477 kcmil, 3M Brand Composite Conductor
High-temperature Connector Sustained Load Tests

3M Company
Purchase Order 0000423016

NEETRAC Project Number: 02-053

May, 2002

National Electric Energy Testing, Research & Applications Center

NEETRAC

ISO 9001 ANSI-RAB QMS ACCREDITED

A Center of
The Georgia Institute of Technology

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Reviewed by: ______________________
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Summary:

3M contracted with NEETRAC for connector sustained load tests in accordance with ANSI C119.4, with the additional provision that the conductor temperature would be held at 240^{o} C during the sustained load test. The test tension was 15% of RBS to account for the fact that ice loading is not relevant at high temperature, and thermal elongation results in low in-service tension during periods of high-temperature operation. Alcoa Fujikura Limited (AFL) splice and dead end samples showed no signs of problems during the load test, and exceeded RBS in a room-temperature tensile test following the 168-hour sustained load period.

Samples:

1) Twenty (20) meters of 477 kcmil, type 16, 3M Composite conductor
2) AFL compound compression dead end terminal (special design for the ACCR conductor)
3) AFL compound compression splice (special design for the ACCR conductor)

References:

1) "Proprietary Information Agreement …." Dated 3/27/01
2) ANSI C119.4 – 1999, (Connector performance requirements)
3) 3M Purchase Order 0000423016.
4) PRJ 02-053, NEETRAC Project Plan

Equipment Used:

1.0 MTS Servo-hydraulic tensile machine, Control # CQ 0195
2.0 Creep frame LabView PC data acquisition system, Control # CN 3040
 2.1 National Instruments AT-MIO-16XE-50 computer interface card
 2.2 BNC 2090 voltage interface (tension measurements).
 2.3 Omega Engineering OMR 6018 thermocouple conditioner
3.0 HBM 10,000 lb load cell and DMD 465WB conditioner, Frame "A", Control # CN 3018
4.0 HBM 10,000 lb load cell and DMD 465WB conditioner, Frame "B", Control # CN 3019
5.0 Omega Engineering type T sheathed thermocouples (calibrated with CN 3040)
6.0 Limitorque lead-screw actuators (2 required), controlled by Measurement Computing CIO SERB-08 PC relay control board.
7.0 High current AC test set, Control # CN 1045.

Procedure:

Testing was conducted in accordance with a NEETRAC procedure entitled "PRJ02053, CONFIDENTIAL – MMC Conductor Evaluation, Sustained Load Test". The procedure controls all technical and quality management details for the project.

Wayne Quesnel of AFL provided a 100-ton crimping press and dies for compressing the core sleeve and the aluminum conductor tube. Two connector – conductor samples were prepared, one each AFL dead-end and AFL full-tension splice. Connector materials and workmanship were under the direction of AFL, who designed the connector system.

Compressing the aluminum tube forces about ¾ inches (20 mm) of excess slack into the aluminum conductor layers. Excess slack was worked by hand to the free end of the sample. This was done for both ends of the splice sample. A cast-resin fitting was installed on both ends of the splice sample, and on the dead-end sample opposite the dead end terminal. The overall sample length eye-to-eye is 23 feet. The lab fittings occupy 18 inches each, so the free span plus the connector length is 20 feet.

Both samples were installed in a load frame. Each sample was loaded with a separate actuator. Tension for both samples was set to 15% RBS (2,921 lbs). Automatic controls maintained the tension within 30 lbs of the setting for the test duration.

The samples were electrically terminated to permit resistance heating. An AC power supply was connected across the samples, which were connected in series (both had identical current). An AC current of 1050 Amperes was required to raise the conductor temperature to 240^{o} C in the enclosed draft-free test enclosure. Thermocouples were installed in the free-span conductor (core and surface), both ends of the splice, and in the dead-end barrel. Figure 1 shows the temperature and load data recorded during the high-temperature load phase.

There was one anomaly during the heat up phase: the aluminum seal plug for the splice center cavity ejected during the initial heat-up. The splice temperature was 100^{o} C, which should not cause vaporization of the compound. The problem did not affect the remainder of the sustained load test. There was no further inhibitor loss or inhibitor degradation during the remainder of the test. Splice temperature was stable. A combination of a poorly sealed plug and an air pocket in the inhibitor compound appears to account for the ejection of the plug.

At the end of the required sustained load period, the AC current was terminated, and the tension reduced to zero. Each sample was subjected to a room-temperature tensile test to destruction to determine residual strength in accordance with the ANSI C119.4 requirements. The splice sample failed at the resin socket at 20,320 lbs, or 103% of the nominal RBS. The dead end sample failed all strands in the mid-span at 21,030 lbs or 106% RBS. These values are comparable to values obtained when the conductor is tested with no splices or dead-end terminals (lab terminations only). Figure 2 shows load versus crosshead position for the tensile tests.

Conclusion:

Neither the splice nor the dead end connector exhibited loss of mechanical strength resulting from sustained load at 240^{o} C. Connector temperature was stable throughout the test period at approximately 100^{o} C (splice), and 85^{o} C (dead-end).

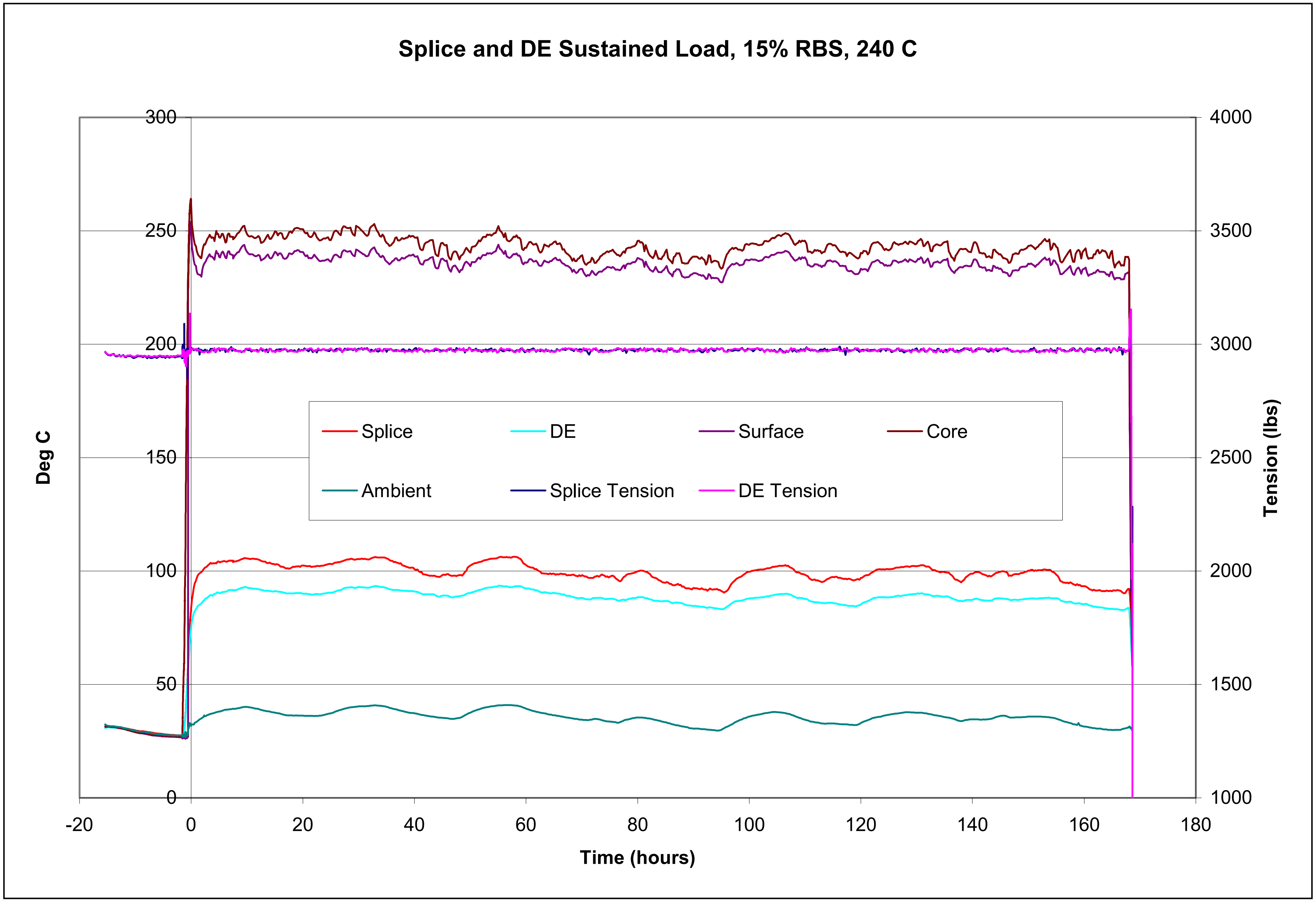

Figure 1, Temperature and Load Data for Sustained Load Test

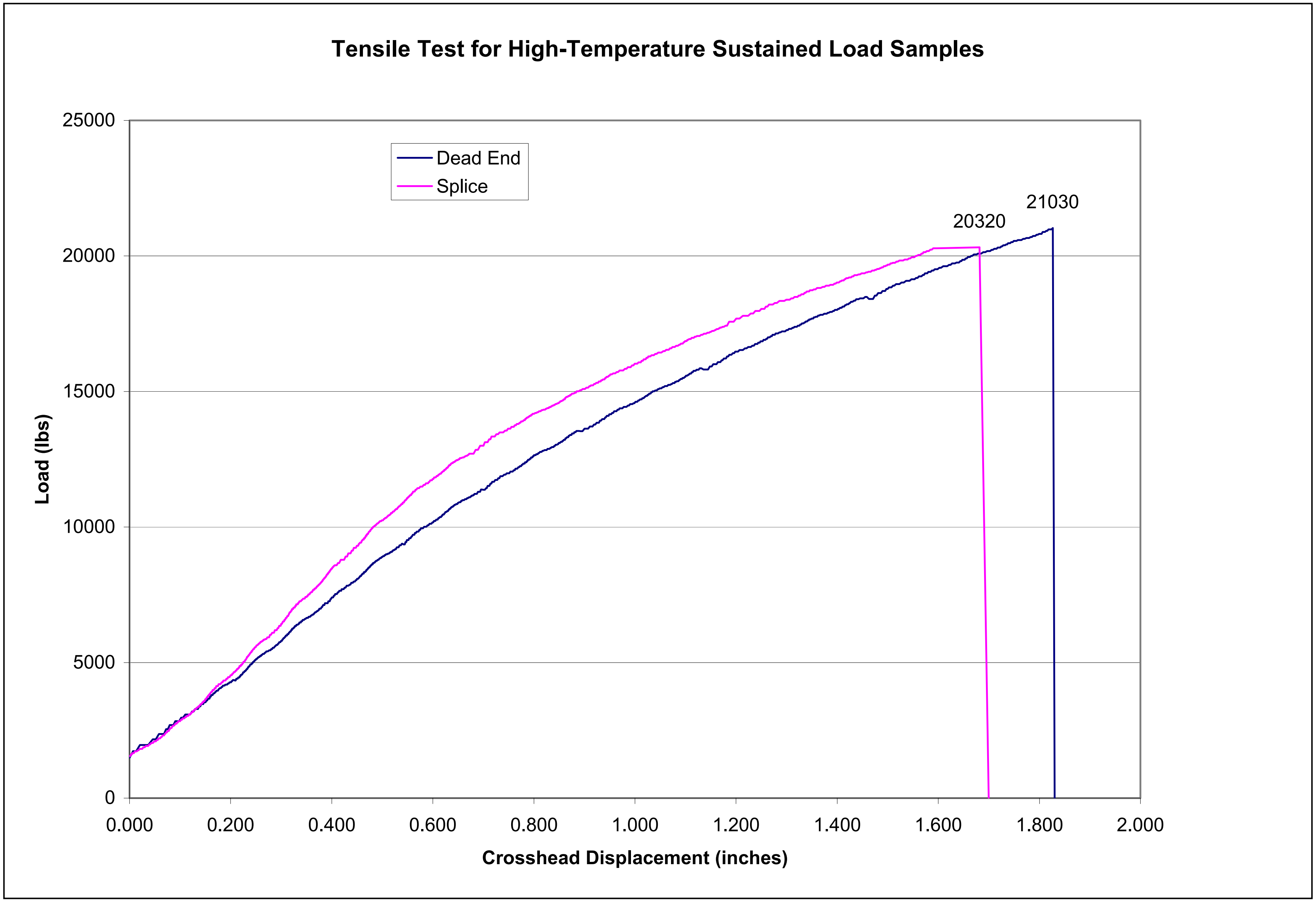

Figure 2
Tensile Test Graph for High-temperature Sustained Load Samples