1272-kcmil 3M^{TM} Composite Conductor (ACCR)
Evaluation of Materials from ORNL Field Test

NEETRAC Project Number: 05-236

February, 2006

A Research Center of the
Georgia Institute of Technology

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Summary

Conductor and connectors from the Oak Ridge National Laboratory (ORNL) outdoor test line were evaluated to determine the effect of exposure to outdoor conditions and in-service temperature cycles. Data from tests on the same materials "as manufactured" were retrieved for baseline property values. Evaluation results show that expected creep has occurred, but mechanical and electrical properties of the conductor are unchanged. Tensile tests on splices, dead ends, and free – span conductor all exceeded the requirements for new materials. Dissection of the compression dead-ends and compression splice revealed two problems with connector installation (procedures not followed correctly). Dissection of a PLP (Preformed Line Products) splice and dead end revealed no problems with connector installation. Dissection of two PLP suspension units revealed minor conductor damage occurred during installation.

Key Findings

1) Stress-strain results show the expected effect of creep from in-service tension.
2) Mechanical and electrical properties of the conductor and connector are unchanged from baseline (new) conditions, other than conductor creep.
3) Connector dissections showed failure to wire-brush the conductor, and failure to inject sufficient inhibitor into the fill port prior to compression. Neither problem affected the field trial, but long-term reliability could be negatively impacted by improper installation.
4) One PLP suspension showed signs of a screwdriver being scraped on the conductor during installation. The problem did not affect the sample during the field trial or testing.

Samples

1) Two (2) ACA Conductor Accessories (formerly Alcoa-Fujikura Ltd., AFL) compression dead ends with conductor tails for 20-foot total length.

2) One (1) ACA compression splice with conductor tails for 20-foot total length.

3) Two (2) PLP dead ends with conductor tails for 20-foot total length.

4) Two (2) PLP suspension samples with conductor tails for 20-foot total length.

5) Free span conductor, approximately 200 feet, with bolted clamps on ends. Free span conductor was used for stress-strain and tensile tests.

Procedure

The samples from the field test site were removed using procedures designed to preserve the in-service position of each core and aluminum strand. This was accomplished by installing bolted clamps on both sides of every conductor cut as the test spans were taken down. After the samples were received at the testing lab, additional clamps were installed on both sides of every conductor cut. The bolted clamps were removed only after a cast-resin termination was installed outboard of the bolted clamps. Liquid resin exerts negligible force while curing, but cured resin holds the full strength of each strand. Therefore, the stress-strain results properly represent the field conductor characteristics. Tensile test results produce the same loads as would be reached if the conductor was overloaded to failure during service in the overhead line.

The scope of the evaluation included the following tests:

I) **Conductor tensile tests:** Three samples were cut from the free-span section to determine aging effects on the free span conductor. Following the dissection of the PLP suspension units, the underlying conductor was terminated and tensile tested. The stress-strain conductor and core samples were also tested to destruction following the stress-strain measurements.

II) **Connector and fittings tensile tests:** Four dead-ends (two ACA and two PLP), and two splices (one each ACA and PLP) were pulled to destruction to determine the effects of field aging on the full-tension fittings.

III) **Resistance:** Resistance was measured on one (1) conductor sample, one (1) ACA splice, one (1) ACA dead end, and one (1) PLP splice. Samples were electrically isolated, and pulled with sufficient tension (about 300 lb) to keep them straight. Copper wire was wrapped around the conductor OD for voltage measurement terminals. Bolted equalizers were installed for current connections. Dead end terminal pads were used for both current and voltage terminals. Terminal pad leads were placed in a manner that ensured that voltage gradients within the terminal pad did not influence the resistance readings. A digital low-resistance ohmmeter was used to make a 4-wire resistance measurement for all samples. Connector resistance measurements are expressed as resistance ratio, a number that expresses the connector resistance relative to the identical length of conductor.

IV) **Dissections:** One (1) ACA splice, one (1) ACA dead end, two (2) PLP suspensions, one (1) PLP splice, and one (1) PLP dead end) were dissected to check for proper component placement and to assess installation practices.

V) **Stress-strain**: A sample from the free-span section was tested in accordance with the 1999 Aluminum Association guide for conductor stress-strain testing. The only deviation from the guide was use of the elastic modulus for the MMC core, where the guide provides values only for steel core conductors. For clarity, the procedure details are in the results section of this report.

Results:

I) Conductor tensile tests:

Sample #	Breaking Load (lb)	% RBS	Failure Mode
Tensile 1 (free span)	46,950	107	All strands fractured in resin fitting
Tensile 2 (free span)	48,810	112	All strands fractured 6" from resin fitting
Tensile 3 (free span)	49,750	114	All strands fractured 6" from resin fitting
Tensile 4 (under PLP suspension)	48,490	111	All strands fractured in the gage section
Tensile 5 (under PLP suspension)	47,700	109	All strands fractured in resin fitting
Stress-strain conductor	50,240	115	All strands fractured in gage section
Stress-strain core	25,510	108	Multiple breaks, multiple locations

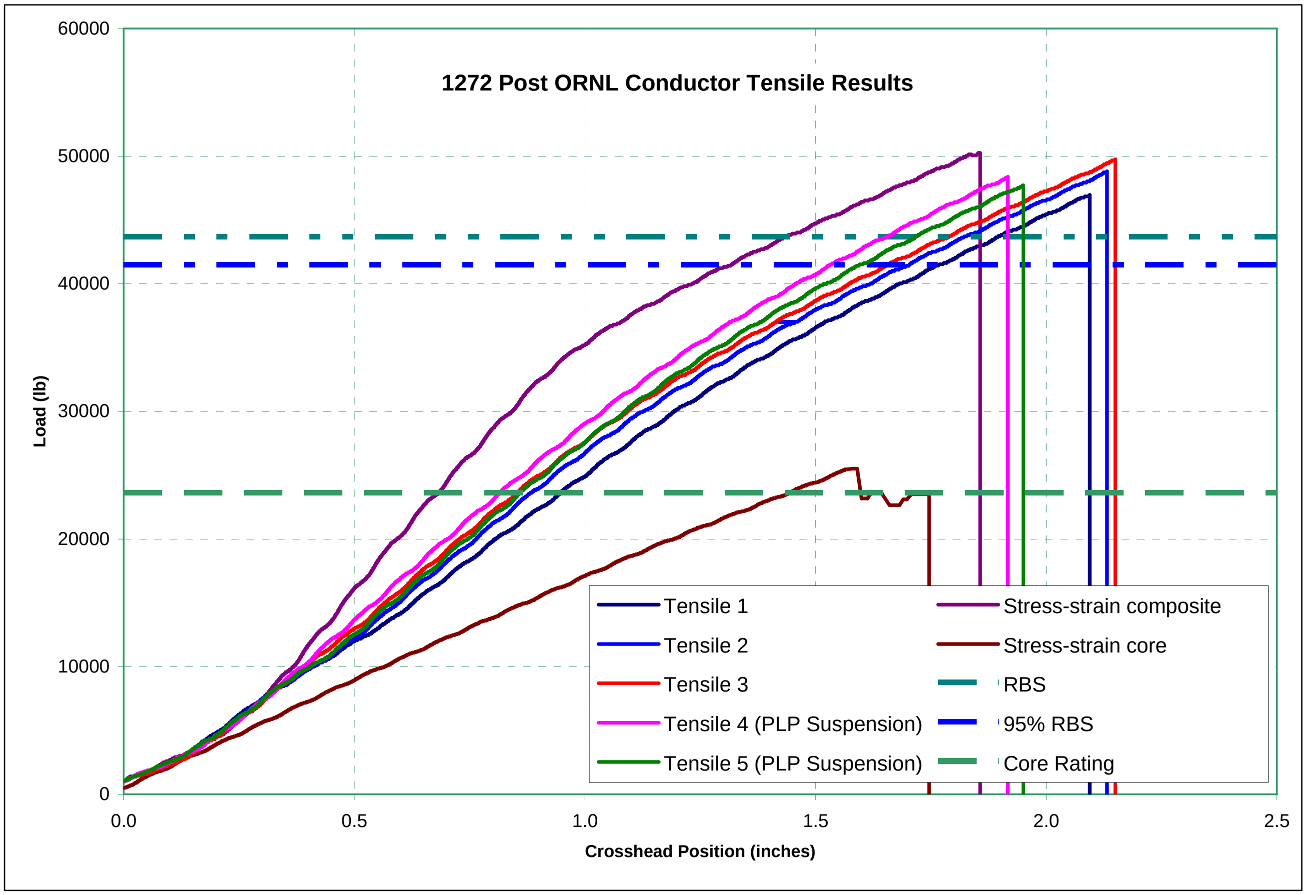


Figure 1, load versus crosshead displacement data for conductor tensile tests

II) Connector and fittings tensile tests:

Sample #	Breaking Load (lb)	% RBS	Failure Mode
ACA splice	47,300	108	All strands at resin fitting
ACA dead end 1	47,960	110	All strands ~ 4" outside dead end
ACA dead end 2	47,230	108	All strands ~ 6" inside dead end
PLP splice	42,810	98	All strands in gage section*
PLP dead end 1	46,690	107	All strands 8" from resin socket**
PLP dead end 2	47,070	108	All strands at resin fitting**

* See dissection results showing that some rods shifted before reaching the breaking load. Figure 2 shows loads where slippage occurred.

** Only one of the two formed wire loops was initially in contact with the dead-end cast fitting. During the test, the formed wire unwrapped from the inner rods until the second loop engaged and took a share of the load. Then the load increased smoothly to failure. See Figure 2 for load profile during the test.

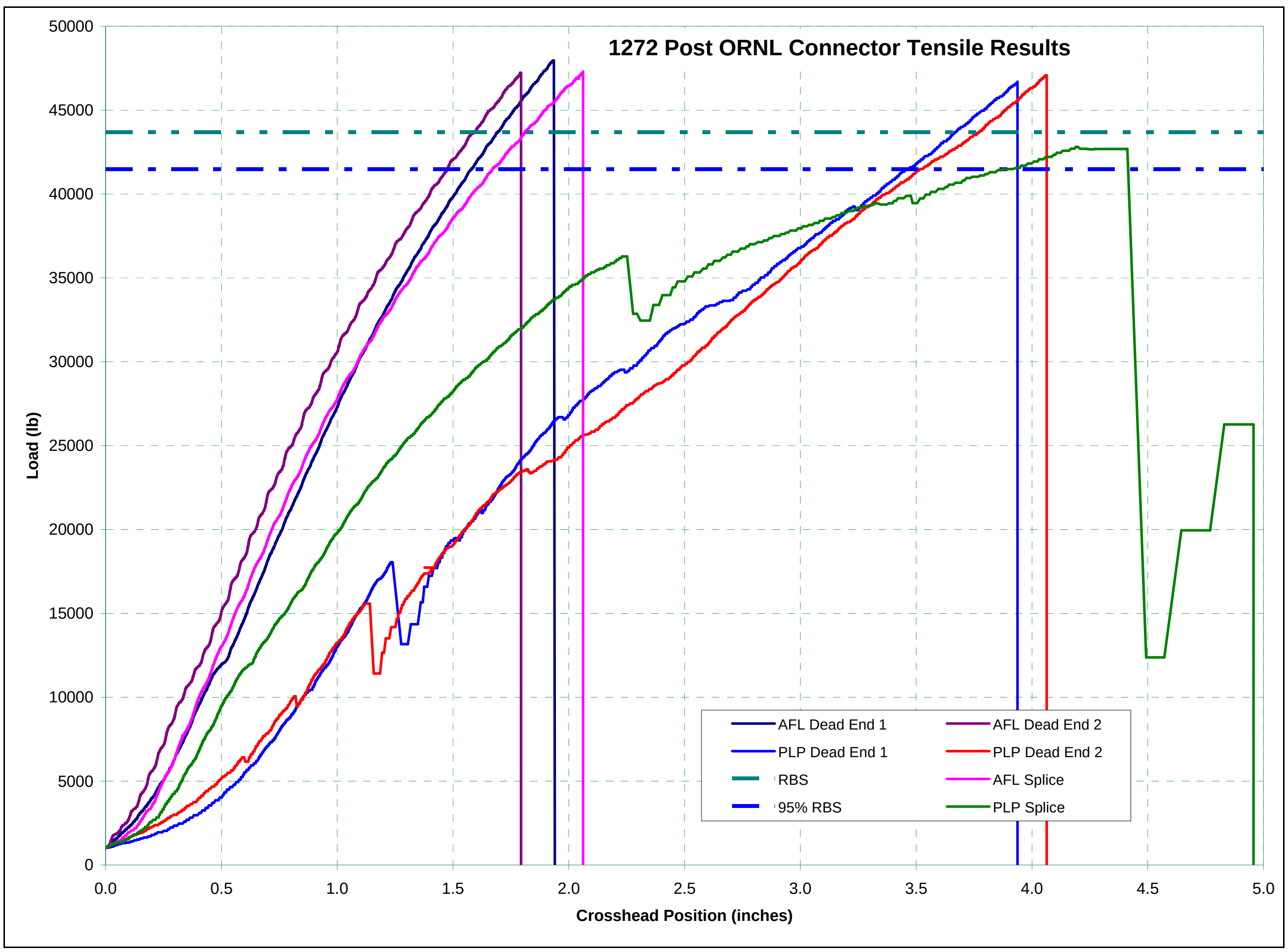


Figure 2, Tensile test results for connectors and PLP dead end fittings

Figure 3, photograph of ACA splice during tensile test

Figure 4, photograph of PLP splice end before tensile test

Figure 5, photograph of PLP splice after tensile test. Note rod slippage.

III) Resistance:

The following worksheets show data and calculations for resistance measurements. Photographs from resistance measurements follow the worksheets.

Conductor Resistance

NEETRAC Project No.	05-236		= Data Input Cells
AVO (Biddle) DLRO, Calibration Control #	CQ1097		= Calculated Value
Temperature Indicator (Instrument)	CN3022		
Temperature coefficient for resistance:	0.0036		

Resistance measurement on a 1272 ACCR sample from the ORNL test line. Bolted end fitting for equalizer (see photos), pulled to ~200-400 lbs tension w/a come-a-long to straighten sample.

These readings taken manually @ 11/21/05 @ 10:19 AM

Conductor Temperature:	20.5	deg C			
Test Section:	16.000	ft			
Resistance Reading 1	*	uOhms	At	20.5	deg C
Resistance Reading 2	*	uOhms	At	20.5	deg C
Resistance Reading 3	*	uOhms	At	20.5	deg C
Average of 3 Readings	209.60	uOhms	At	20.5	deg C
Ohms/ft:	1.3100E-05	Ohm/ft	At	20.5	deg C
Ohms/ft:	1.3076E-05	Ohm/ft	At	20.0	deg C
Ohms/mi	0.06917	Ohm/mi	At	20.5	deg C
Ohms/mi @ 20C:	**0.06904**	Ohm/mi	At	20.0	deg C
3M nominal	0.07000	Ohm/mi	At	20.0	deg C

* Individual readings were inadvertently not recorded. The average was computed from three readings

AFL Splice Resistance Ratio Worksheet

NEETRAC Project No.	05-236		
AVO (Biddle) DLRO, Calibration Control #	CQ1097		= Data Input Cells
Temperature Indicator (Instrument)	CN3022		= Calculated Value
Temperature coefficient for resistance:	0.0036		

Resistance measurement on a 1272 ACCR Compression Splice Setup in the tensile room on the MTS frame, Bolted end fitting for equalizer (see photos), pulled to ~200 - 400 lbs tension w/a come-a-long to straighten sample.

X1 =	29.875	Inches from end of splice to P1
X2 =	23.0	Inches from end of splice to P2
L =	52.6875	Inches, Length of Splice (end to end)
Current =	10.0	Amps DC

These readings taken manually @ 12/02/2005 @ 9:03 AM

Conductor Temperature:	20.0	deg C					
Test Section:	8.792	ft	P1 to P2				
Resistance Reading 1	81.1	uOhms		At	20	deg C	
Resistance Reading 2	81.1	uOhms		At	20	deg C	
Resistance Reading 3	81.0	uOhms		At	20	deg C	
Average of 3 Readings	81.07	uOhms		At	20	deg C	= measured resistance over length X1 + X2 + L
Corrrected to 20C:	81.07	uOhms		At	20.0	deg C	

These readings taken manually @ 12/02/2005 @ 9:21 AM

Conductor Temperature:	20.0	deg C					
Test Section:	8.792	ft	P1 to P2				
Resistance Reading 1	81.1	uOhms		At	20.0	deg C	
Resistance Reading 2	81.1	uOhms		At	20.0	deg C	
Resistance Reading 3	81.1	uOhms		At	20.0	deg C	
Average of 3 Readings	81.10	uOhms		At	20.0	deg C	= measured resistance over length X1 + X2 + L
Corrrected to 20C:	81.10	uOhms		At	20.0	deg C	

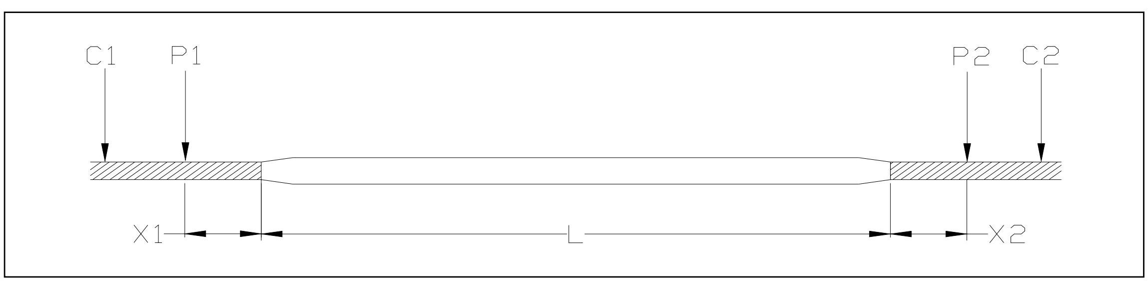
Average	81.08	uOhms	At	20.0	deg C

Calculated Resistance Ratio:

CR =	1.09	uOhms/Inch	Conductor Resistance
DEC =	81.08	uOhms	Splice Resistance + Conductor Resistance P1 to P2

$$RR = \frac{(DEC) - [(X1 + X2) * (CR)]}{(L) * (CR)} = 0.41$$

Splice Resistance: 23.5 uOhms at 20.0 C



AFL Dead-End Resistance Ratio Worksheet

NEETRAC Project No.	05-236
AVO (Biddle) DLRO, Calibration Control #	CQ1092
Temperature Indicator (Instrument)	CN3022
Temperature coefficient for resistance:	0.0036

= Data Input Cells
= Calculated Value

Resistance measurement on a 1272 ACCR Dead-End Setup in the tensile room on the MTS frame, Bolted end fitting for equalizer (see photos), pulled to ~200 lbs tension w/a come-a-long to straighten sample.

X =	87.06	Inches of conductor from end of DE to P2, (length of exposed conductor to P2)
L =	32.938	Inches, Length from P1 to Mouth of Dead-End
X + L =	120.0	Inches from P1 to P2
Current =	10.0	Amps DC

These readings taken manually @ 11/30/2005 @ 10:28 AM

Conductor Temperature:	20.6	deg C					
Test Section:	10.000	ft	P1 to P2				
Resistance Reading 1	109.0	uOhms		At	20.6	deg C	
Resistance Reading 2	109.1	uOhms		At	20.6	deg C	
Resistance Reading 3	109.1	uOhms		At	20.6	deg C	
Average of 3 Readings	109.07	uOhms		At	20.6	deg C	= measured resistance over length X + L
Corrrected to 20C:	108.83	uOhms		At	20.0	deg C	

These readings taken manually @ 11/30/2005 @ 10:57 AM

Conductor Temperature:	20.7	deg C					
Test Section:	10.000	ft	P1 to P2				
Resistance Reading 1	109.0	uOhms		At	20.7	deg C	
Resistance Reading 2	109.0	uOhms		At	20.7	deg C	
Resistance Reading 3	109.1	uOhms		At	20.7	deg C	
Average of 3 Readings	109.03	uOhms		At	20.7	deg C	= measured resistance over length X + L
Corrrected to 20C:	108.76	uOhms		At	20.0	deg C	

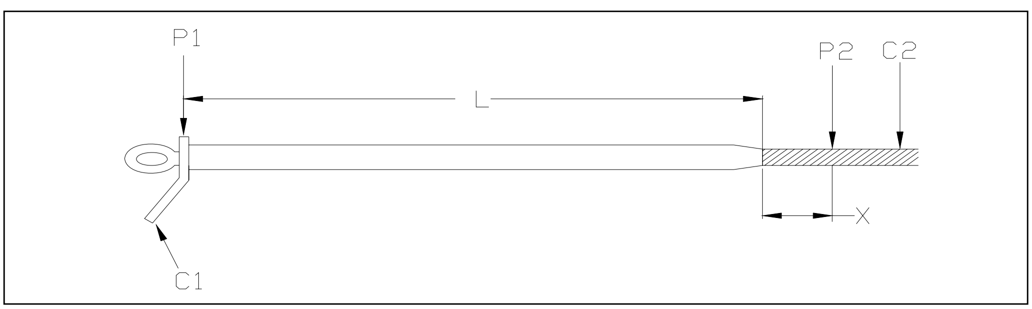
Average	108.79	uOhms	At	20.0	deg C

Calculated Resistance Ratio:

CR =	1.090	uOhms/Inch	Conductor Resistance
DEC =	108.79	uOhms	Splice Resistance + Conductor Resistance P1 to P2

$$RR = \frac{(DEC) - [(X) * (CR)]}{(L) * (CR)} = 0.39$$

Connector Resistance = 13.9 uOhms At 20.0 deg C



PLP Splice Resistance Ratio Worksheet

NEETRAC Project No.	05-236		
AVO (Biddle) DLRO, Calibration Control #	CQ1097		= Data Input Cells
Temperature Indicator (Instrument)	CN3022		= Calculated Value
Temperature coefficient for resistance:	0.0036		

Resistance measurement on a 1272 ACCR formed wire splice (PLP), for equalizer (see photos), pulled to ~200 - 400 lbs tension with a come-a-long to straighten sample. (Note: drawing at bottom of page is representative only for location of measurements.)

X1 =	0	Inches from end of splice to P1
X2 =	0	Inches from end of splice to P2
L =	174	Inches, Length of Splice (end to end)
Current =	10.0	Amps DC

These readings taken manually @ 12/02/2005 @10:50 AM

Conductor Temperature:	20.2	deg C					
Test Section:	14.500	ft	P1 to P2				
Resistance Reading 1	147.8	uOhms	At	20.2	deg C		
Resistance Reading 2	147.7	uOhms	At	20.2	deg C		
Resistance Reading 3	147.8	uOhms	At	20.2	deg C		
Average of 3 Readings	147.77	uOhms	At	20.2	deg C	= measured resistance over length X1 + X2 + L	
Corrrected to 20C:	147.66	uOhms	At	20.0	deg C		

These readings taken manually @ 12/02/2005 @ 1:04 AM

Conductor Temperature:	20.1	deg C					
Test Section:	14.500	ft	P1 to P2				
Resistance Reading 1	146.4	uOhms	At	20.1	deg C		
Resistance Reading 2	146.5	uOhms	At	20.1	deg C		
Resistance Reading 3	146.3	uOhms	At	20.1	deg C		
Average of 3 Readings	146.40	uOhms	At	20.1	deg C	= measured resistance over length X1 + X2 + L	
Corrrected to 20C:	146.35	uOhms	At	20.0	deg C		

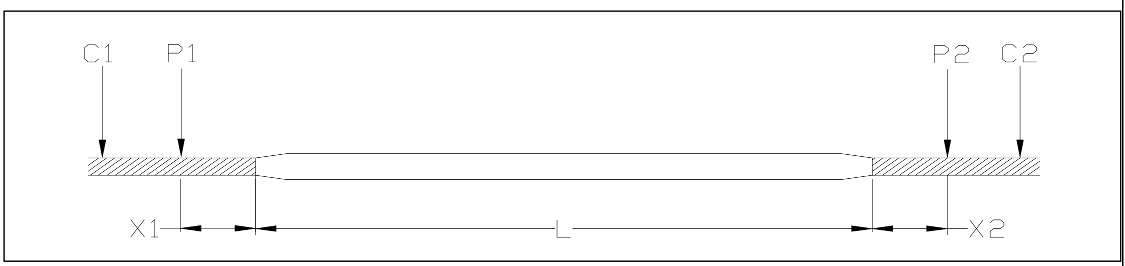
Average	147.00	uOhms	At	20.0	deg C

Calculated Resistance Ratio:

CR =	1.09	uOhms/Inch	Conductor Resistance
DEC =	147.00	uOhms	Splice Resistance + Conductor Resistance P1 to P2

$$RR = \frac{(DEC) - [(X1 + X2) * (CR)]}{(L) * (CR)} = 0.78$$

Splice Resistance: 147.0 uOhms at 20.0 C



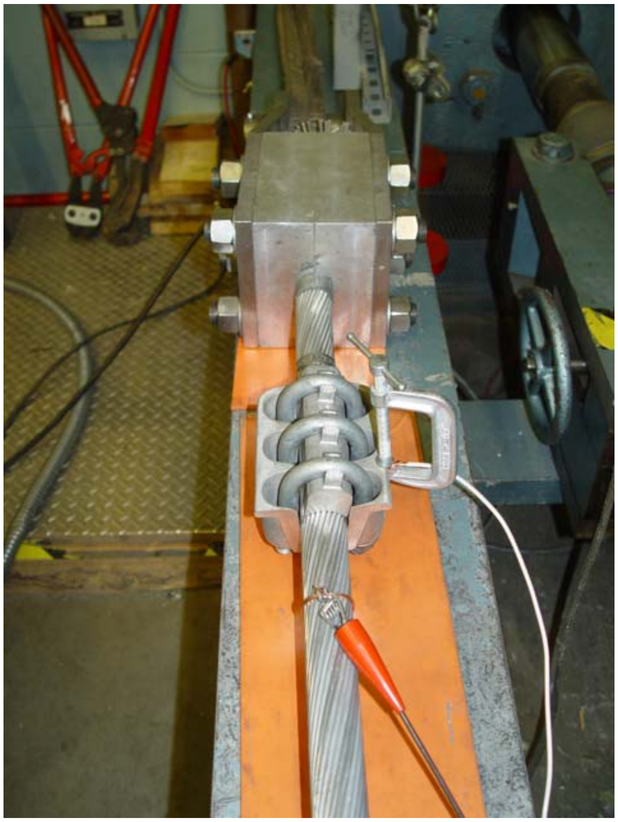


Figure 6, voltage equalizer, voltage lead and sense lead

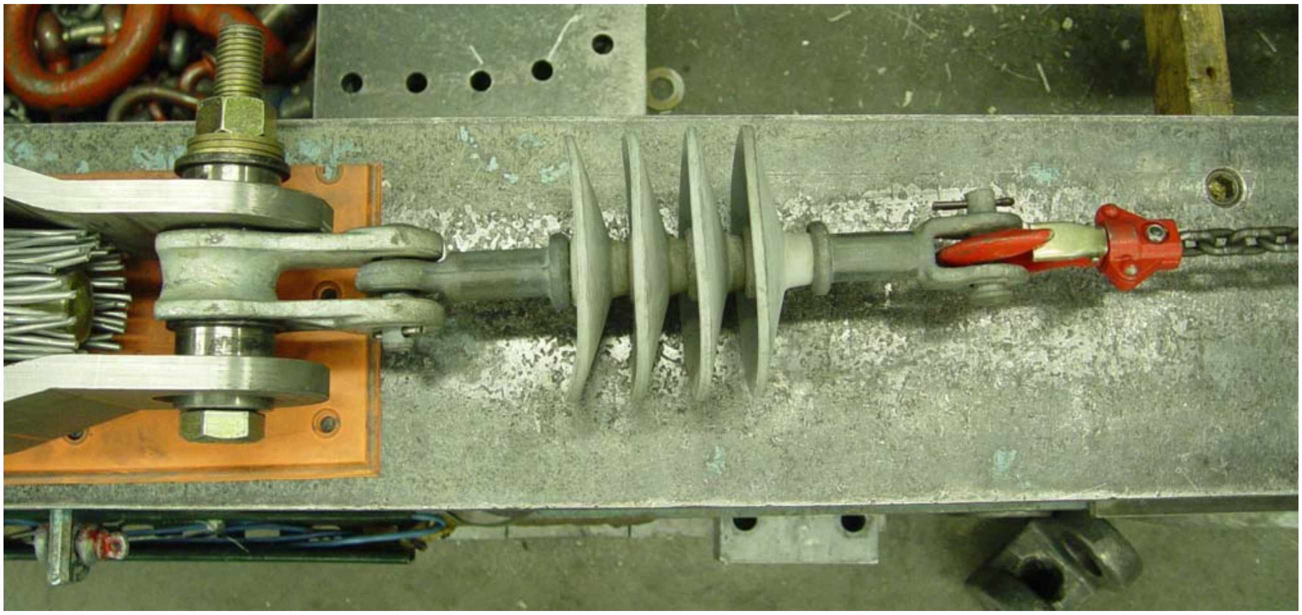


Figure 7, resistance sample tensioning device, insulator and rubber pads (insulator and pads ensure electrical isolation)


Figure 8, ACA splice setup for resistance measurement


Figure 9, ACA dead end setup for resistance measurement

IV. Stress-strain:

The term "initial modulus" is used with the field-aged test data for consistency with the test procedure. "Initial" is in quotes because the conductor is not at initial condition following the field test. Stress-strain results are similar to results from the same conductor prior to the field test. The principal difference is that creep during the 30% load hold phase is less on the field sample, apparently because the field loads caused the initial creep to be removed from the conductor.

Detailed Procedure:

Composite conductor:

1) Apply load of 1,000 lbs. Remove sag with a mid-span support
2) Install extensometer, and set to zero.
3) Pull to 30% of RBS (13,103 lbs)
4) Hold for 30 minutes.
5) Relax load to 1,000 lbs.
6) Pull to 50% RBS (21,839 lbs)
7) Hold for one hour
8) Relax load to 1,000 lb
9) Pull to 70% RBS (30,574 lb)
10) Hold for one hour.
11) Relax load to 1,000 lbs.
12) Pull to 75% RBS (32,758 lbs).
13) Relax load to 1,000 lbs, and remove the extensometer (for its own protection).
14) Pull sample to destruction.

Core strands:

1) Pull to calculated initial tension (in this case, 330 lbs). Remove sag with a mid-span support
2) Install extensometer, and set to zero
3) Pull to same strain as conductor at start of 30% of RBS test (0.11569%)
4) Hold for 30 minutes.
5) Relax load to 330 lbs.
6) Pull to same strain as conductor at start of 50% of RBS test (0.20940%)
7) Hold for one hour.
8) Relax load to 330 lbs.
9) Pull to same strain as conductor at start of 70% of RBS test (0.33324%)
10) Hold for one hour
11) Relax load to 330 lbs.
12) Pull to 75% of the core RBS (17,717 lbs)
13) Relax load to 330 lbs, and remove the extensometer (for its own protection).
14) Pull sample to destruction.

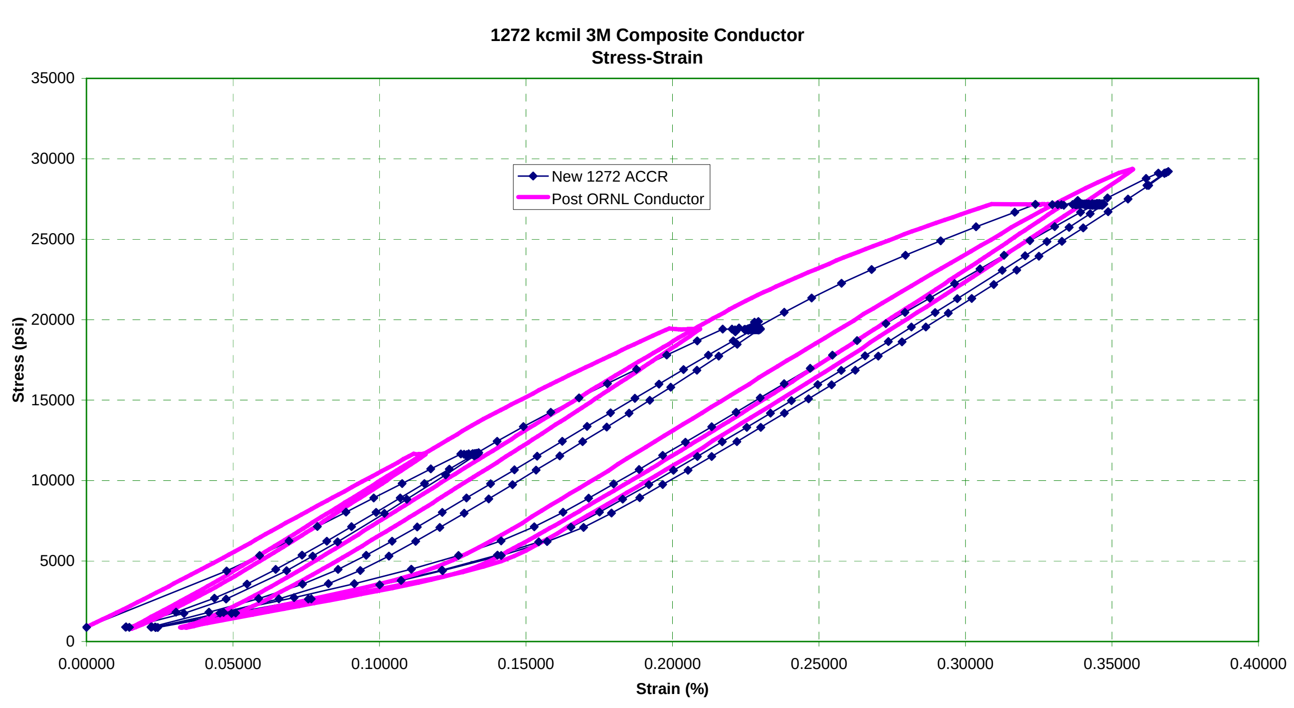


Figure 10, plot of raw data recorded during conductor stress-strain test (pink), and stress-strain data for conductor tested from same lot before the field test (blue)

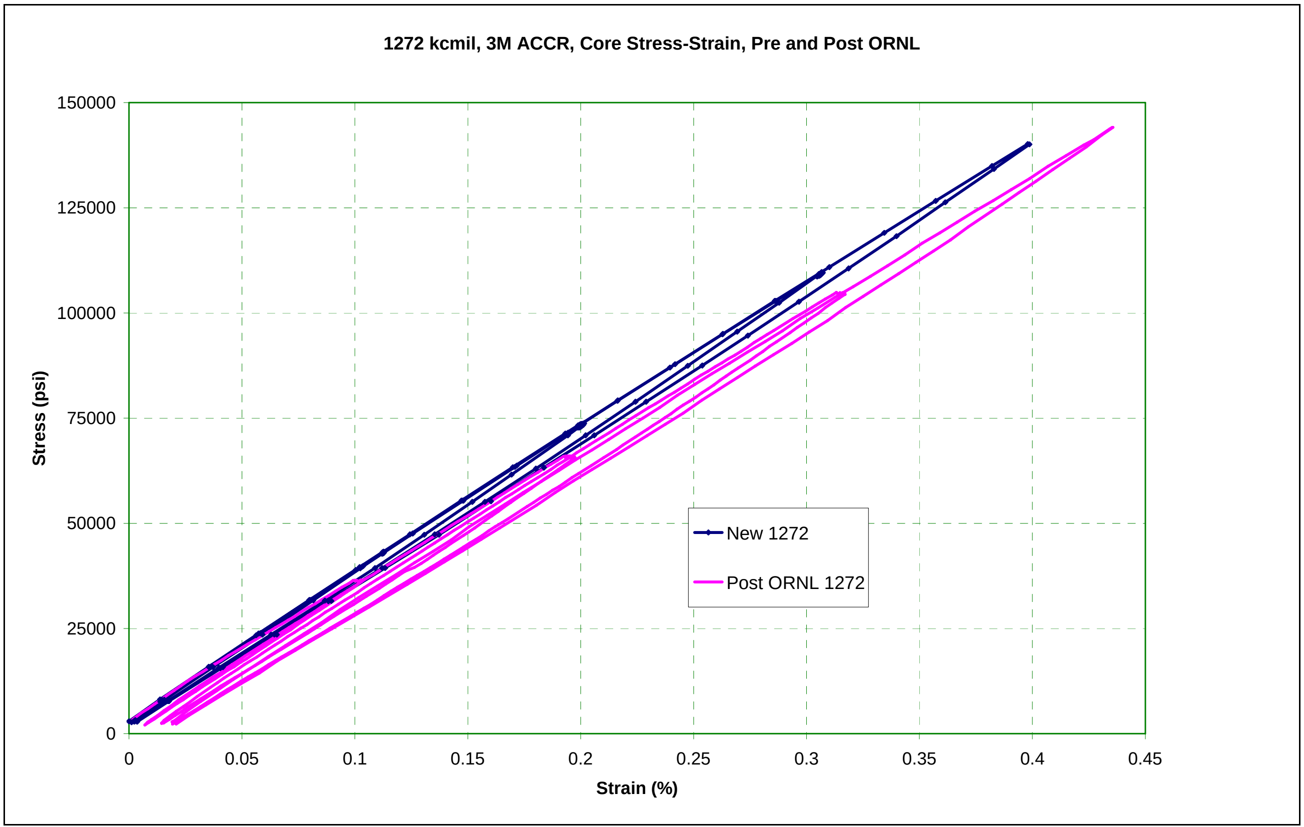


Figure 11, core stress-strain shows some change due to field test

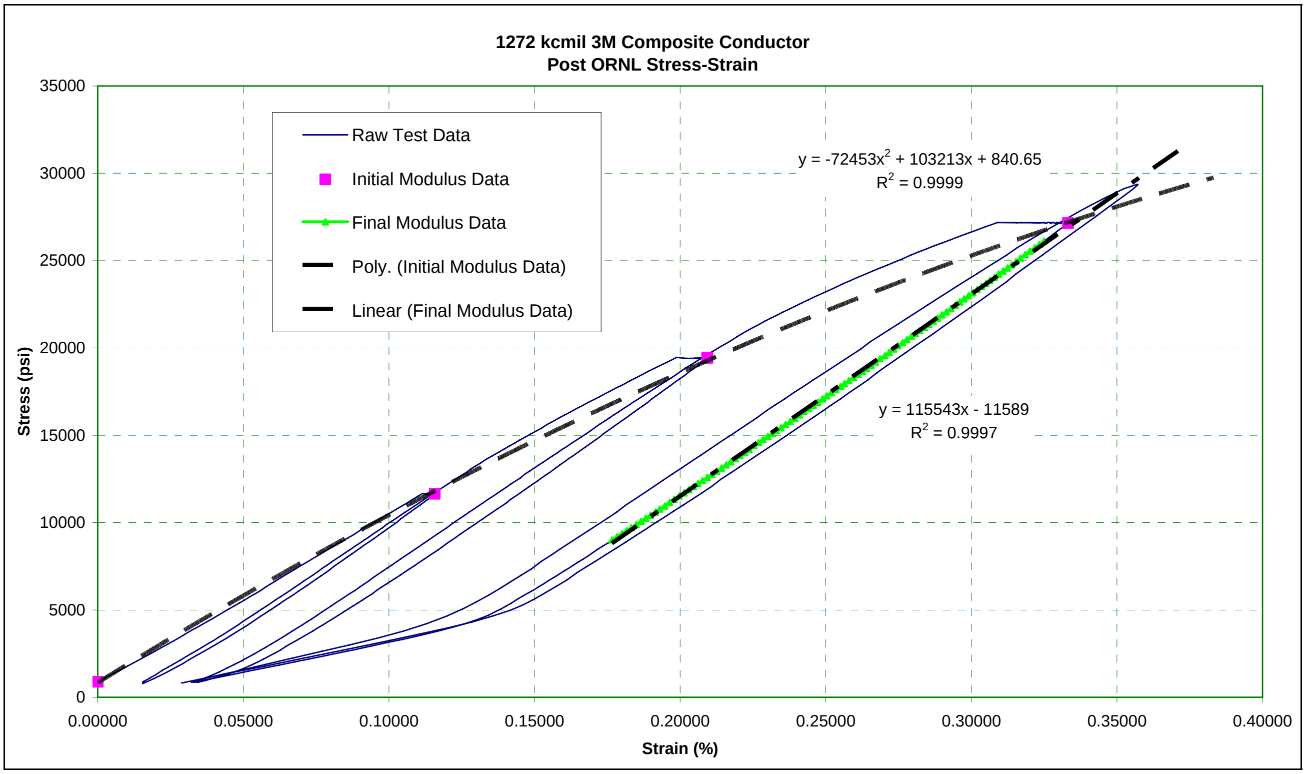


Figure 12, construction of conductor "initial" and final modulus on stress-strain data

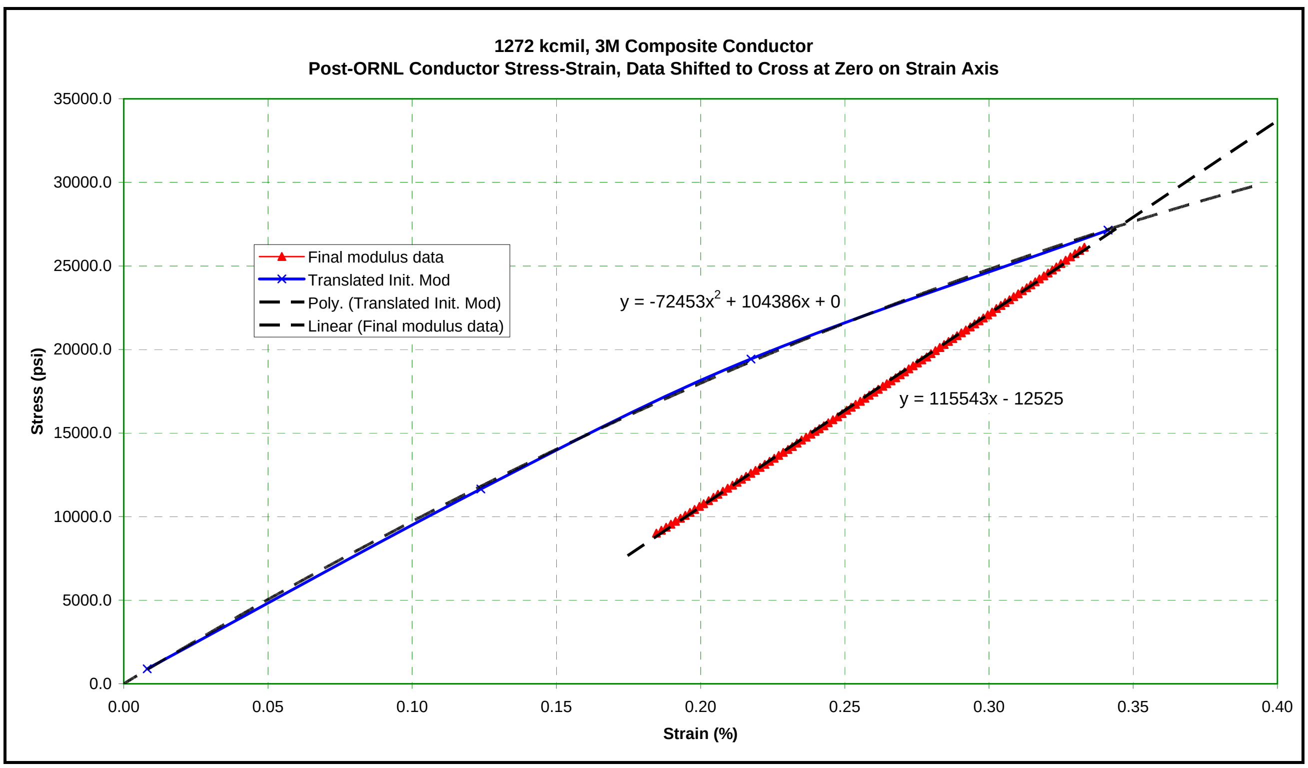


Figure 13, initial and final conductor modulus, translated to zero along strain axis

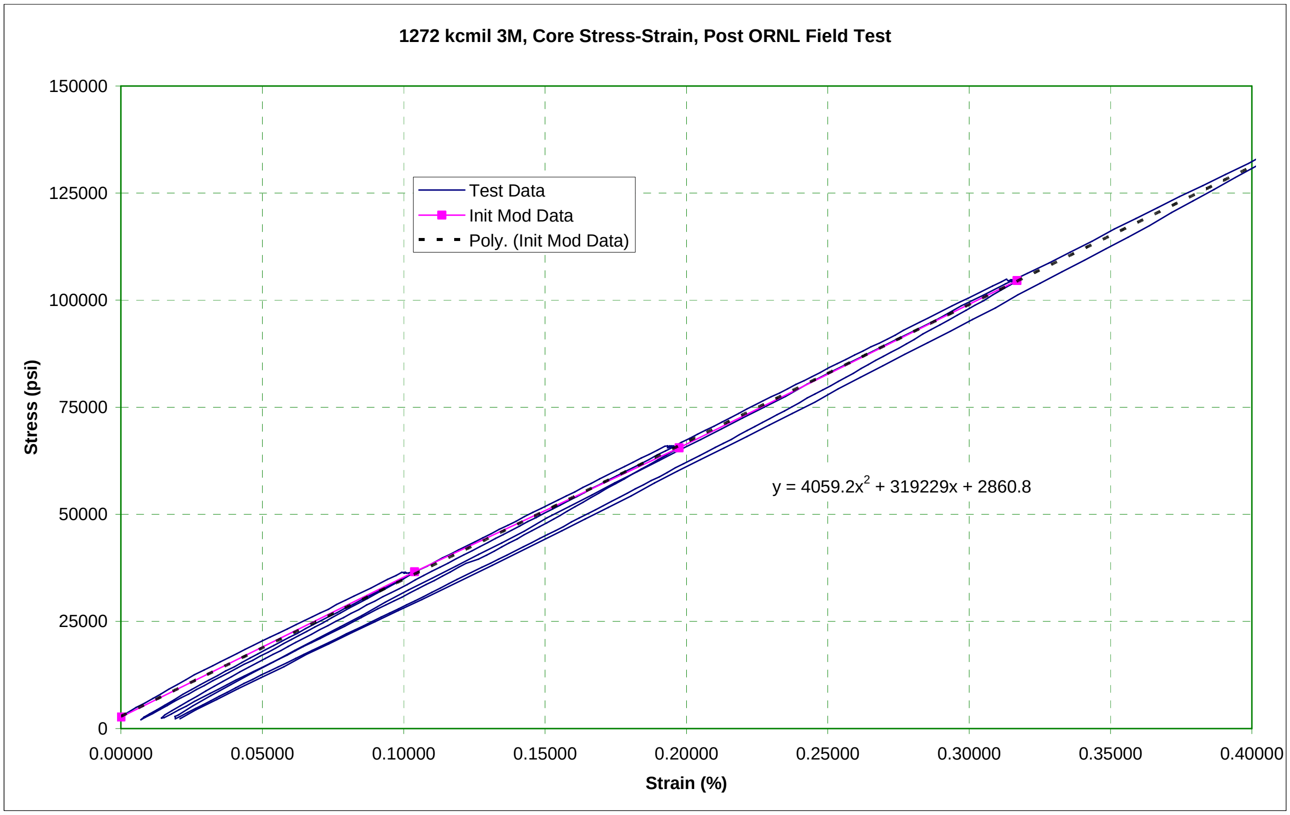


Figure 14, construction of core “initial” modulus on stress-strain data

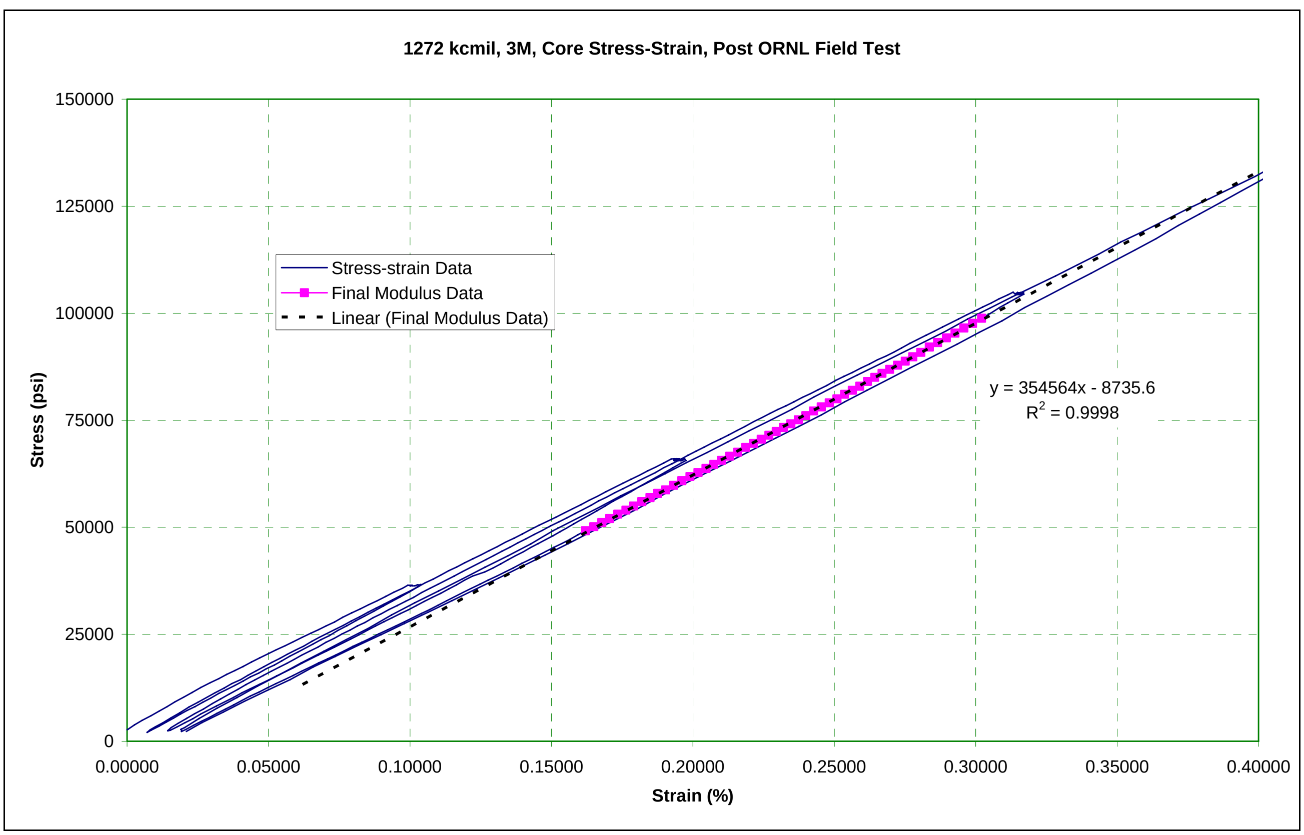


Figure 15, construction of core final modulus on stress-strain data

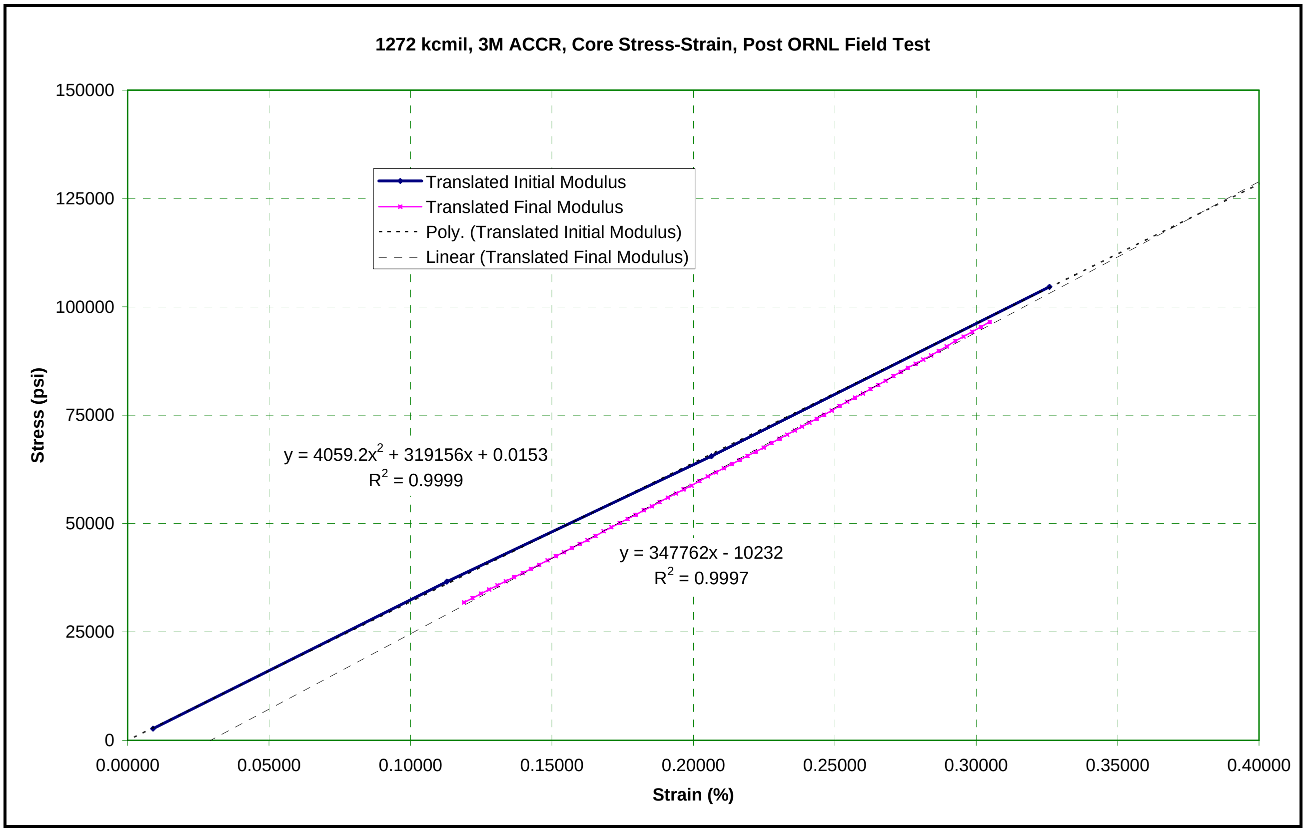


Figure 16, initial and final core modulus, translated to zero along strain axis

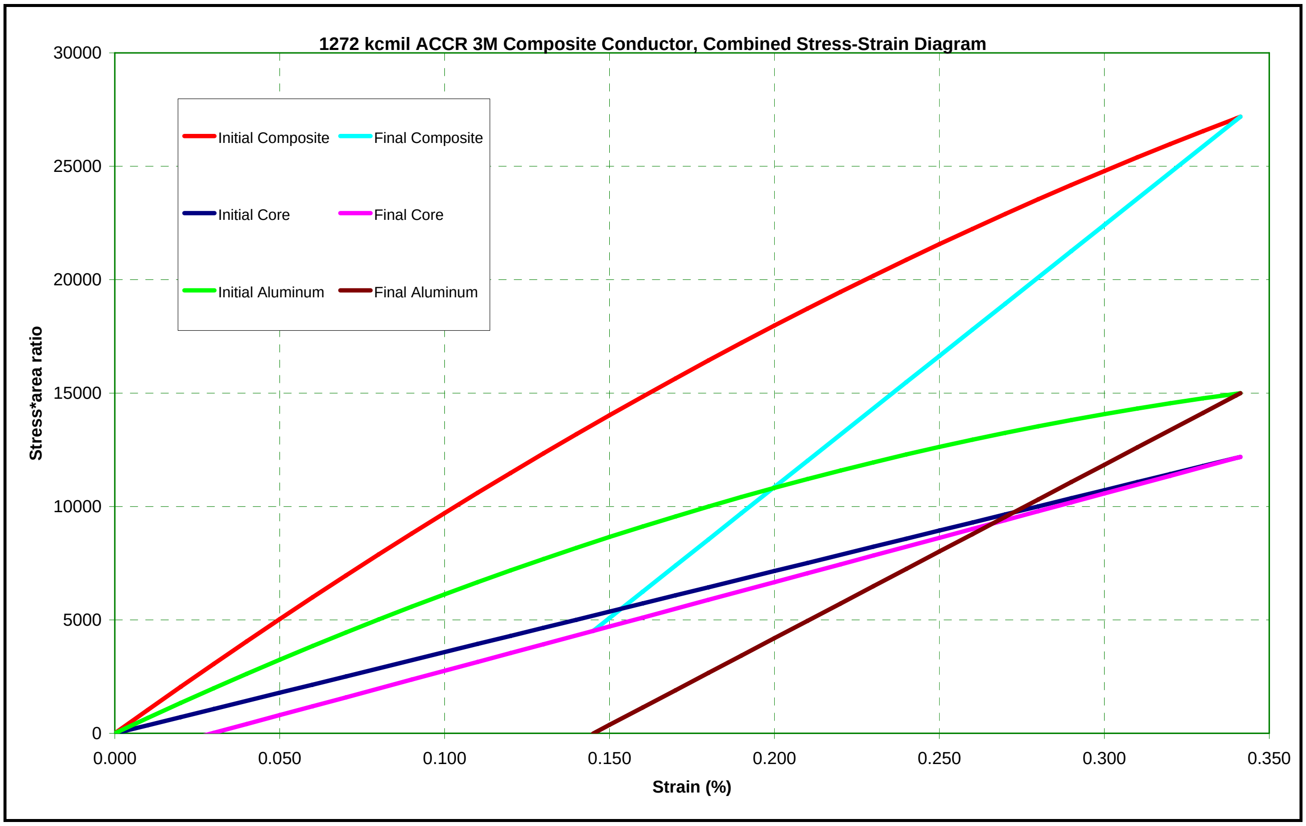


Figure 17, combined stress-strain graph (see following text for equations)

Equations for Stress-Strain Properties (Post ORNL results in report text, reference data from pre-ORNL test is shown in *blue italics text)*:

Composite Conductor Properties, direct test values:

"Initial" Modulus for Stress Strain Curve:	Stress (psi) = $-72453*(\text{Strain\%})^2+103213*(\text{Strain\%})+841$
Initial Modulus for Stress Strain Curve:	*Stress (psi) =* $-31623*(\text{Strain\%})^2+87144*(\text{Strain\%})+818$
Final Modulus for Stress Strain Curve:	Stress (psi) = 115543*(Strain%) - 11589
Final Modulus for Stress Strain Curve:	*Stress (psi) = 112980*(Strain%) – 12193*
Tensile Test, Stress Strain Sample:	50240 lb (115% RBS)
Tensile Test, Stress Strain Sample:	*47890 lb (110% RBS)*

Composite Conductor, data shifted along strain axis to provide correct zero strain reference:

"Initial" Modulus for Stress Strain Curve:	Stress (psi) = $-72453*(\text{Strain\%})^2+104386*(\text{Strain\%})$
Initial Modulus for Stress Strain Curve:	*Stress (psi) =* $-31846*(\text{Strain\%})^2 + 87852*(\text{Strain\%})$
Final Modulus for Stress Strain Curve:	Stress (psi) = *115543**(Strain%) – *12525*
Final Modulus for Stress Strain Curve:	*Stress (psi) = 112980*(Strain%) – 12925*

Core Strand Properties, direct test values:

"Initial" Modulus for Stress Strain Curve	Stress (psi) = 4059.2*(Strain%)2+319229*(Strain%)+2861
Initial Modulus for Stress Strain Curve	*Stress (psi) = -42072*(Strain%)2+361069*(Strain%)+2971*
Final Modulus for Stress Strain Curve:	Stress (psi) = 354564*(Strain%) - 8736
Final Modulus for Stress Strain Curve	*Stress (psi) = 365886*(Strain%) - 2906*
Tensile Test, Stress Strain Sample:	25510 lb (108% of nominal rating)
Tensile Test, Stress Strain Sample:	*34420lb (99% of nominal rating)*

Core Properties, data shifted along strain axis to provide correct zero strain reference:

"Initial Modulus" for Stress Strain Curve:	Stress (psi) = $4059.2*(\text{Strain\%})^2 + 319156*(\text{Strain\%})$
Initial Modulus for Stress Strain Curve:	*Stress (psi) =* $-42073*(\text{Strain\%})^2 + 361082*(\text{Strain\%})$
Final Modulus for Stress Strain Curve:	Stress (psi) = 347762*(Strain%) - 10232
Final Modulus for Stress Strain Curve:	*Stress (psi) = 365904*(Strain%) - 7002*

Aluminum Properties (computed, direct measurement is not possible):

"Initial" Modulus for Stress Strain Curve:	Stress (psi) = $-71996*(\text{Strain\%})^2+68515*\text{Strain}$
Initial Modulus for Stress Strain Curve:	*Stress (psi) =* $-30899*(\text{Strain\%})^2 + 53862*(\text{Strain\%})$
Final Modulus for Stress Strain Curve:	Stress (psi) = 76456*Strain -11096
Final Modulus for Stress Strain Curve:	*Stress (psi) = 81877*(Strain%) – 13830*

V. Dissections:

1) **ACA Compression Fittings** (one splice, one dead end)

The dissections and inspections showed good workmanship for core and aluminum insertion depth, component placement, and the crimping operation. Two problems were noted for the dead end and one problem was noted for both the dead end and the splice:

i. Installation instructions stipulate that the center cavity be filled with oxide inhibitor compound through an injection port. On the dead end sample, there was less than a full charge of inhibitor, showing that this step was not properly followed. Compound was found to be injected, but was insufficient to fully charge the dead end. This is not a serious issue for a short-term field test. Over a long period of time, water and contaminants could build up in the hollow spaces, and cause problems – particularly corrosion of the steel core grip.

ii. There is no evidence that the conductor was wire-brushed prior to splice installation. ACA instructions require wire-brushing of the conductor OD. Overwhelming field and lab experience shows that failure to wire-brush new conductor correlates strongly with premature connector failures. Installation crew training procedures now reinforce the importance for wire brush cleaning of conductor.

ACA Splice

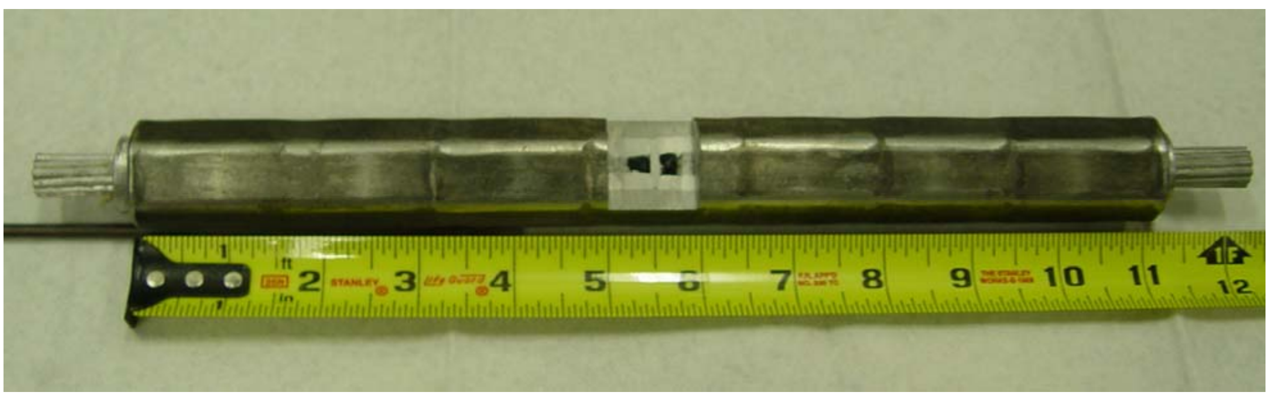


Figure 18: Core sleeve. The core was properly inserted into the core sleeve, with approximately ¼ inch spacing between core and center stop.

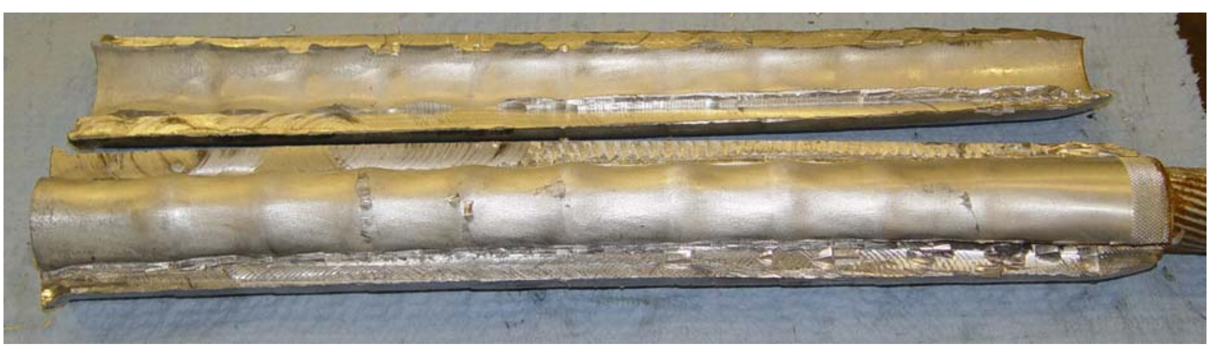


Figure 19: Inner and outer aluminum sleeves, with 10 compressions. Note inhibitor on conductor OD shows full charge was injected.

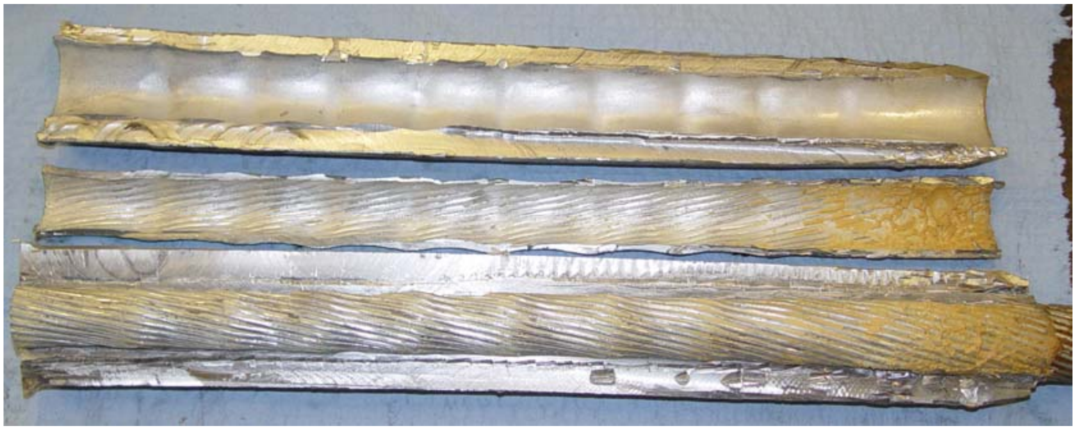


Figure 20: Splice has proper inhibitor charge

Figure 21: Conductor OD shows no evidence of wire-brush marks

ACA Dead End

Figure 22: inhibitor charge at core sleeve shows injection port was used

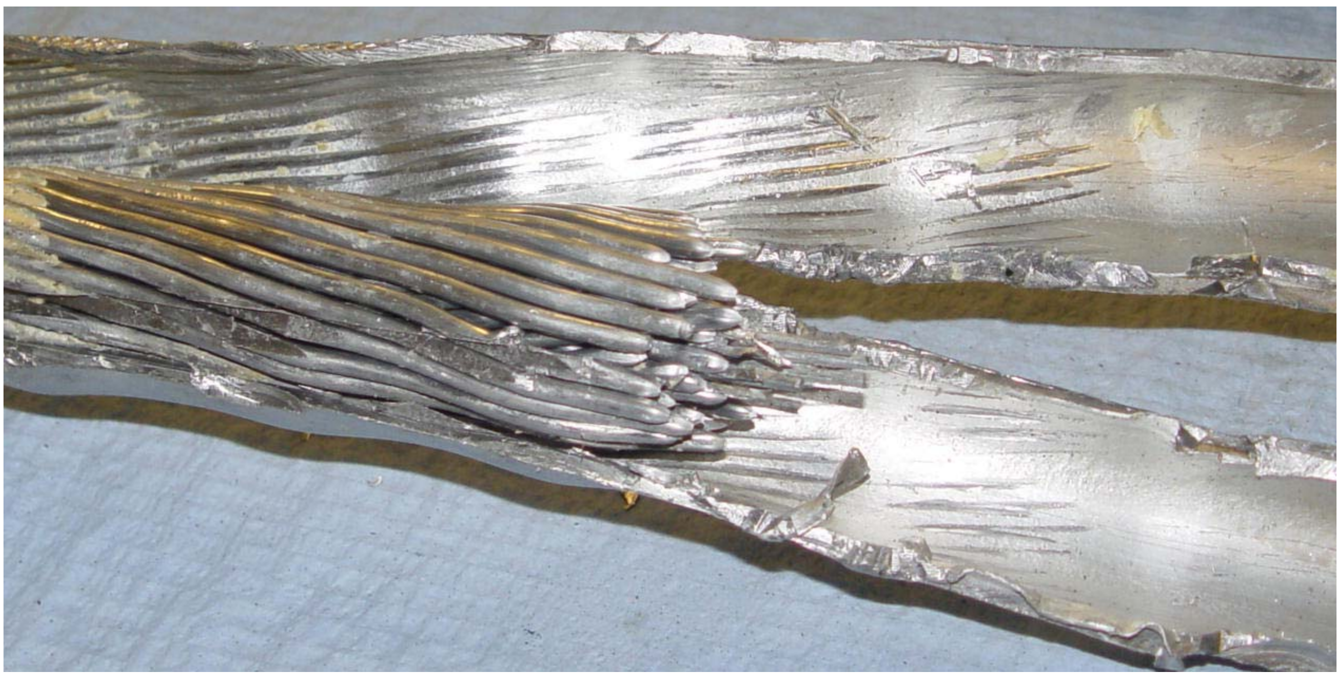


Figure 23: lack of inhibitor charge filling conductor shows fill port was not completely filled. Also note conductor has no evidence of wire brushing.

Figure 24: Inhibitor stops approximately 10 inches from mouth of dead end. Proper inhibitor charge should fill all conductor interstices to block water migration into the splice internals.

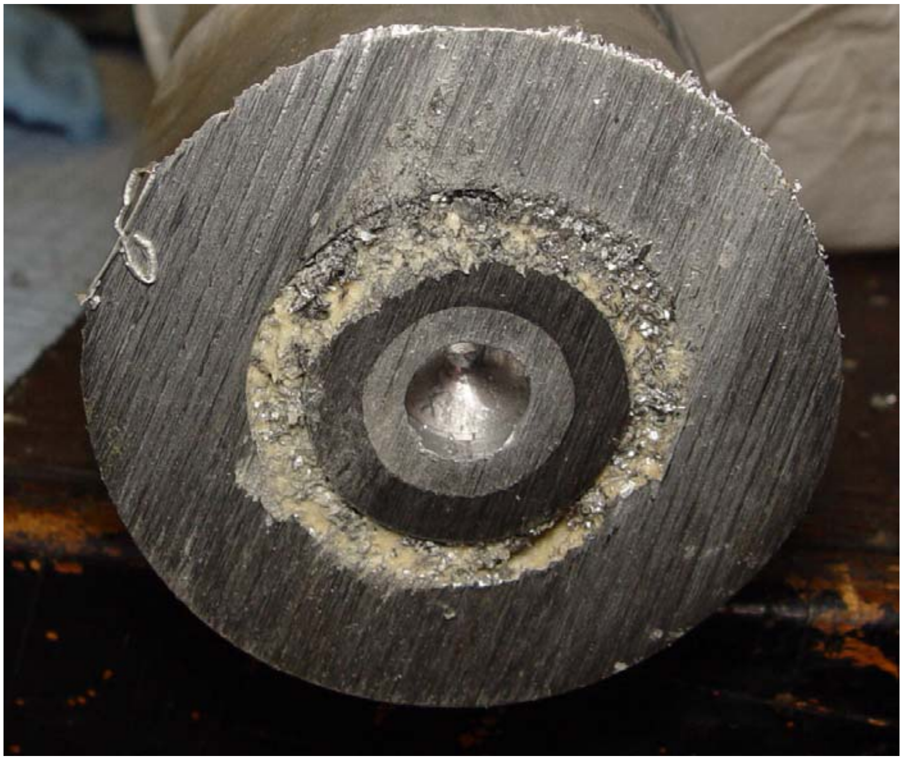


Figure 25: End of core sleeve. The core was inserted up to approximately 3/8 inch from the end of the bore.

2) PLP Dissections (one dead end, one splice, two suspensions):

PLP Suspensions (two samples)

The PLP fittings were dissected by removing the formed wire rods one at a time. Findings were documented on note paper and by photograph.

One problem was noted for one of the suspension dissections: conductor beneath the inner rods exhibited gouges consistent with screwdriver marks created by prying the formed wire rod. These gouges are under two layers of formed wire rods during service ,and therefore are not likely to cause a problem. The conductor section from the suspension unit held 111% of RBS during the tensile test, further confirming that outer strand damage is not a serious issue with formed wire fittings.

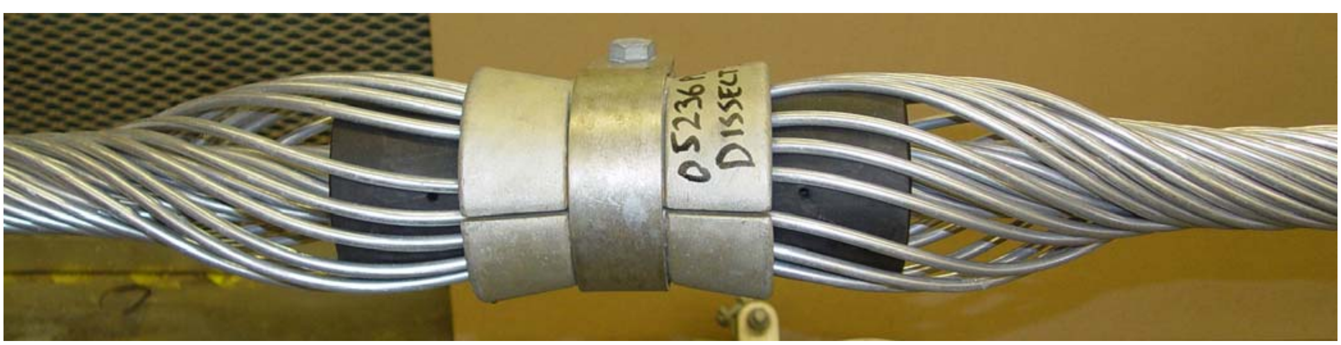


Figure 26: PLP suspension assembly prior to dissection

Figure 27: center marks on rods are not aligned, but there is no evidence this caused any problems

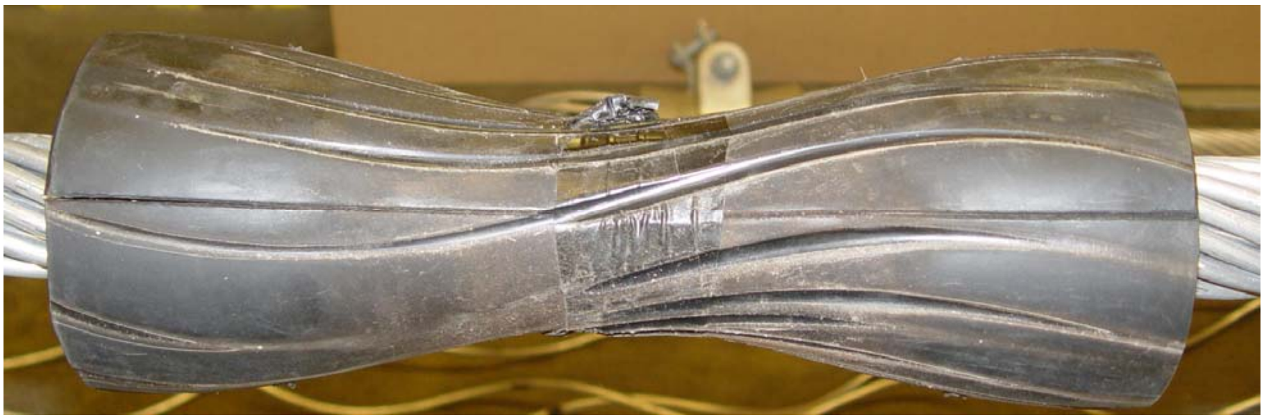


Figure 28: OD of rubber conductor cushion is in good condition

Figure 29: Inside of rubber conductor cushion is also in good condition

Figure 30, Metal housing is in good condition after field test

Figure 31, Formed wire rods slipped somewhat out of alignment, but the system appears to tolerate less than perfect installation

Figure 32, inner rods sustain imprint from outer rods, but underlying conductor is not harmed

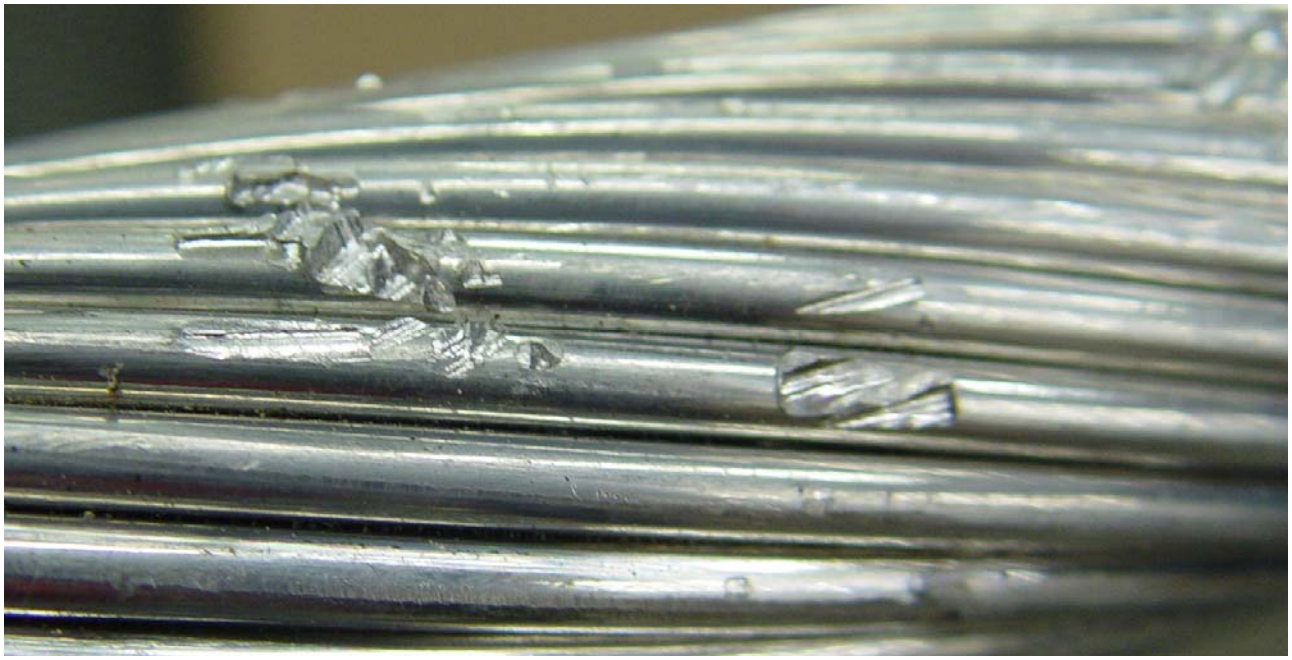


Figure 33: screwdriver marks from attempt to pry rods into position.

PLP Splice (after the tensile test):

Figure 34: outer rods shifted under load

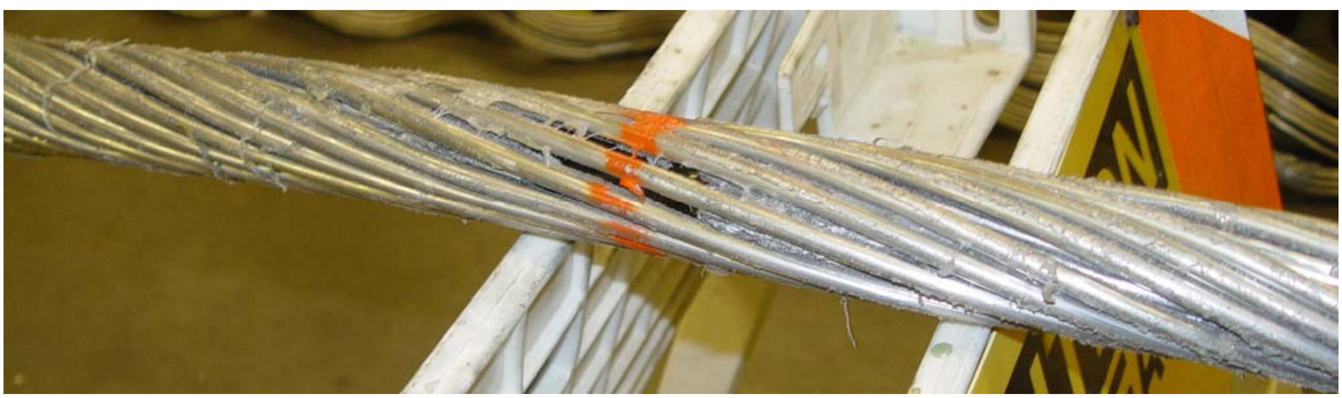


Figure 35: centering marks on inner rods are aligned with conductor ends

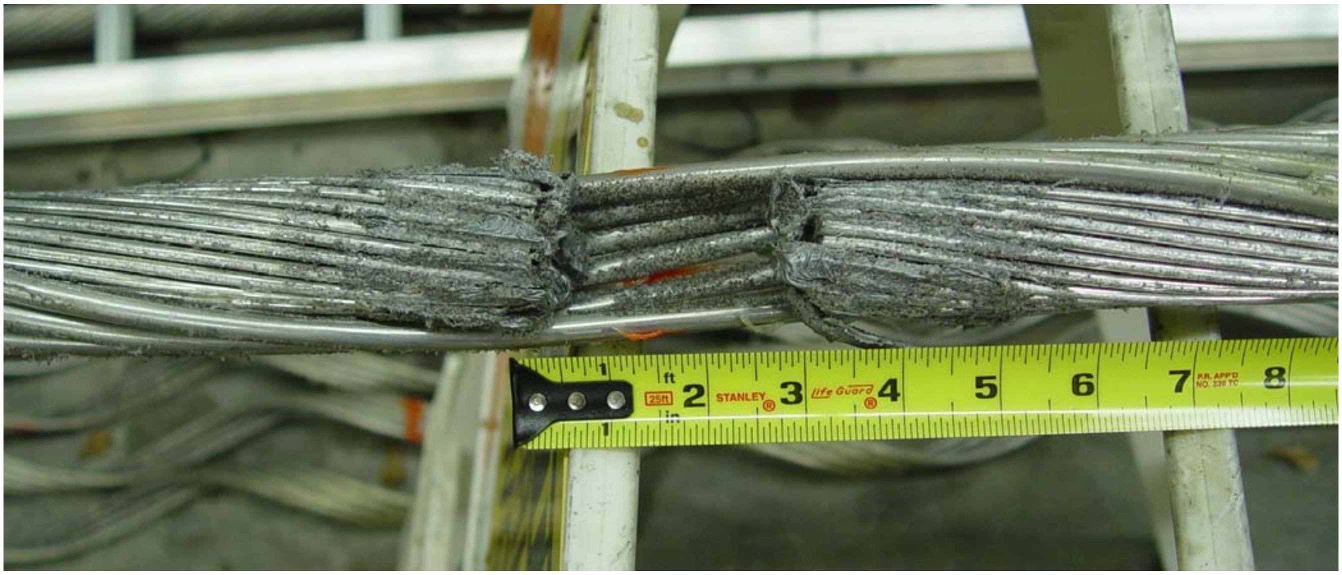


Figure 36: two inch gap between conductors inside the splice may be partly due to tensile test loads


Figure 37: outer conductor strands are shifted due to tensile test load. Conductor broke in free-span section

PLP Dead End

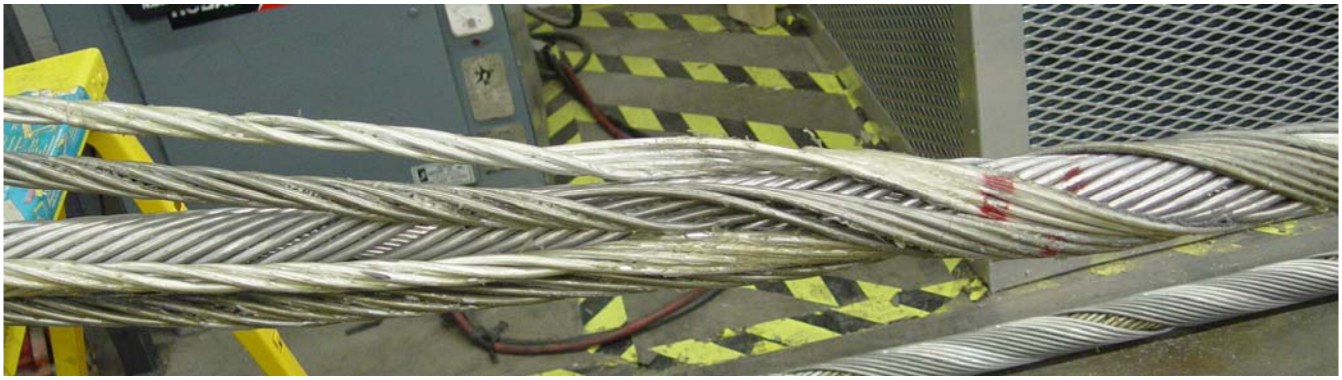


Figure 38: rods shifted during service and tensile test, but break occurred elsewhere

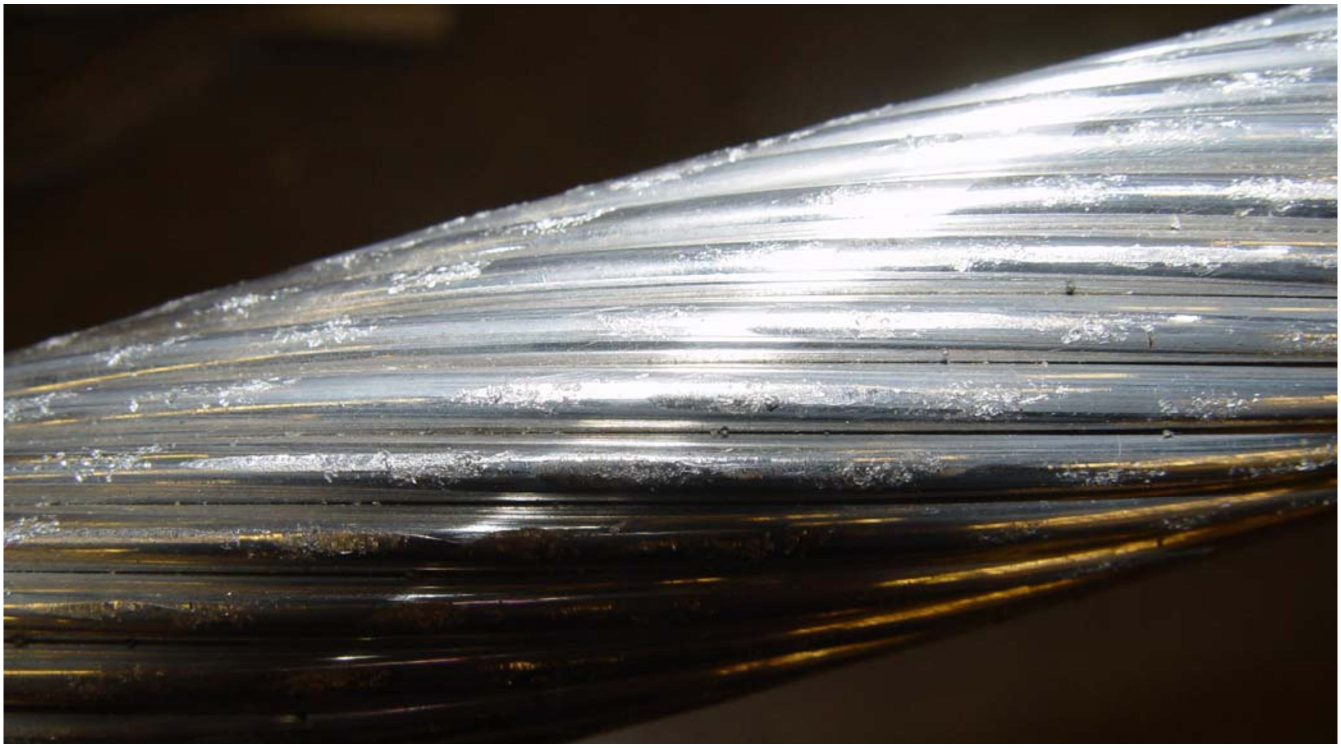


Figure 39: abrasion of conductor surface from grit on rods. Abrasion was present in all PLP samples.

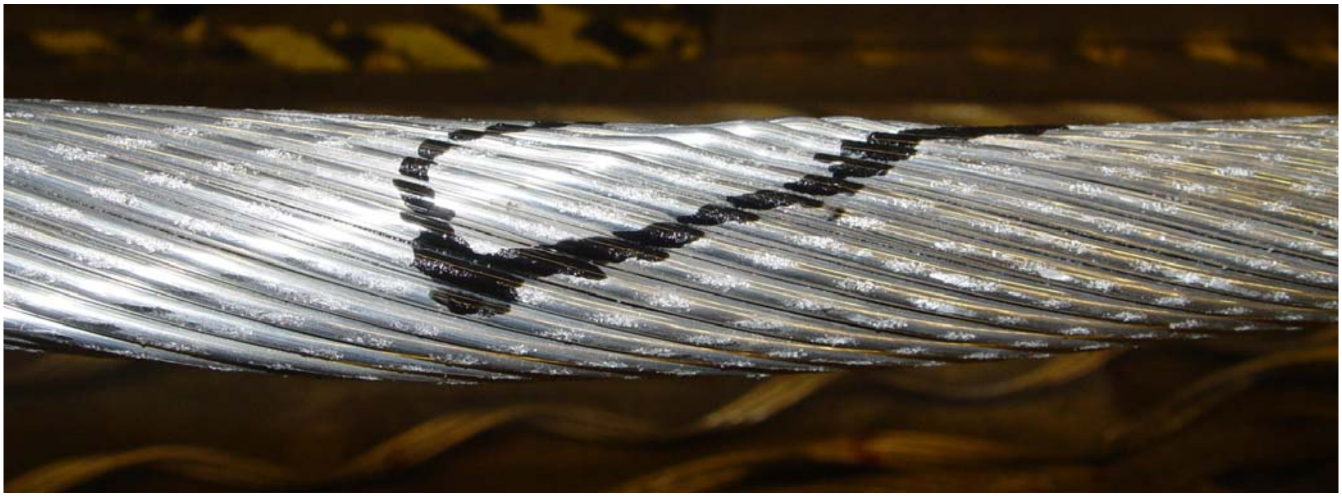


Figure 40: slight birdcaging of conductor strands under inner rods of PLP dead end after reaching 108% RBS in the tensile test

CONCLUSION:

Test results show the conductor and fittings are not significantly degraded by the field trial. Mechanical strength of connectors and fittings is unchanged, from values measured for the same fittings before the field trial. The only significant difference is the change in the stress-strain results for both the conductor and the core. Expected conductor creep accounts for the differences. Discrepancies with conductor preparation and inhibitor injection during the installation of compression fittings show that crew training and installation monitoring continue to be important to ensure long-term reliability of conductor installations.

EQUIPMENT LISTING

1) MTS Servo-hydraulic tensile machine, Control # CQ 0195 (load and crosshead data)
2) Dynamics Research Corporation (DRC)/NEETRAC cable extensometer, Control # CQ 3002 (strain data).
3) Yokogawa DC100 data acquisition system, Control # CN 3022 (temperature data)
4) HBM linear position indicator for crosshead displacement (for reference only)
5) AVO/Biddle Digital Low Resistance Ohmmeter, Calibration Control #CQ 1097
6) Brooklyn Thermometer set, Control # CN 0155

REFERENCES AND STANDARDS LISTING

1) ASTM E4, (Calibration of Load Testing Machines)
2) ANSI C119.4, (Connector testing)
3) NEETRAC Project 02-327 (1272 ACCR Qualification Tests)

ACKNOWLEDGEMENT

This material is based upon work supported by the U.S. Department of Energy under Award No. DE-FC02-02CH11111.

DISCLAIMER

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of Energy.