477 kcmil, 3M Brand Composite Conductor Core High-temperature Creep Tests

3M Company
Purchase Order 0000572787

NEETRAC Project Number: 02-179

February, 2003

National Electric Energy Testing, Research & Applications Center

NEETRAC

ISO 9001

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A Center of
The Georgia Institute of Technology

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Summary:

3M contracted with NEETRAC for high-temperature creep tests on the metal matrix composite (MMC) core strand from 3M's 477 kcmil ACCR conductor. The Aluminum Association's 1999 guide on creep testing was used as a reference, with the exception that samples were tested at 150^{o} C and 250^{o} C. The test results demonstrate extremely low creep at both temperatures.

Samples:

1) Sixteen (16) meters of 477 kcmil, type 16, 3M Composite conductor, from reel received 8/16/02.

References:

1) "Proprietary Information Agreement …." Dated 3/27/01
2) "A Method for Creep testing of Aluminum and ACSR Conductors", Aluminum Association, 1999.
3) 3M Purchase Order 0000572787.
4) PRJ 02-179, NEETRAC Project Plan

Equipment Used:

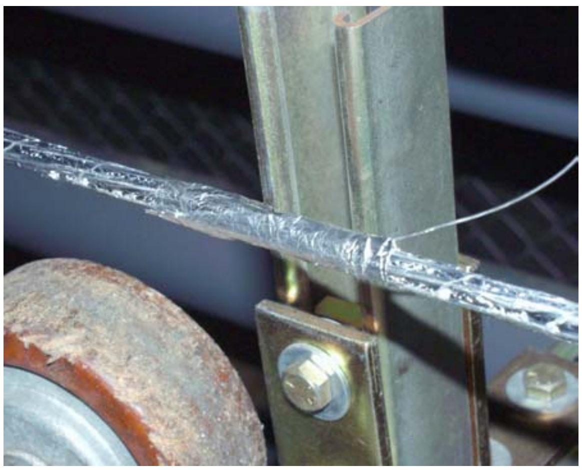
1) Limitorque creep actuator
2) Mitutoyo creep frame extensometer, Control # CN 3041.
3) Creep system LabView data acquisition system, Control # CN 3040
4) National Instruments AT-MIO-16XE-50 computer interface
5) HBM 10,000 lb load cell, Model USB-XX108, Control # CN 3018.
6) Omega Engineering DMD load cell conditioner, used to condition HBM load cell
7) High current AC test set, Control # CN 3007

Procedure and Results:

Testing was conducted in accordance with a NEETRAC procedure entitled "PRJ02179, CONFIDENTIAL – MMC Conductor Evaluation, 477 kcmil ACCR Core High-temperature Creep Test, 150^{o} C and 250^{o} C". The procedure controls all technical and quality management details for the project.

For each sample, an 8-meter section was cut from the reel. All aluminum strands were removed, leaving a naked core. Two complete sets of aluminum strands each approximately 3 feet long, were wrapped over the sample ends to provide connections for electrical terminations. Cast-resin terminations were then fitted to each end of the sample. The aluminum strands were connected to tubular-to flat NEMA four-bolt connectors. This arrangement allows for application of mechanical tension (resin termination), and loading current (NEMA connector).

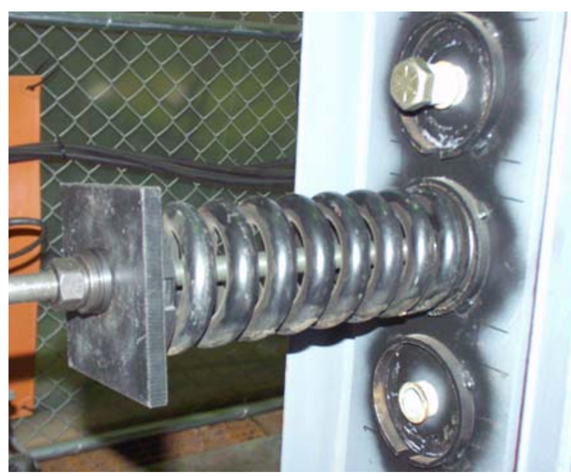
Each sample was installed in the creep frame, which has a computer interface for load control and automatic logging of test data. Nominal tension of 400 lbs was applied during the set up phase. Supports are provided in three locations along the sample to minimize sag. The Mitutoyo cable extensometer is an aluminum box beam, which hangs from springs. The springs hold the beam in a neutral position next to the sample, and senses elongation without applying significant loads. The instrument is shielded from the hot sample by a four-inch air gap and a thick rubber blanket. The gage beam and the sample are instrumented for temperature. Photographs 1 through 4 show the test in progress.



Photograph 1, sample temperature sensor

Photograph 2, Mitutoyo digital indicator, electrical connection, and rubber heat shield for gage rod

Photograph 3, tension actuator



Photograph 4, Railroad spring used to buffer the actuator.

Room temperature was controlled, although the data show a daily temperature cycle due to solar heating of the room, and cycling of the heating equipment. Both tests ran over 1000 hours with no interruption in temperature or tension. Creep at the applied loads is very small – near the level of instrument noise and extraneous effects. Extraneous effects include thermal and time-dependent drift of the load cell conditioners, and temperature effects on the load frame and the gage-reference rod. The sample and the gage rod are instrumented for temperature. Raw elongation data was corrected for temperature effects, but the correction does not result in smooth data. Factors contributing to non-smooth data are believed to be the following:

1) Instrument noise
2) Instrument temperature drift
3) Sample temperature gradients (the hot sample reacts to room drafts)
4) Gage rod temperature gradients (the rod will bow if it is warmer on one side, and that will introduce measurement errors
5) Discrepancy in the thermal time constant of the sample (short TC) versus the gage rod (long TC).

The creep measured during the test is small relative to extraneous effects on the instruments and test equipment. For temperature compensation, values of 0.00006% per degree C is used for the sample, and 0.00023% per degree C is used for the aluminum gage rod. For load compensation a coefficient of 0.000055% per pound was used for load compensation. Figures 1 and 2 show a summary of the data collected, along with the logarithmic fit to the compensated creep data.

In spite of the ragged appearance of the data, the logarithmic fit to the corrected creep data appears to be reasonable:

$\text{Creep}_{150C@15\%RBS}$ (%)= 0.00036*Ln(hours) + 0.0009

$\text{Creep}_{250C@15\%RBS}$ (%)= 0.00050*Ln(hours) + 0.0029

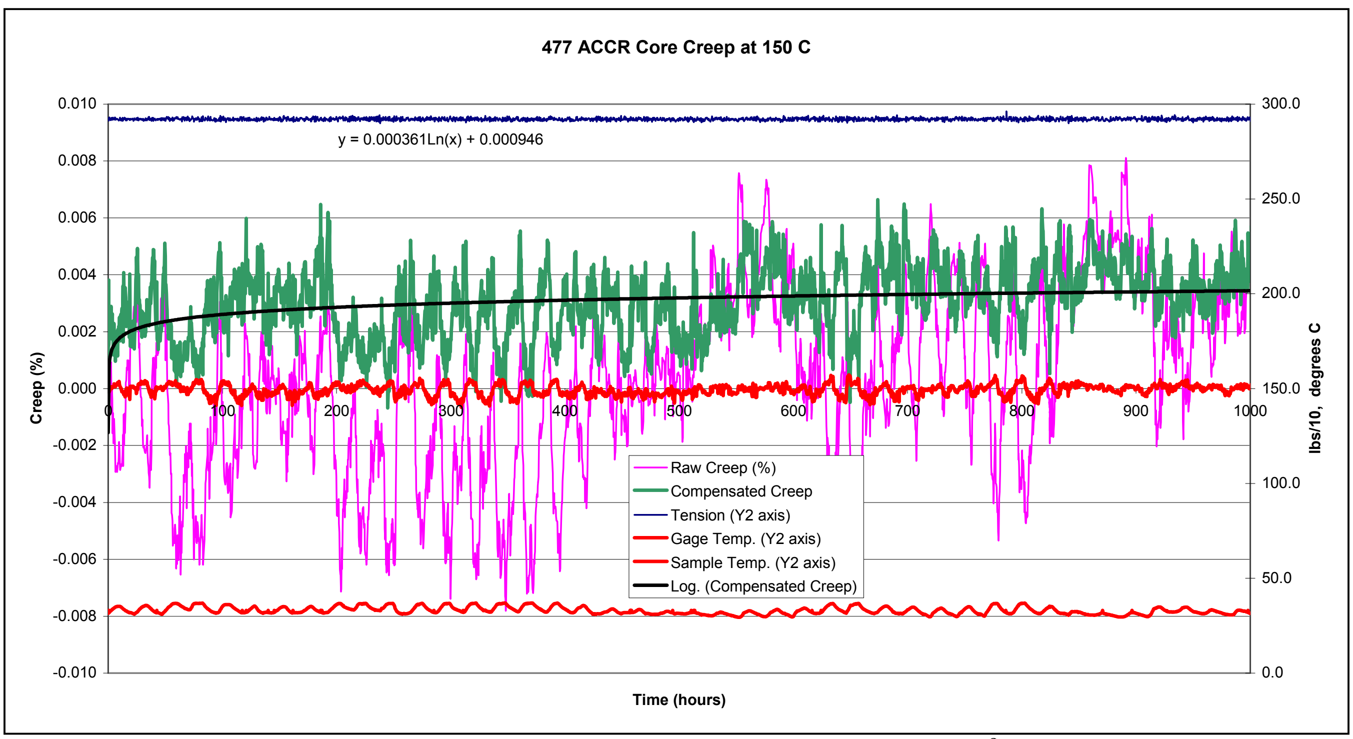


Figure 1, tension, temperatures, creep, and the fit curve for the 150^o C core creep test

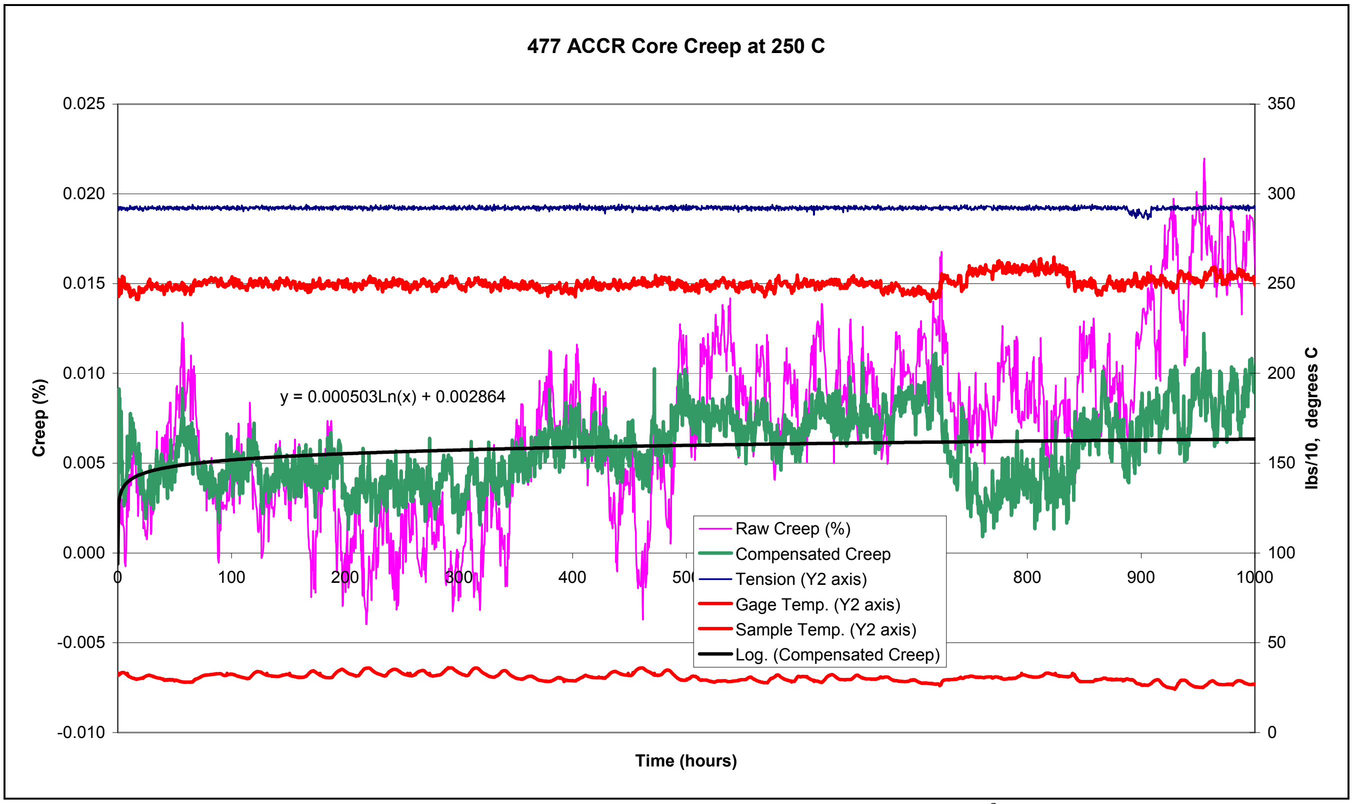


Figure 2, tension, temperatures, creep, and the fit curve for the 250^o C core creep test

Bonus Data:

At the end of the 1000-hour creep test, it was possible to control the load and temperature to provide data on the properties of the core strand in the "fully aged" condition. Figures 3 and 4 show the cool-down curves, and the linear and polynomial fits to the cool-down data.

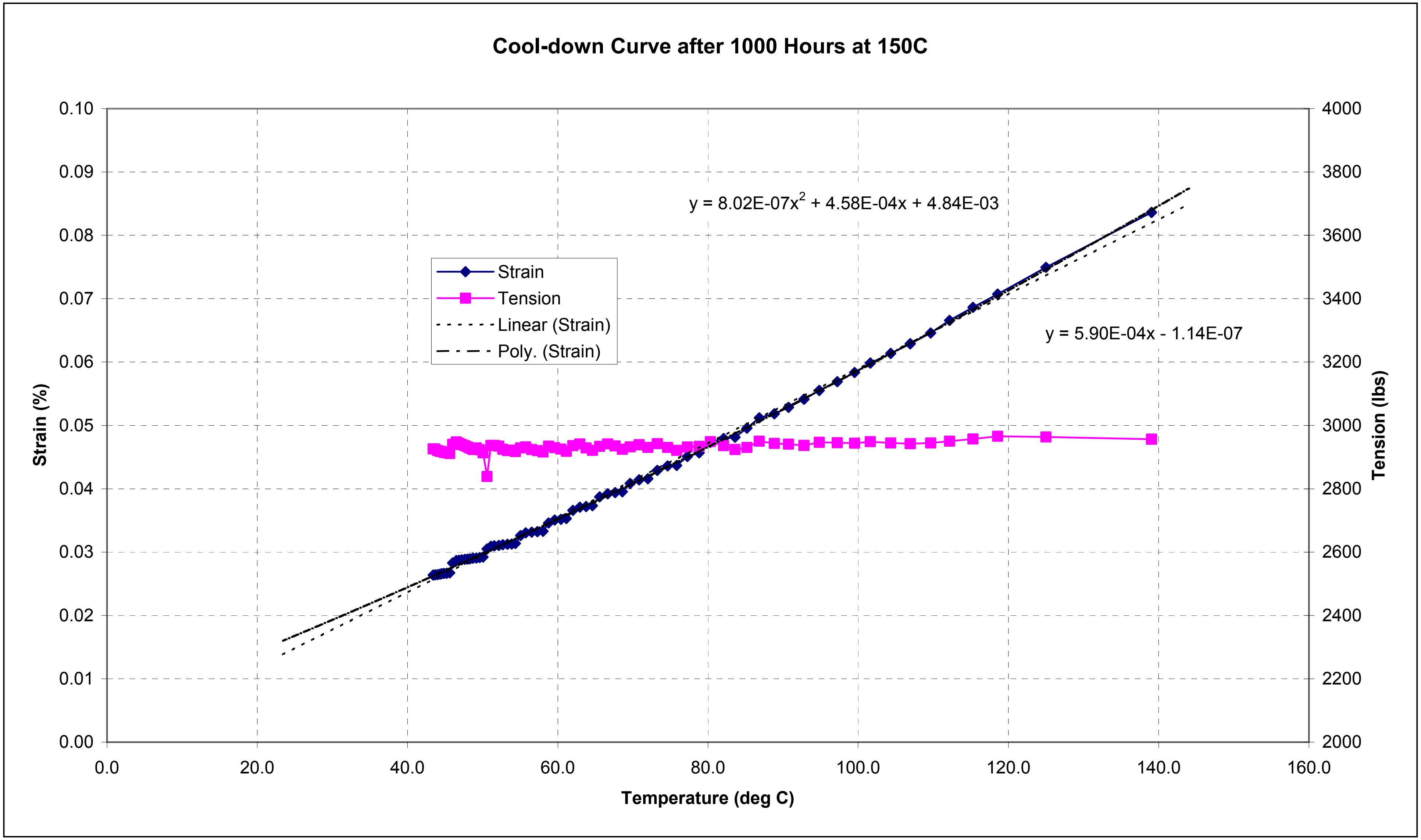


Figure 3, Cool-down data following the 150° C Creep Test

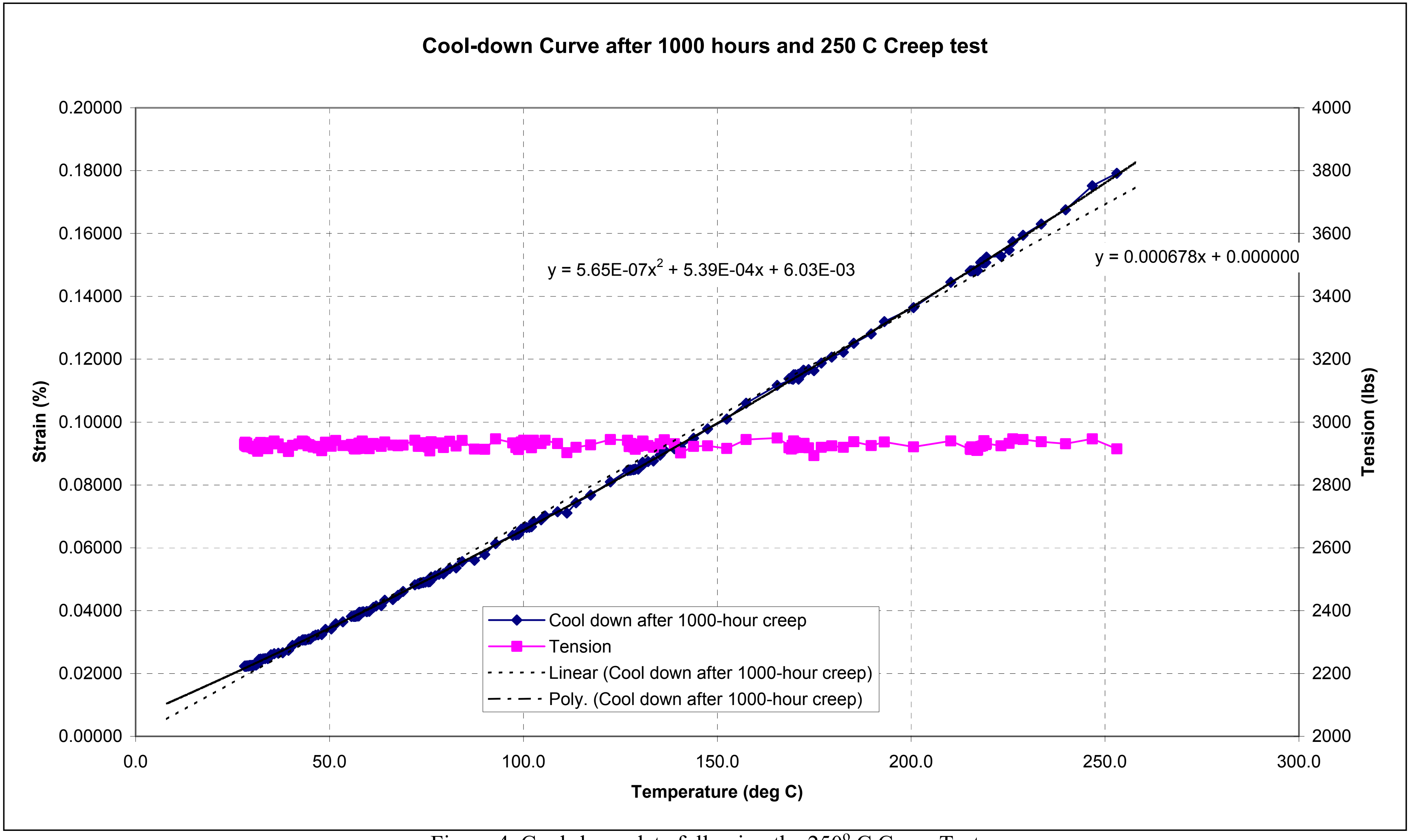


Figure 4, Cool-down data following the 250° C Creep Test