477 kcmil, 3M Brand Composite Conductor
Sustained Load Test
for AFL Compression Splice

3M Company
Purchase Order 0000637117

NEETRAC Project Number: 02-247

November, 2002

A Center of
The Georgia Institute of Technology

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Summary:

3M contracted with NEETRAC for a connector sustained load test in accordance with ANSI C119.4. Alcoa Fujikura Limited (AFL) installed their compound compression splice designed for the 477 ACCR conductor. ANSI C119.4 requires that a splice hold 77% of the conductor RBS for 168 hours (7 days), and still hold 95% of the conductor RBS following the sustained load period. Following 170 hours at 77% RBS, the conductor failed mid-span at a load of 20,353 lbs (104.5% RBS). Therefore, the connector passes the ANSI requirement for sustained load. This report contains data on conductor stress-strain and creep. Splice elongation was measured before, during, and after the test. This "bonus" material is not required by ANSI C119.4, but is provided for information on the system performance.

Samples:

1) Twenty four (24) meters of 477 kcmil, type 16, 3M Composite conductor, with AFL compression splice in center, received from AFL on 10/24/2002.

References:

1) "Proprietary Information Agreement …." Dated 3/27/01
2) ANSI C119.4 – 1999, (Connector performance requirements)
3) 3M Purchase Order 0000637117.
4) PRJ 02-247, NEETRAC Project Plan

Equipment Used:

1) NEETRAC indoor 25-meter test span.
2) National Instruments AT-MIO-16XE-50 computer data acquisition system.
3) Lebow 25,000 lb load cell with HBM bridge conditioner, Calibration control # CN 3006.
4) Tinius Olsen RS400-24 cable extensometer, Control # CN0171.
5) 48: Caliper micrometer, Control # CN 0171.
6) Simplex hydraulic cylinder (tensile test).

Procedure and Results:

Testing was conducted in accordance with a NEETRAC procedure entitled "PRJ02247, CONFIDENTIAL – MMC Conductor Evaluation, Sustained Load Test". The procedure controls all technical and quality management details for the project.

I. Sample and test preparation:

AFL provided an 80-ft sample with their splice in the center. NEETRAC installed cast-resin end terminations. There was an attempt to work any "birdcaging" in the conductor to the free-end before installing the resin terminations. Offset between the core strand and the aluminum layers was measured before installing the end fitting. The outer aluminum layer was displaced 5/16 inch at end "A", and 7/16 inch at end "B". The inner aluminum layer was displaced 3/16 inch at end "A", and 1/4 inch at end "B". Birdcaging has significant effects on short laboratory test samples, and therefore is monitored. The cast-resin fittings are designed specifically to permit removal of free slack (birdcaging) from the conductor test samples. The test span active gage section measured 68 ft – 10 inches, including the splice, but not including any part of the end fittings or tensioning mechanism.

II. Initial Loading:

A system of springs with a stud and nut arrangement was used to pull the sample to a load of 14,997 lbs, and maintain the load within +/- 300 lbs of the target. The Tinius Olsen cable extensometer was installed in the center of one of the conductor sections. Load and conductor elongation were recorded automatically for the duration of the test. Splice length was recorded manually before and after the test, and periodically during the sustained load phase. The gage section of the Tinius Olsen cable extensometer is 24.000 inches, but its output should be representative of the free-conductor properties.

Figure 1 shows the conductor stress-strain during the loading phase of the test. Also plotted are initial modulus data from stress-strain testing on 477 ACCR conductor. The discrepancy between the two stress-strain curves is due to differences in the source of the conductor sample. The sustained load sample conductor is believed to be from the same lot as the 02-097 stress strain test. The discrepancy between the 02-097 curve and the sustained load sample is due to the splice, and also due to significant differences in the loading rate and load hold times included in the initial modulus curve.

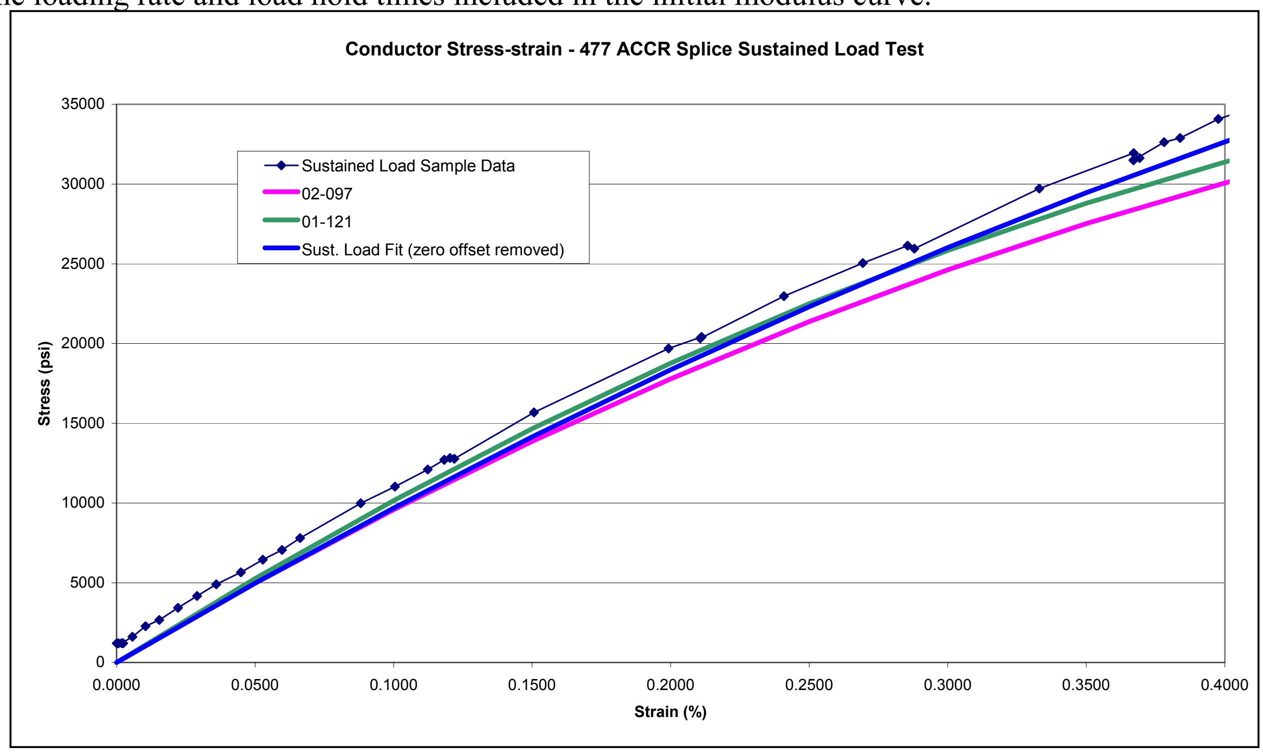

Figure 1, stress-strain for the sustained load conductor, and historical stress-strain data for 477 ACCR conductor.

III. Sustained Load Phase:

Data from the load cell and the cable extensometer were logged automatically every 20 minutes. Splice length and temperature were recorded manually during the workday, but not measured during normal off hours. There was no automatic tensioning system, but manual adjustments maintained tension within the +/- 300 lb target. Figure 2 shows the tension and creep data during the 77% RBS sustained load test. The sustained load phase duration was 170 hours (2 hours longer than the minimum).

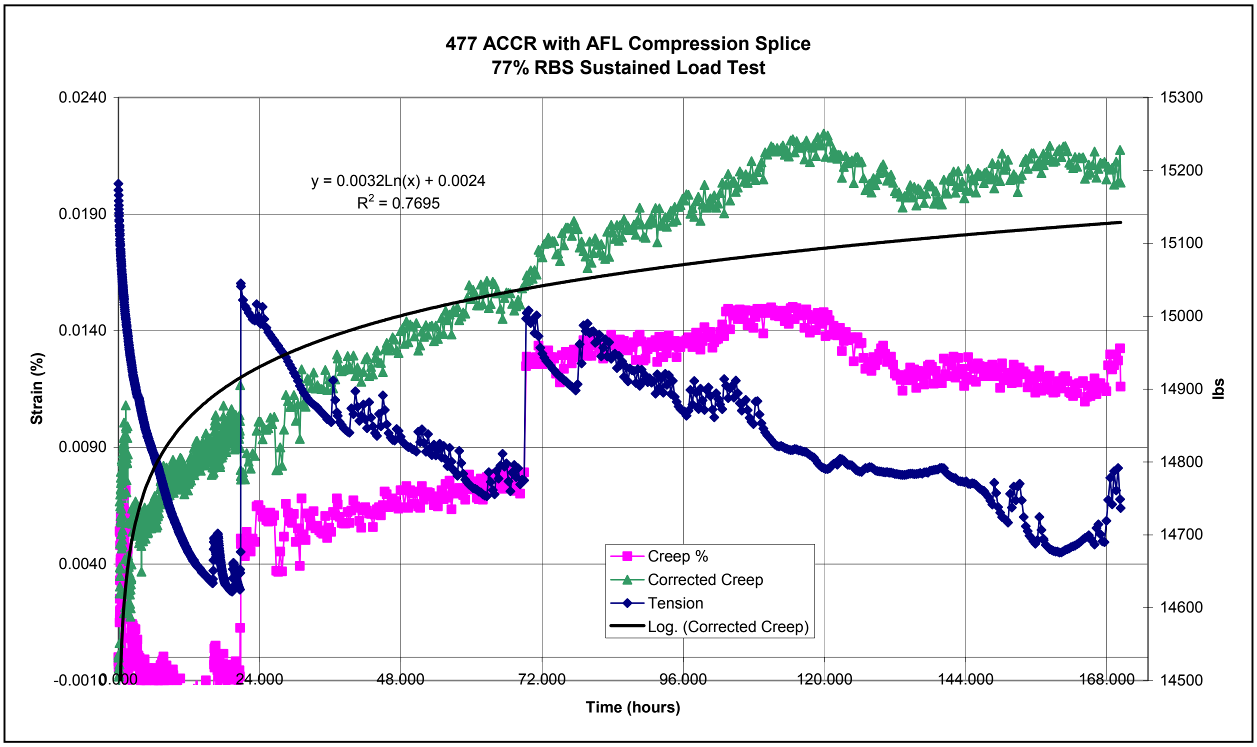

Figure 2, Tension, raw elongation, compensated creep curve, and best data fit. Note that system is not designed for creep measurement, but nonetheless shows typical shape for creep trend

IV. Residual Strength Test:

At the end of the sustained load, a hydraulic cylinder was fitted to the end support. The spring loading system was mechanically shunted to ensure that the sample could be loaded as rapidly as practical. The test data show four (4) brief rest stops. The load released during the stop, probably due to slight leakage in the hydraulic system. The break occurred precisely 90 seconds in to the test. All strands separated in the mid section between the splice and one of the end fittings. Peak load was 20,353 lbs, or 104.5% RBS. Figure 3 shows the data recorded during the residual strength test.

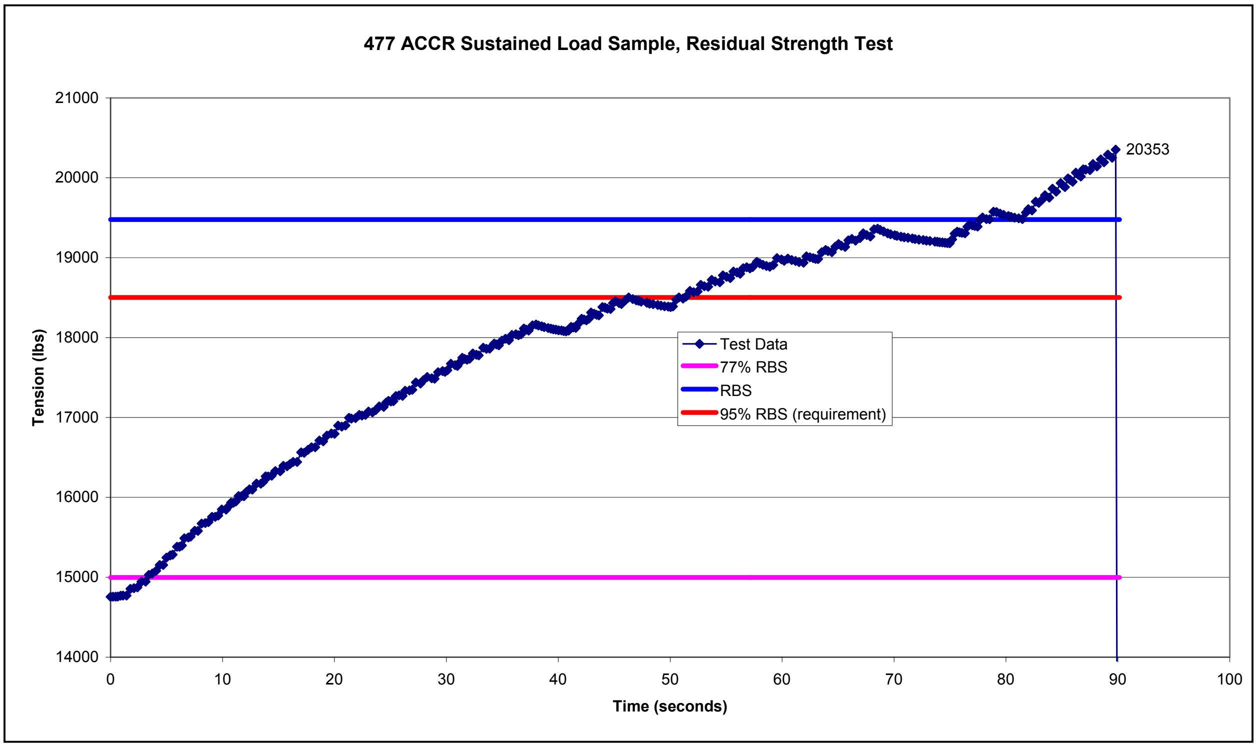

Figure 3, data from the residual strength test

V. Splice Measurements:

The overall splice length marginally exceeded the span of the largest available caliper micrometer. It was possible to obtain accurate splice length change by making gage marks approximately ½ inch from each end. There was no significant tensile load outboard of the gage marks. Therefore, gage mark separation is a close approximation of the change in overall splice length. The following dimensions were recorded (all in inches):

Zero stress, before initial loading (gage mark initial separation):	39.850
15,124 lbs conductor tension, immediately following tensioning:	39.924 (+ 0.074)
14,691 lbs conductor tension, 170 hours into sustained load phase:	39.926 (+ 0.076)
Zero stress, following 20,353 lb residual strength test:	39.942 (+ 0.092)

Conclusions:

The AFL connector system comfortably exceeds the ANSI C119.4 sustained load requirements. The splice shows signs of yield during tensile loading, but there is little evidence of creep during sustained load at 77% RBS.