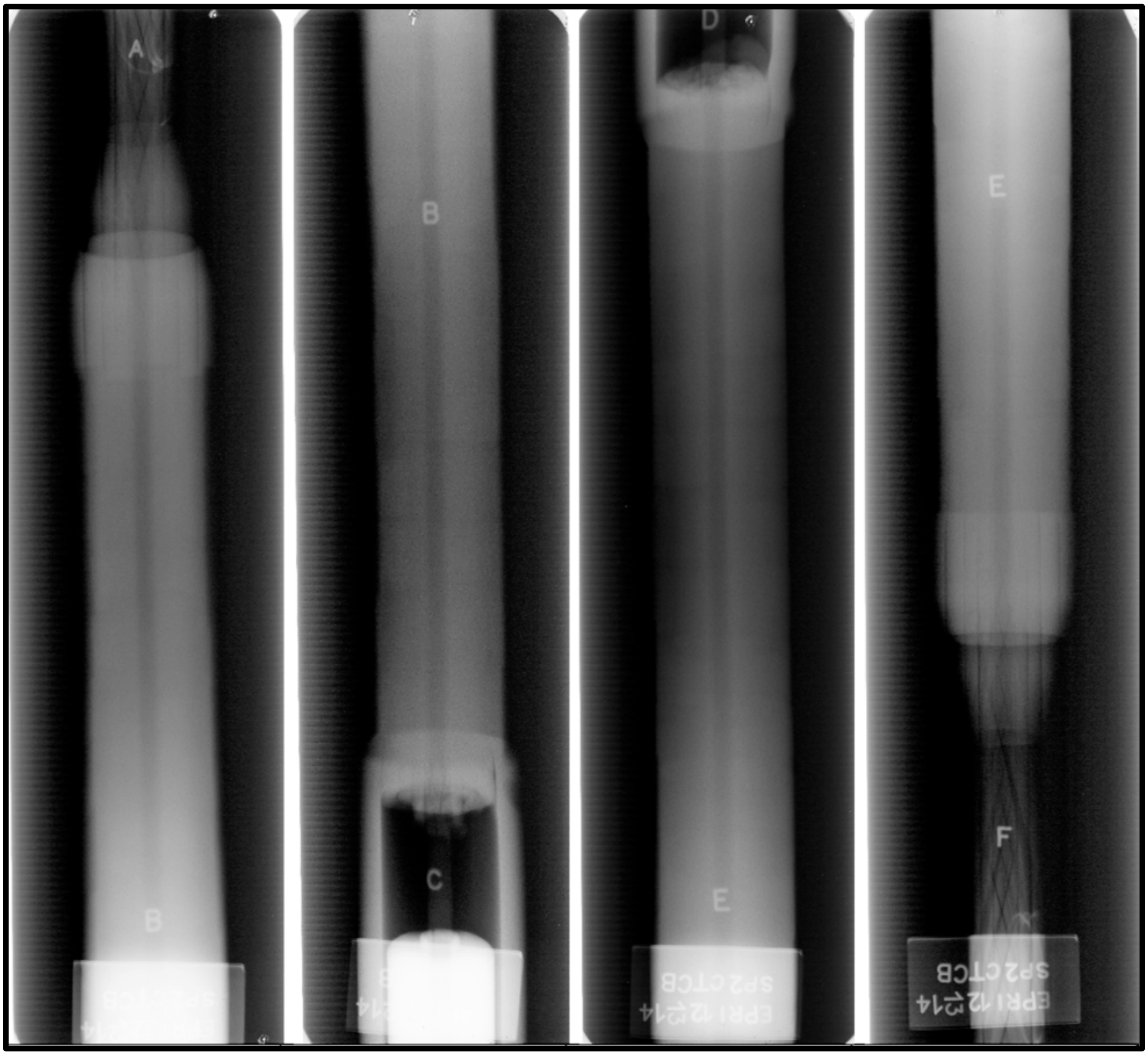
### Splice 1 – 0 Cycles



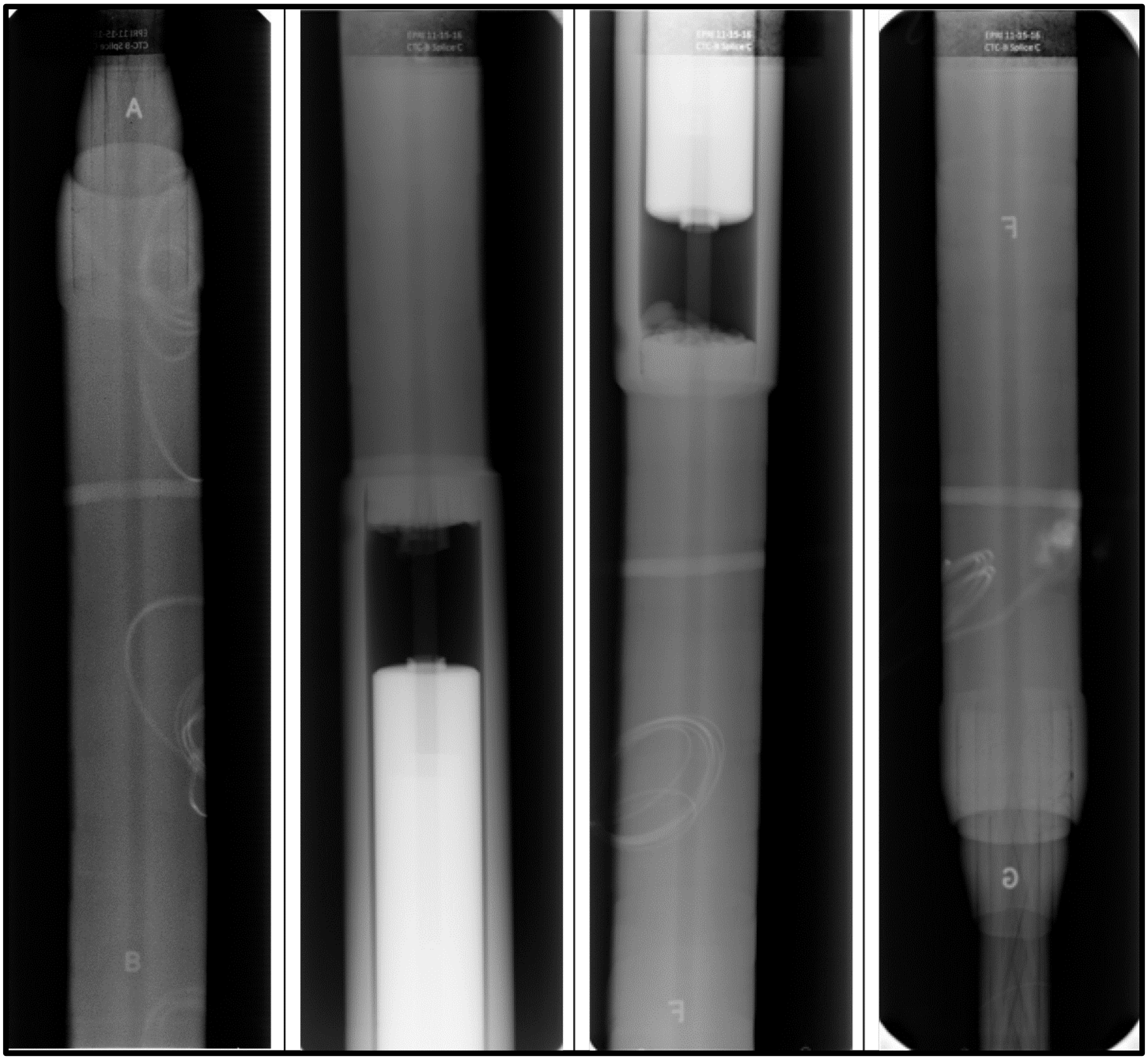
## Splice 1 – 1500 Cycles



### Splice 2 – 0 Cycles



## Splice 2 – 1500 Cycles



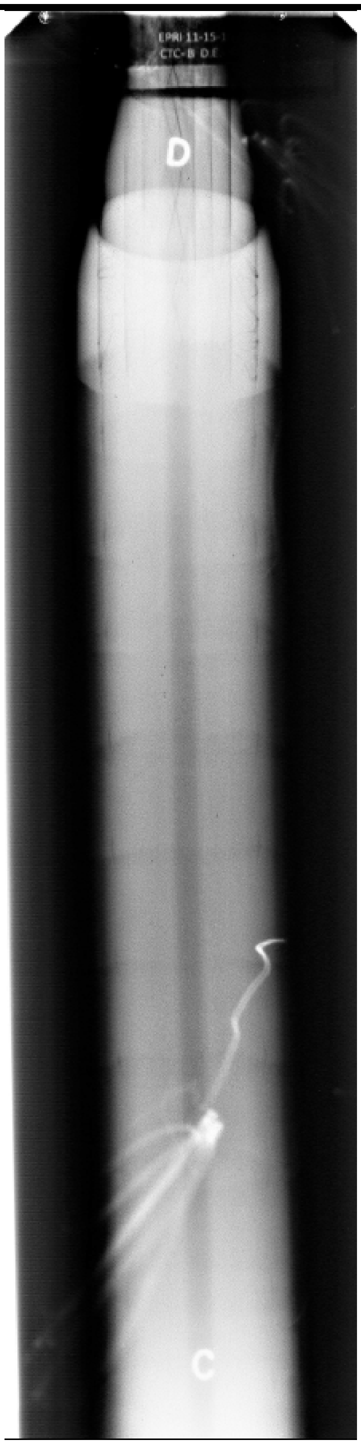
# D

# RADIOGRAPHS OF BURNDY DEAD-ENDS

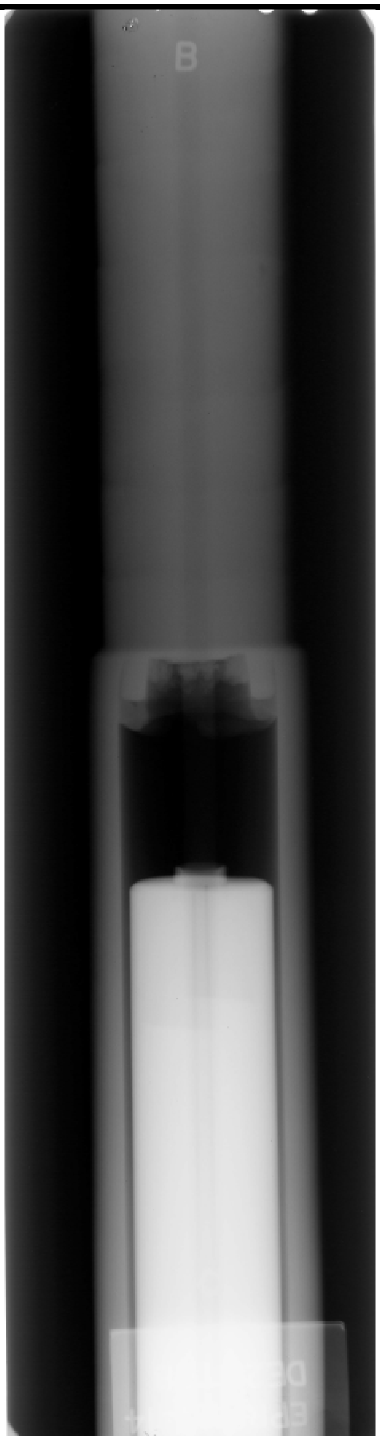
The physical condition of the conductor and connectors has not changed significantly from when they were installed.

## Dead-end 1 – 0 Cycles

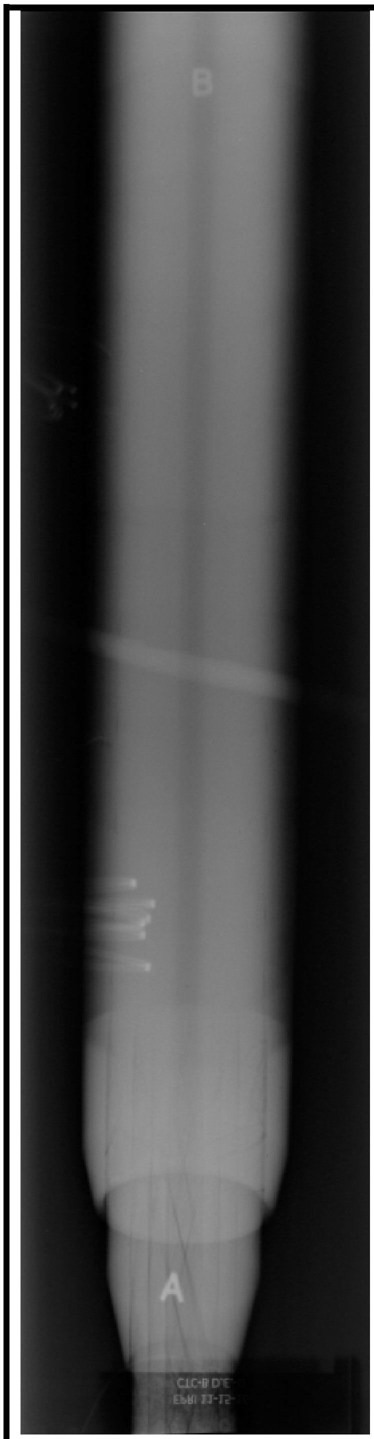
## Dead-end 1 – 1500 Cycles

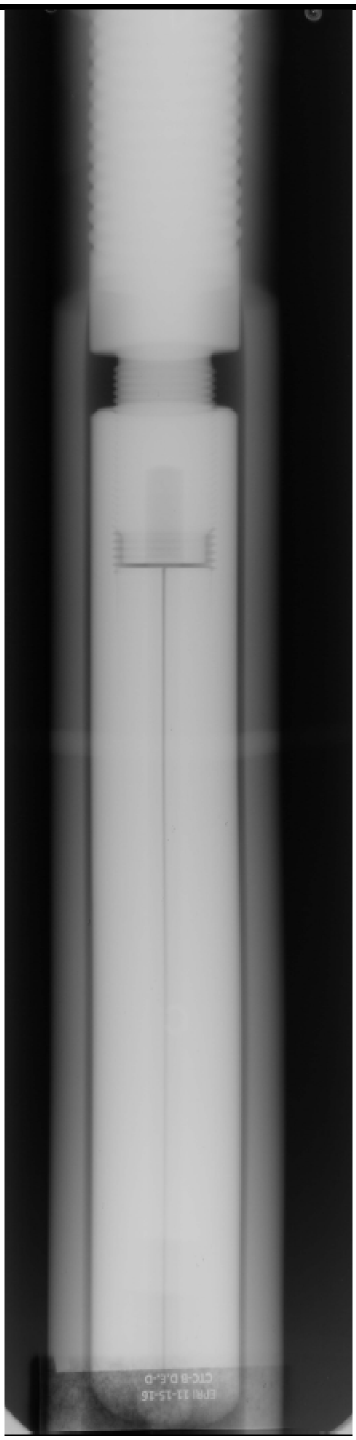


## Dead-end 2 – 0 Cycles



**Dead-end 2 – 1500 Cycles**





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