596TW kcmil Type 13, 3M Brand Composite Conductor Compression Connector Qualification - Tensile, Sustained Load, and High-temperature Sustained Load

3M Company
Purchase Order 0000883024

NEETRAC Project Number: 03-081

September, 2003

A Research Center of
The Georgia Institute of Technology

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Summary:

3M contracted with NEETRAC for a series of qualification tests for Alcoa Conductor Accessories (ACA) full-tension splice connectors and dead-end terminal connectors. One dead-end connector was subjected the ANSI C119.4 sustained load test. All splice and dead end samples exceed the ANSI mechanical requirements for full-tension connectors. A second dead end sample was subjected to a special version of the sustained load test. Conductor temperature was maintained at 240^{o} C with the tension at 15% RBS. The high-temperature sustained load sample exceeded RBS in the residual strength test following the high-temperature sustained load phase. These test results provide reasonable assurance of reliable service for this connector system in overhead lines.

Samples:

1) 596TW, Type 13, 3M Brand Composite Conductor, from reel received from 3M on 3/31/03.
1) Two (2) ACA compression splice connectors (special 3M Composite Conductor design), catalogue number B9095-H.
2) Four (4) ACA compression dead end connectors (special 3M Composite Conductor design), catalogue number B9085-G.

References:

1) "Proprietary Information Agreement …." Dated 3/27/01, and renewed 3/03.
2) ANSI C119.4 – 1999, (Connector performance requirements).
3) 3M Purchase Order 0000883024.
4) PRJ 03-081, NEETRAC Project Plan.

Equipment Used:

1) MTS Servo-hydraulic tensile machine, Control # CQ 0195.
2) Fowler 42-inch caliper micrometer, Control # CN3020.
3) Load frame 25K load cells Control #s CN 3056 and CN 3057
4) Load frame extensometers, Control #s CN 3041 and CN 3042

Procedure:

1.0 Tensile Tests on compression splices and dead-end terminals:

Fittings were installed on the conductor by ACA at their factory in South Carolina. NEETRAC installed special cast resin terminations on the free ends of the samples. Two resin terminations are needed for the ends of the splice sample. Dead end samples need only one fitting. All samples were approximately 22 feet long overall, with approximately 20 ft of conductor in the test section. Samples were pulled to destruction at a loading rate of 10,000 lb/min. ANSI C119.4 requires that a connector hold a minimum of 95% of the conductors rated breaking strength. According to the 3M conductor specifications, the rated breaking strength (RBS) for the 596TW 3M Composite Conductor is 21,263 lbs. Two additional dead end samples were tested to determine residual strength following the sustained load test. See the section on the sustained load test for those results. Initial tensile test results are as follows:

Sample	Max. load (lbs)	%RBS	Failure description
Splice 1	22,710	107	Tensile break, all strands, 5 ½" inside splice
Splice 2	22,610	106	Tensile break, all strands, 8" inside splice
Splice 3	23,200	109	Tensile break, all strands, 5 ½" inside splice
Dead end 1	21,240	100	Tensile break, all strands, 8" inside dead end
Dead end 2	22,210	104	Tensile break, all strands, 8" inside dead end

Figures 1 and 2 show the tension versus actuator displacement for the splice and dead end tests, respectively.

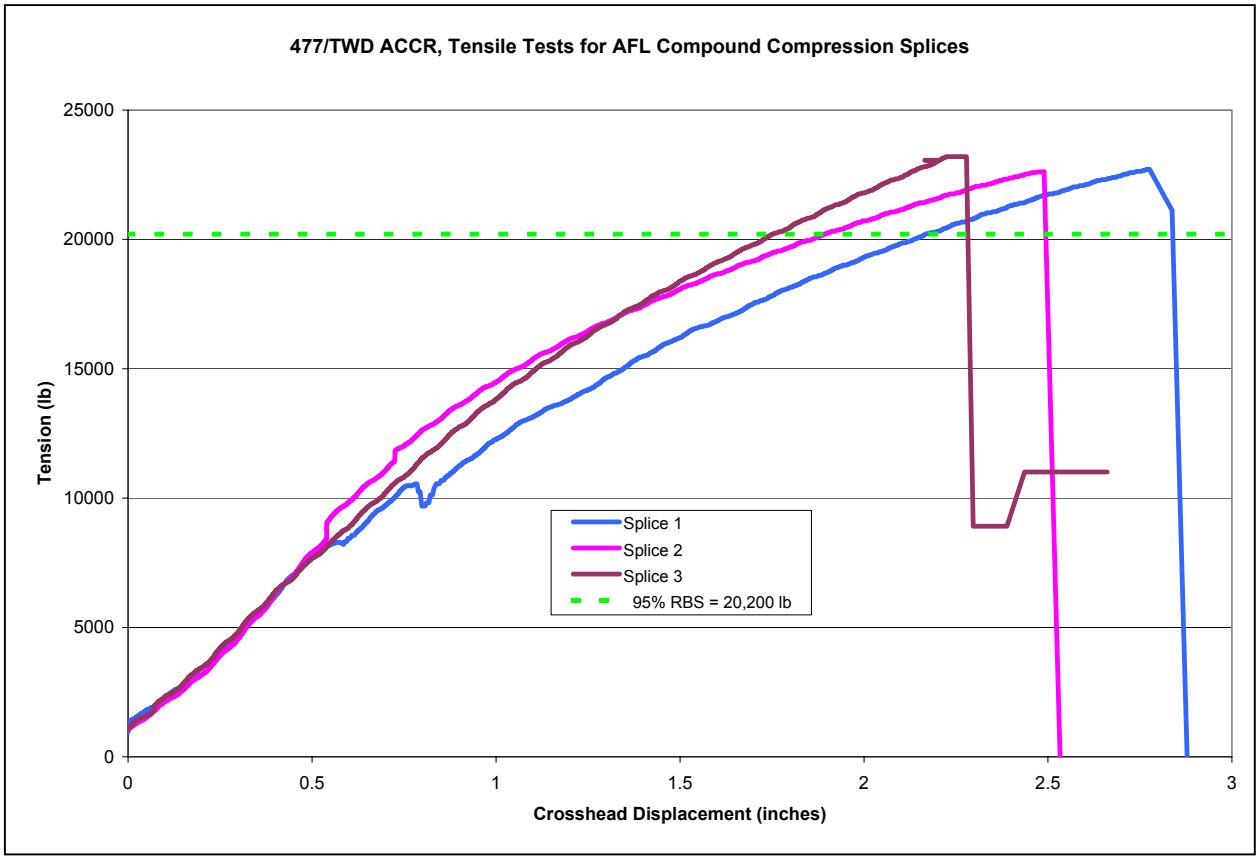

Figure 1, Tensile Test Data for ACA Compression Splices

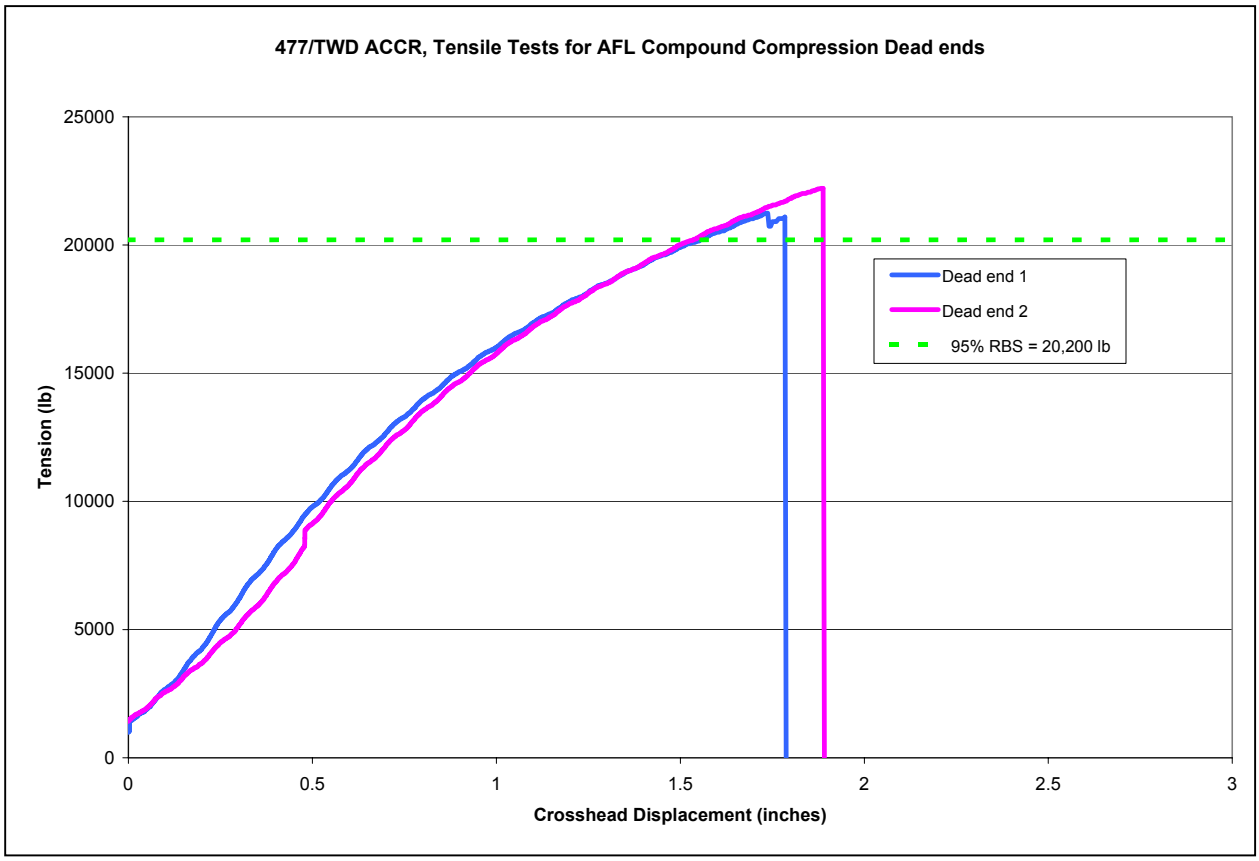

Figure 2, Tensile Test Data for ACA Compression Dead Ends

2.0 Sustained Load Test Per ANSI C119.4:

Dead end terminal fittings were installed by ACA at their factory in South Carolina. Two samples were shipped to NEETRAC with a connector on one end, and bare conductor on the opposite end. NEETRAC installed special cast resin terminations on the free end of each sample. One of the samples was subjected to the standard ANSI C119.4 sustained load test. To qualify under the ANSI standard, a connector must hold 77% of the conductor's rated breaking strength (RBS) for seven days (168 hours). At the end of the sustained load period, the residual strength must exceed 95% of the conductor RBS. The second sample was subjected to a test designed to demonstrate sustained load performance of the connector system at extreme high temperature. AC current was used to raise the conductor temperature to 240^{o} C for the duration of the 168 hour test. Tension for the high temperature sample was 15% RBS. Lower tension is appropriate for this test because high tension caused by wind and ice loading cannot coincide with extreme conductor temperature. Thermal elongation due to high temperature operation will ensure that tension is below 15% RBS for all normal installed line tensions.

Both samples were installed in a load frame. Both samples were fitted with extensometers to monitor conductor creep. The barrel of each dead end connector was marked with a center-punch to provide a reference section to monitor for creep in the connector body. Both samples are maintained at the tension target by computer control. An electric-drive lead screw operates to correct tension whenever the load falls outside of a +/- 20 lb deadband. The high temperature sample was instrumented for temperature in the center surface, center core, and at both ends. A data acquisition system logs tension, elongation, and temperature data.

Figure 3 shows the data for the room temperature sample. Figure 4 shows data for the 240° C sample. The high-temperature sample was cooled slowly to ambient temperature before the tension was removed. Both samples appeared to be in good condition at the end of the sustained load phase.

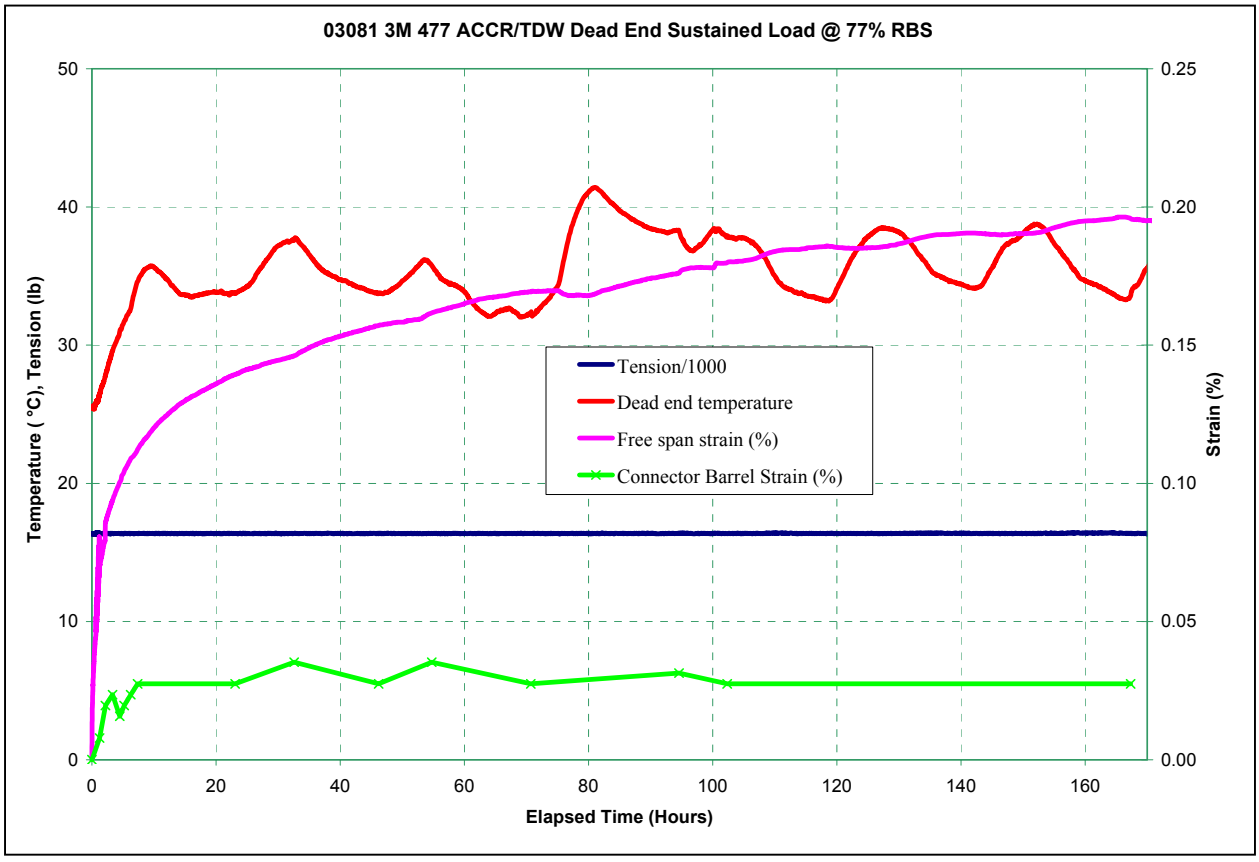

Figure 3, Data Recorded during the Room Temperature Sustained Load Test

Notes:

1) Temperature (red curve) is warm, and somewhat erratic because the sample was located next to the 240° C sample. Heat from the high temperature test overloaded the room AC system during high daytime temperatures.
2) Initial creep is high for both the dead end barrel and the conductor. Connector creep is near zero after 5 hours into the test. Conductor creep is leveling off, but still increasing at the end of the test.

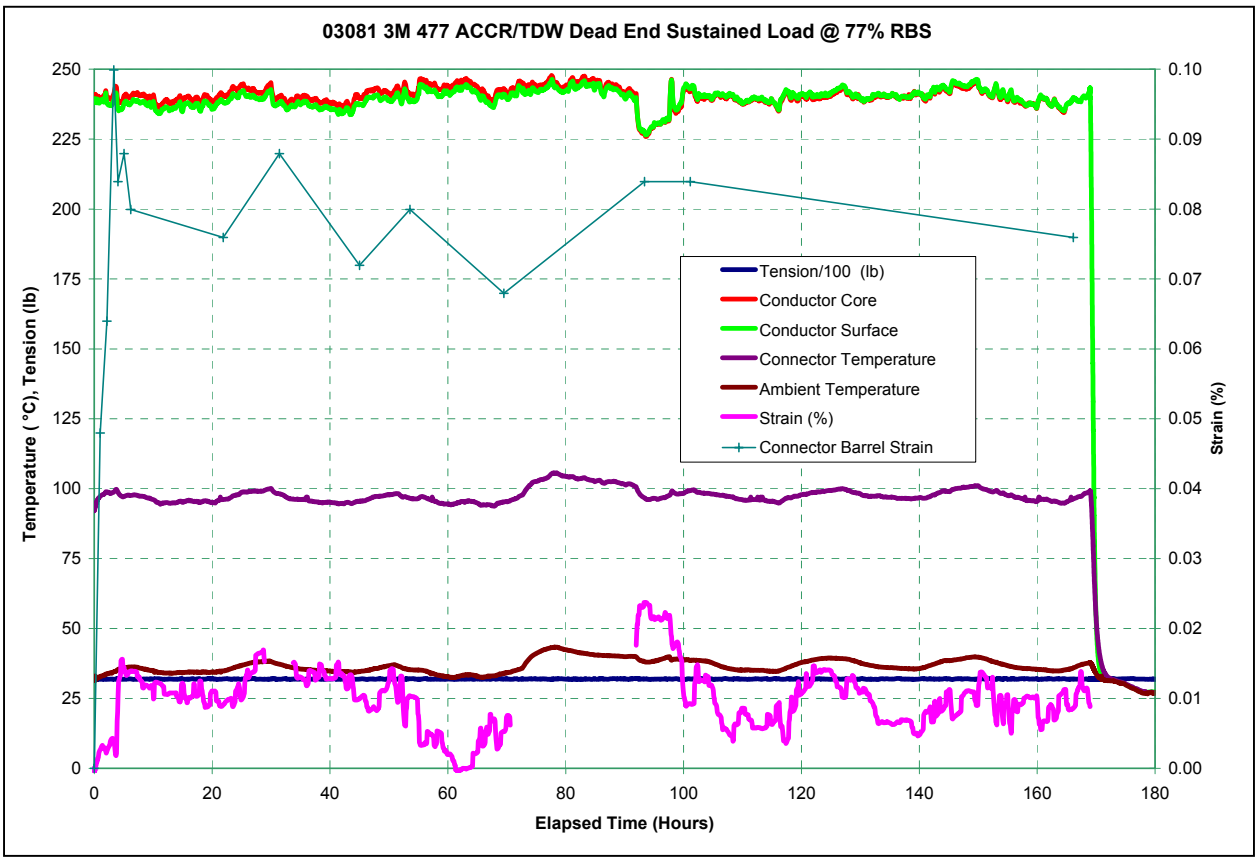

Figure 4, Data Recorded during the High Temperature Sustained Load Test

Notes:

1) Conductor creep is essentially zero (noise) during this test. Gaps in the conductor creep data are due to a loose connector. There is no evidence of problems with any of the data recorded.
2) Small initial creep is evident in the connector barrel, but is essentially zero after 5 hours into the test.
3) The core thermocouple evidently worked its way to the surface during the test. Note there is a 7^{o} C gradient at the start of the test, but the temperatures converge later in the test.

3.0 Residual Strength Test:

Following the sustained load period, the samples were loaded to destruction at room temperature at a loading rate of 10,000 lb/min. The room temperature sample ruptured at 22,100 lb, or 104% RBS. The high temperature sample ruptured at 22,840 lb, or 107% RBS. Both samples failed in the middle of the gage section. Figure 5 shows the load versus actuator motion data for the two samples.

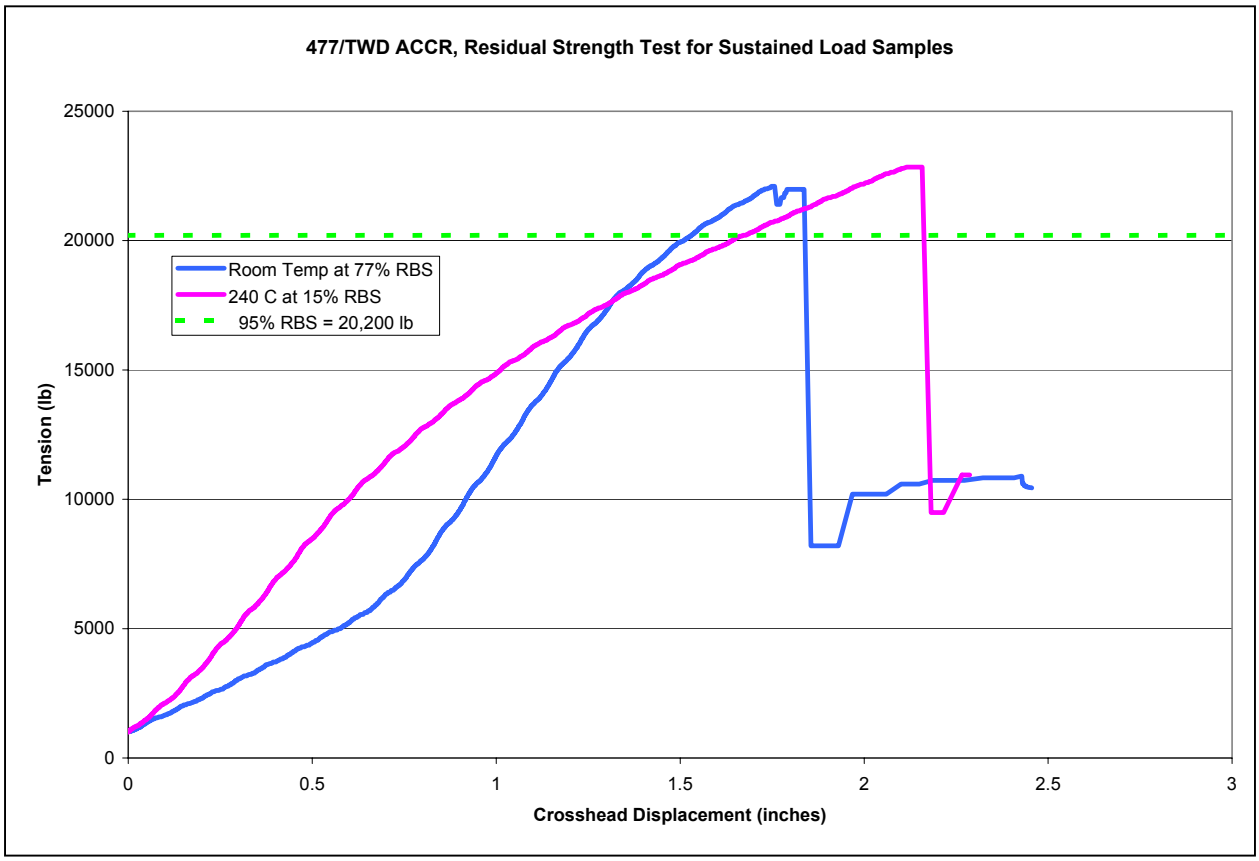

Figure 5, Tensile Test Data for the Residual Strength Test

Notes:

1) Knee point for the 77% RBS sample is likely due to creep during the sustained load phase.
2) Curves are smoother than the initial tensile test results because the resin terminations settled in during the sustained load phase, and therefore did not slide as much during the tensile test.

Conclusions:

The tests were designed to qualify the ACA dead end connector for the 596TW conductor with an RBS value of 21,263 lb. All samples exceeded RBS, demonstrating good conformance to the 95% RBS minimum requirement of ANSI C119.4. The high temperature sustained load test is not required by ANSI C119.4, but was performed to demonstrate connector performance during extreme high temperature operation. Overall test results demonstrate that the connector system is suitable for service on overhead lines up to the 240^{o} maximum conductor rating for 3M Composite Conductors.

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