795 kcmil, 3M Brand Composite Conductor
Tensile Tests on Bowed Dead End Connectors

3M Company
Purchase Order 0000702317

NEETRAC Project Number: 03-062

April, 2003

A Center of
The Georgia Institute of Technology

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Summary:

3M contracted with NEETRAC to perform tensile tests to determine the degree of strength loss caused by varying degrees of bowing of the end fittings. AFL compression dead ends were installed with deliberate attempts to cause the compression sleeve to bow during the compression operation. The phenomenon is called “banana-ing”, because the deformed connectors take that shape. ANSI C119.4 requires that a full-tension connector hold 95% of the conductor RBS before failure. The tests show that in the most extreme case, the ACCR conductor breaks at 94% of conductor RBS. The two tests with less extreme bowing all exceeded the ANSI strength requirement. Extreme effort was required to bow the sample that failed at 94% RBS. It is, therefore, considered unlikely that inadvertently bowed connectors in field service will cause problems.

Samples:

1) 795 ACCR conductor from reel received 06/03/2002
2) Three (3) compound compression dead end connectors, provided by AFL

References:

1) “Proprietary Information Agreement ….” Dated 3/27/01
2) 3M Purchase Order 0000702317
3) 3M data file dated June 27, 2002 containing conductor technical specifications
4) PRJ 02-327, NEETRAC Project Plan
5) ANSI C119.4 – 1998 (connector requirements)

Equipment Used:

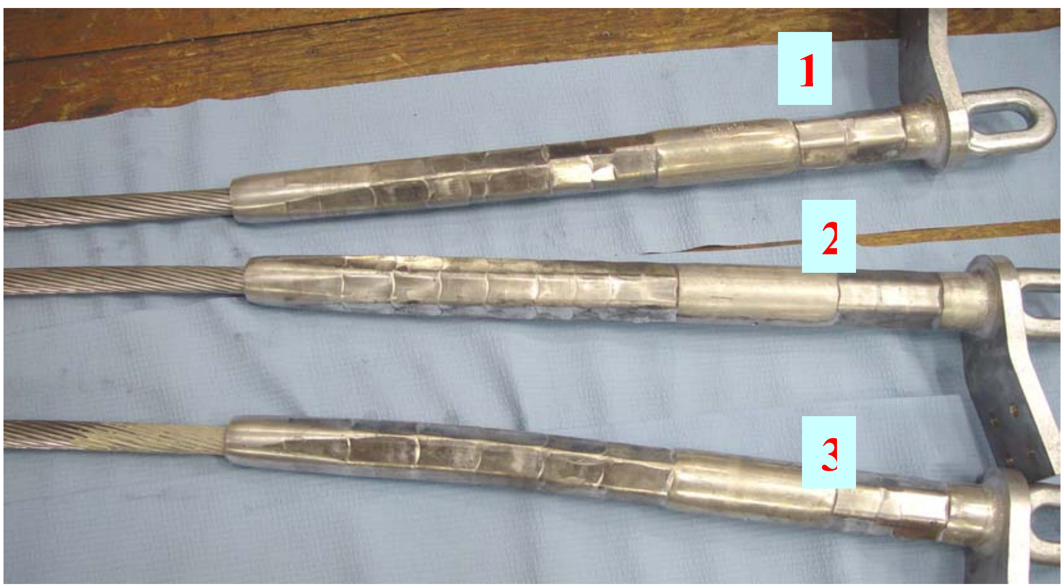
1) MTS Servo-hydraulic tensile machine, Control # CQ 0195 (load and crosshead data)
2) AFL compression tool and dies, provided by AFL

Procedure:

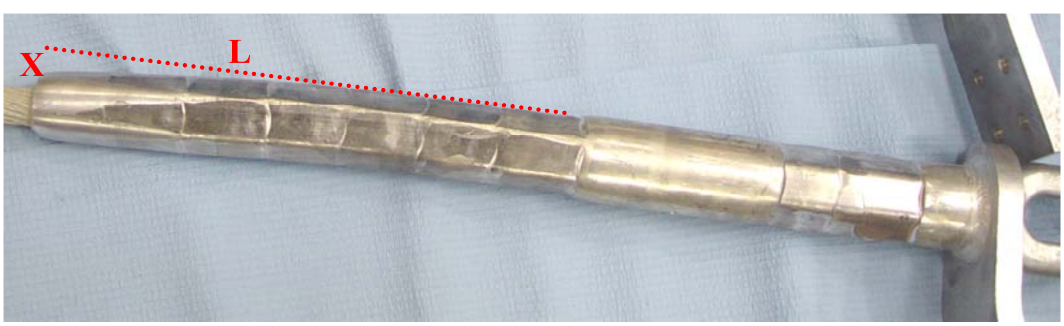
Kamal Amin of 3M and Wayne Quesnel of Alcoa Fujikura Limited (AFL) visited NEETRAC on February 18, 2003 to construct test samples designed to determine the effort needed to cause connector bowing, and to prepare samples with varying severity of bowing. Samples 1 and 2 were prepared with the following examples of deliberate poor practice:

1) The conductor was not straightened before insertion into the sleeve
2) The weight of the conductor was not supported during compression (applied bending on the sleeve)
3) No die lubrication was applied to the compression dies
4) Haphazard application of die bites (varying angle and overlap)

Even with deliberate poor practice, the connectors exhibited only slight bowing. Samples 1 and 2 in Photograph 1 show the result of this effort. For the third sample, Wayne Quesnel applied his maximum force (approximately 80 lbs) to the connector end during each crimp. Photograph 2 shows the degree of bowing measured on sample 3.



Photograph 1, dead end samples after installation on 795 ACCR conductor (photograph courtesy of 3M Company)



Photograph 2, sample 3, X/L was 0.058, or 3.3 degrees (photograph and measurement courtesy of 3M Company)

After dead-end connector installation, the opposite conductor end was terminated with a cast-resin termination. Cast-resin terminations are used for lab testing because they develop the full conductor strength, and permit “birdcaging” from the compression operation to be removed from the test section. Slack removal is important for laboratory testing, because the samples are very short relative to typical field spans (a 20 ft section was tested for this project). Birdcaged lab samples will not behave in the same manner as conductor in field spans because the slack is a large proportion of the sample length. With a resin termination, the laboratory sample has all conductor components loaded in a manner similar to field loading. Therefore, the results are representative of the conductor’s field performance.

Each sample was loaded in the tensile machine, and loaded at a steady rate of 20,000 lb/min to destruction. The machine automatically records the maximum load. The operator observes the failure, and records the failure mode before the file is saved to a computer disc for safe storage. As a back up, a printer is used to record the test data on paper as well.

Results:

Sample	Max load (lbs)	% RBS	Failure mode
1 (moderate bow)	30,640	98	All strands failed, 1 inch from dead end
2 (moderate bow)	30,270	97	All strands failed, ~4 ½” inside sleeve
3 (extreme bow)	29,210	94	All strands failed, ~4 ½” inside sleeve

Conclusions:

The test data show that there is the expected relationship between bowed connectors and loss of tensile strength. However, the connector system demonstrates good tolerance for mild bowing.

The data shows that for a bow of up to 3 degrees offset from the line angle (L/D of 0.052), the connector still meets the ANSI C119.4 tensile strength requirements. Any sleeves with bowing exceeding 3 degrees offset from the line will likely not meet the ANSI requirement, and should be rejected. Because bowing was extremely difficult to induce for this investigation, any severe bowing that occurs during connector installation is likely due to extreme die wear or other problems that were not duplicated in the lab. Therefore, should bowing occur, an investigation should be conducted to identify the cause and take appropriate corrective action.