DMC POWER

Next Generation Power Connections

KINECTRICS

Speaker
Dan Stanton
DMC Power

IEEE PES GENERAL MEETING 2017, CHICAGO

OVERHEAD LINES COMMITTEE

OVERHEAD CONDUCTORS & ACCESSORIES W.G.

THERMAL-MECHANICAL TESTING ON SWAGE TECHNOLOGY CONNECTORS

DMCPOWER KINECTRICS

Thermal-Mechanical Test on Swage Technology: Single Stage ACSR

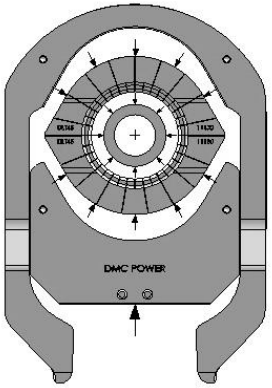
- **Investigate the effects of tension on thermal cycling of single stage ACSR connector systems**
- **Investigate the effects of inhibitor compound on both temperature and resistance, including post aging mechanical performance**
- **Compare results to previous tests performed on conventional Single Stage Connector (SSC) systems**

Single Stage Connector (SSC)

Two Stage Connector (TSC)

Swage 360^{0} Flex Die Technology

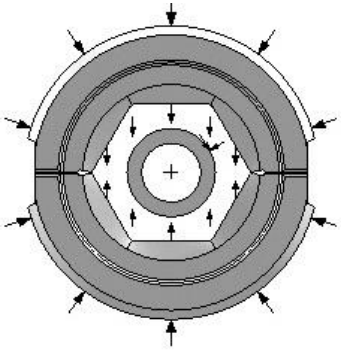
Comparison of Swage 360° degree Flex Die vs. Fixed Die Compression



Swage Force

Swage core

Swage cable



Fixed Die Force

Fixed Die core

Fixed Die cable

Thermal-Mechanical Cycling Test: current is passed through connector/conductor assemblies while under mechanical tension

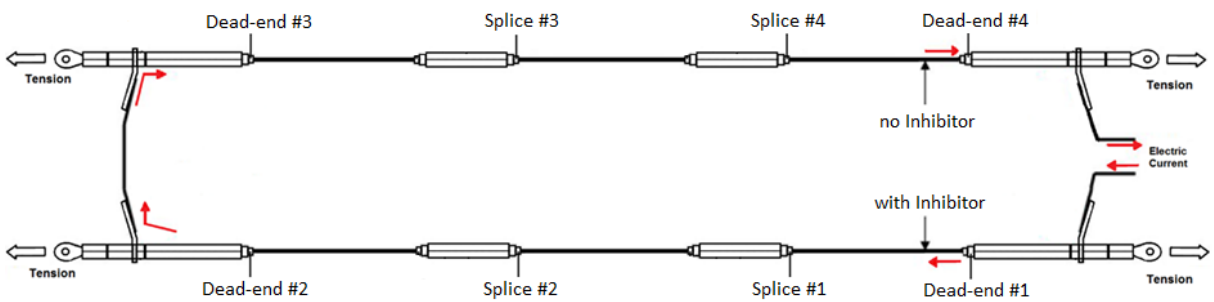
ANSI C119.4 Current Cycling Test: current is passed through connector/conductor assemblies while static

Test loop included:

- Two (2) 795 kcmil ACSR “Drake” spans
- Two (2) dead-ends and two (2) splices each on span

One (1) span included oxide inhibitor compound prior to connector installation

One (1) span was installed without inhibitor compound for connector installation



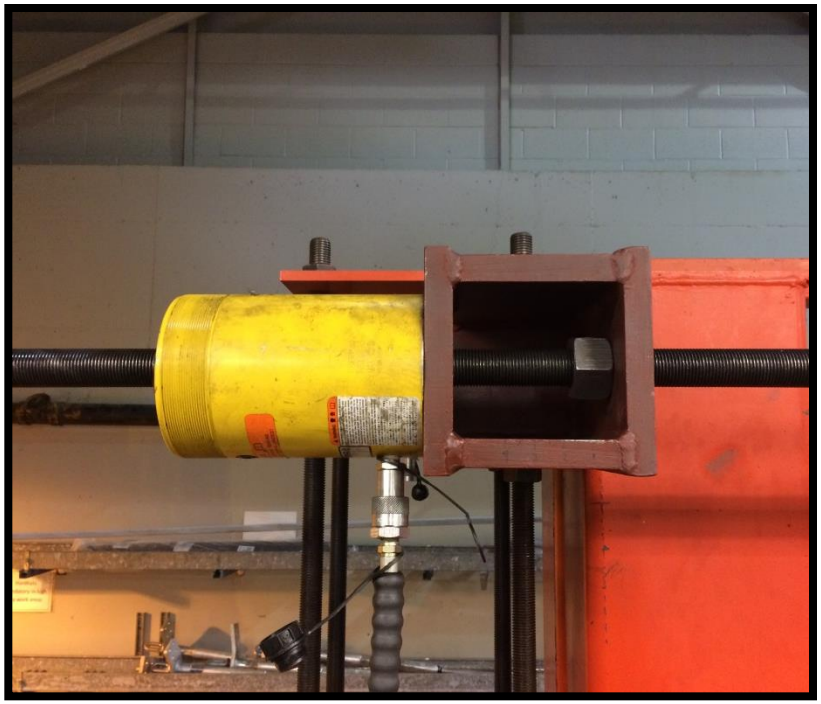
Using previously established protocol as a guideline, Single Stage Swage Type Connectors were tested in an accelerated aging process

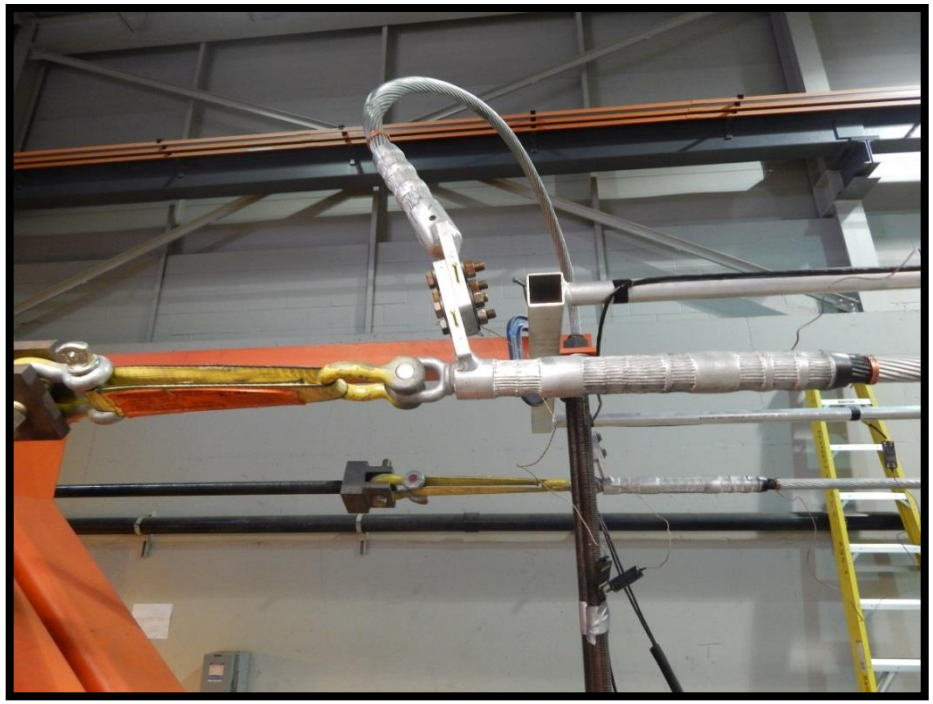
- Steady state temperature = 150°C
- Total number of current cycles = 1,100
- Soaking Time (at 150°C) = 2 hours

Pass/Fail Criteria:

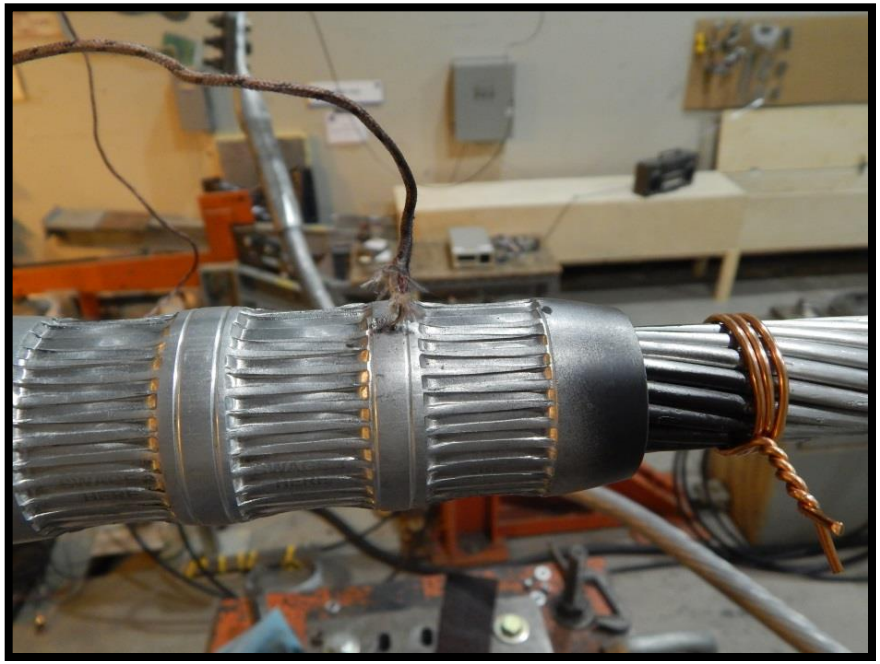
- Connector temperature shall not exceed control temperature (150°C)
- Subsequent Tensile Test > 95% RTS

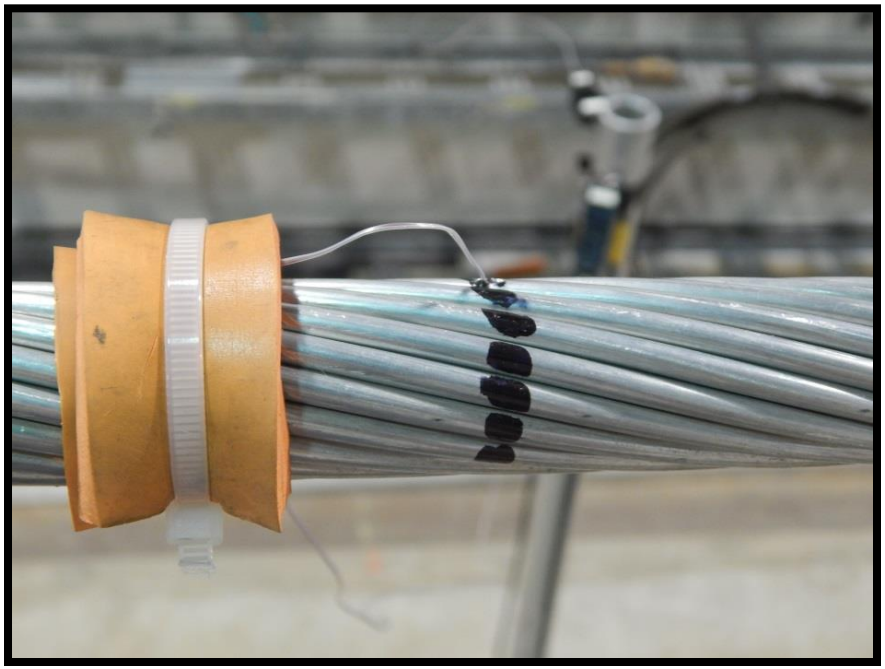
Both spans tensioned to 25% RTS of ACSR Drake (7,800 lb) using a hydraulic cylinder and threaded push rod





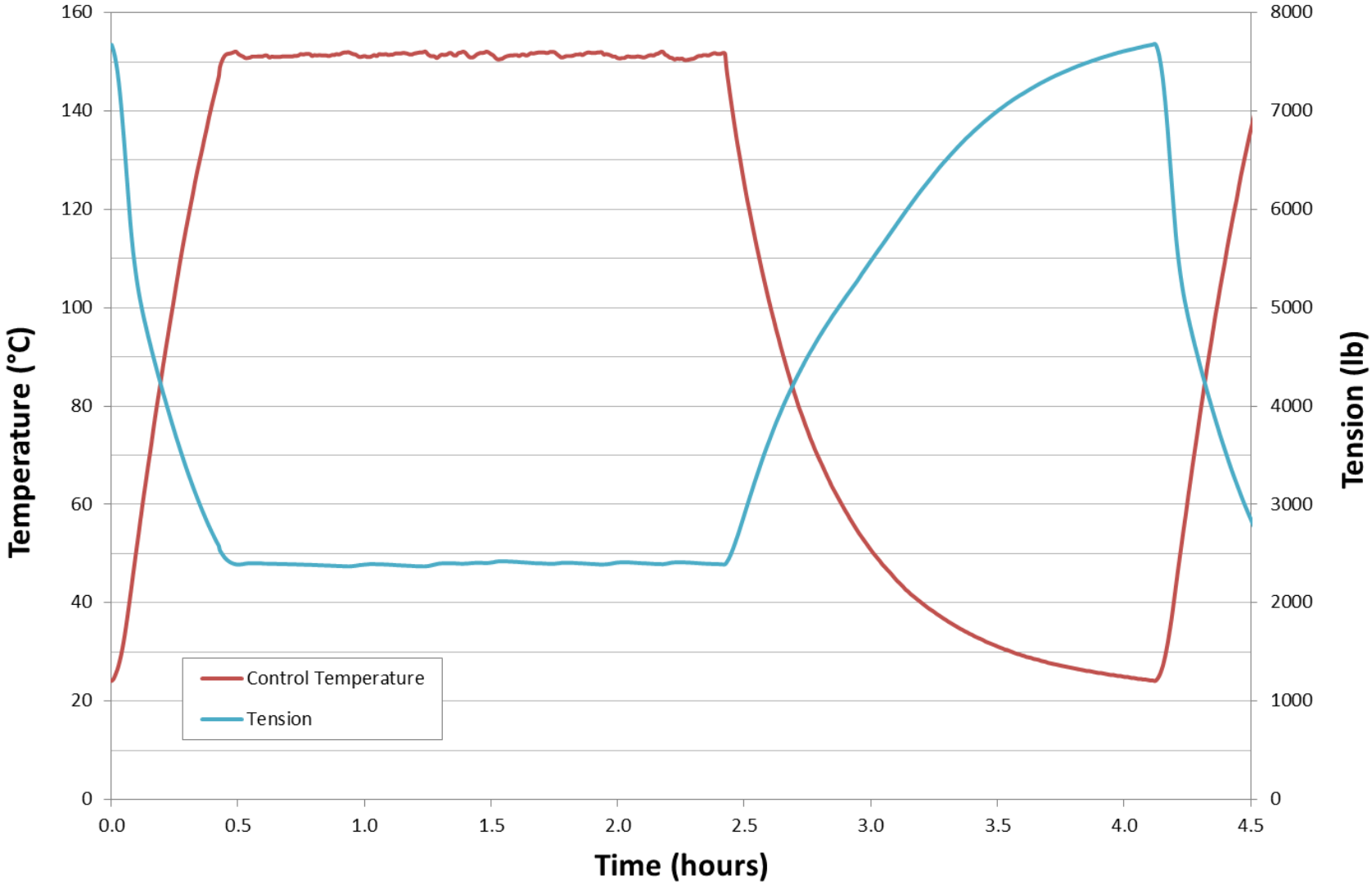
Thermocouples drilled and peened/cemented to monitor connector and conductor temperatures



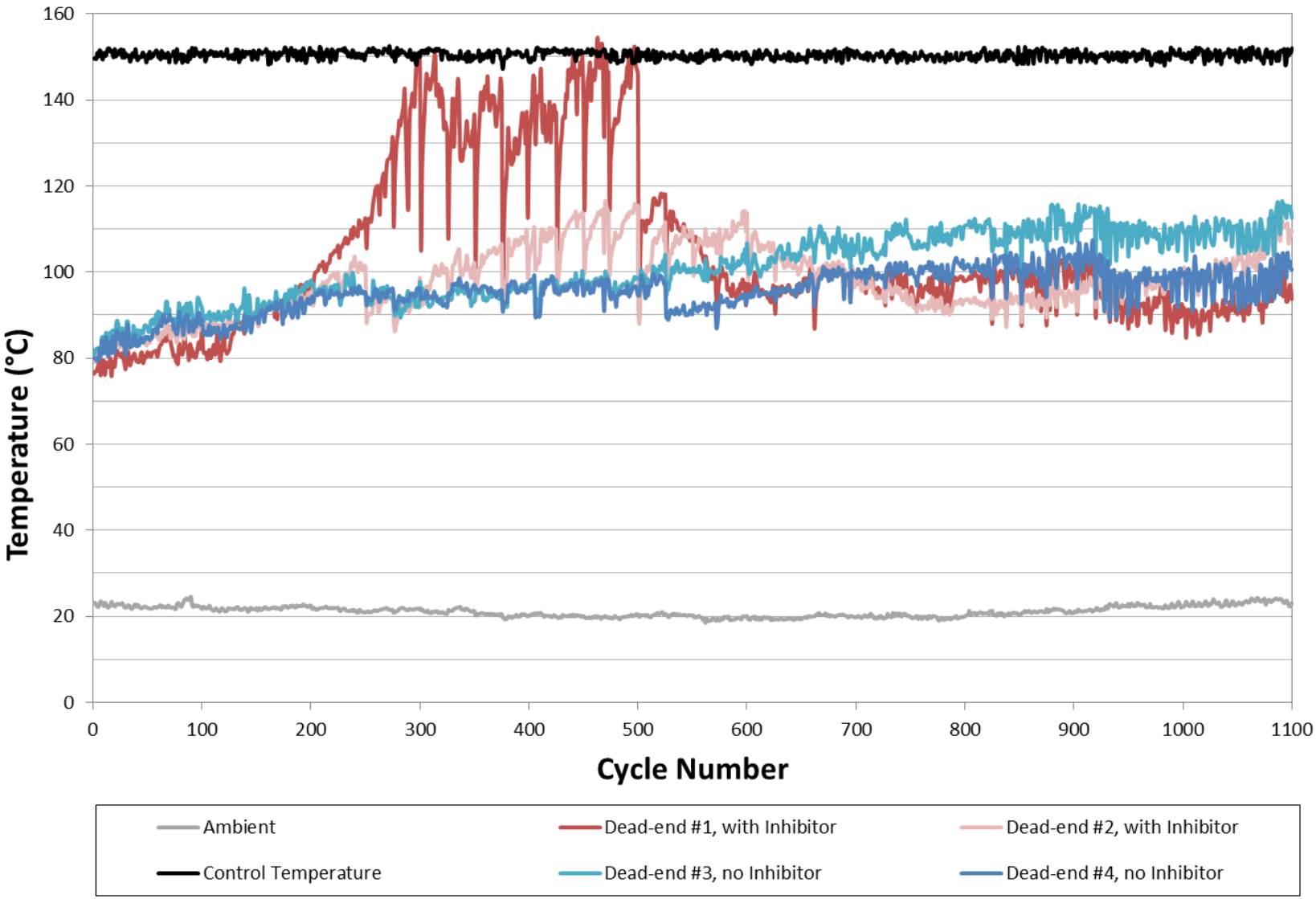


Twisted copper wire positioned one (1) inch from connector ends for contact resistance measurements

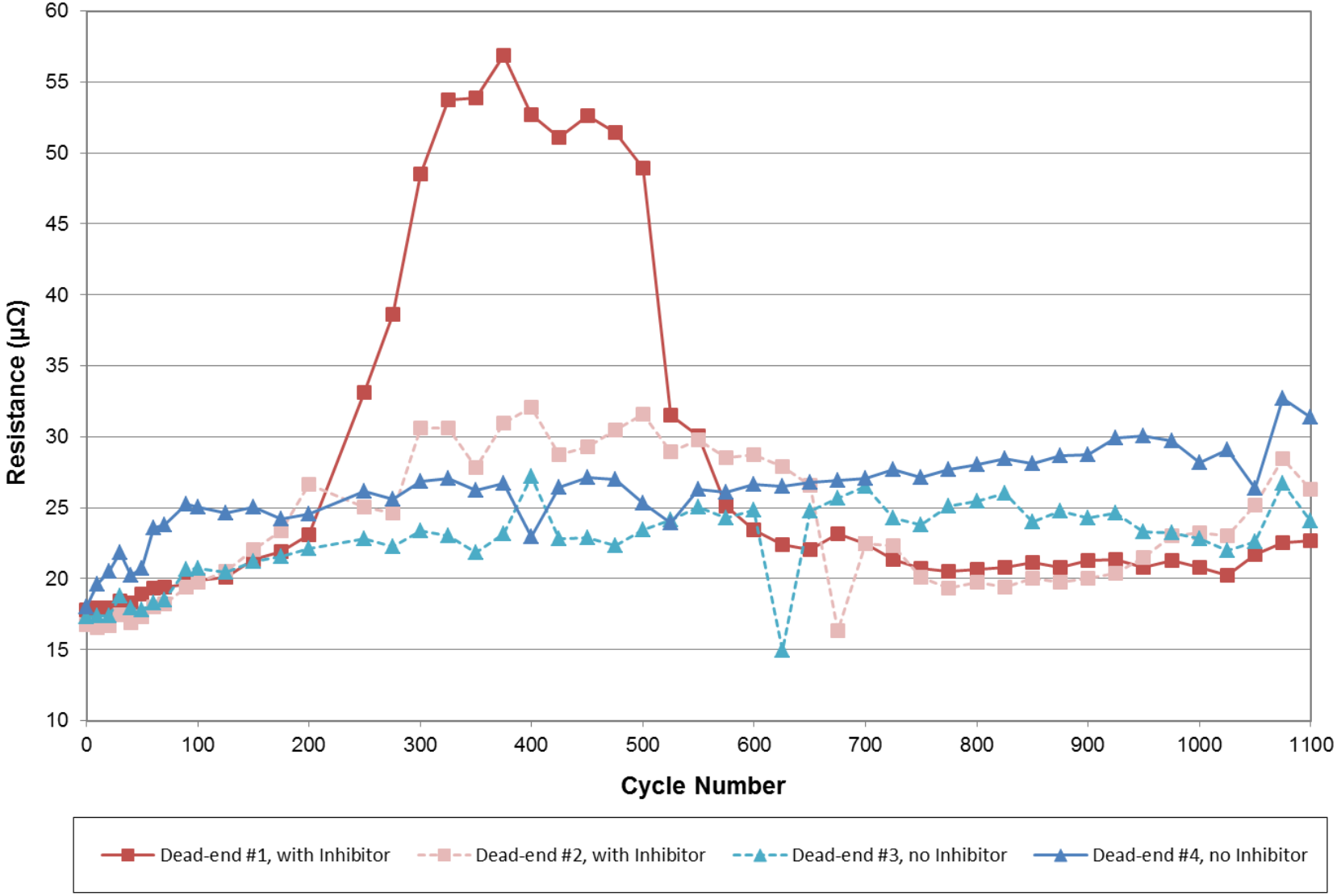
Temperature plot of typical current cycle



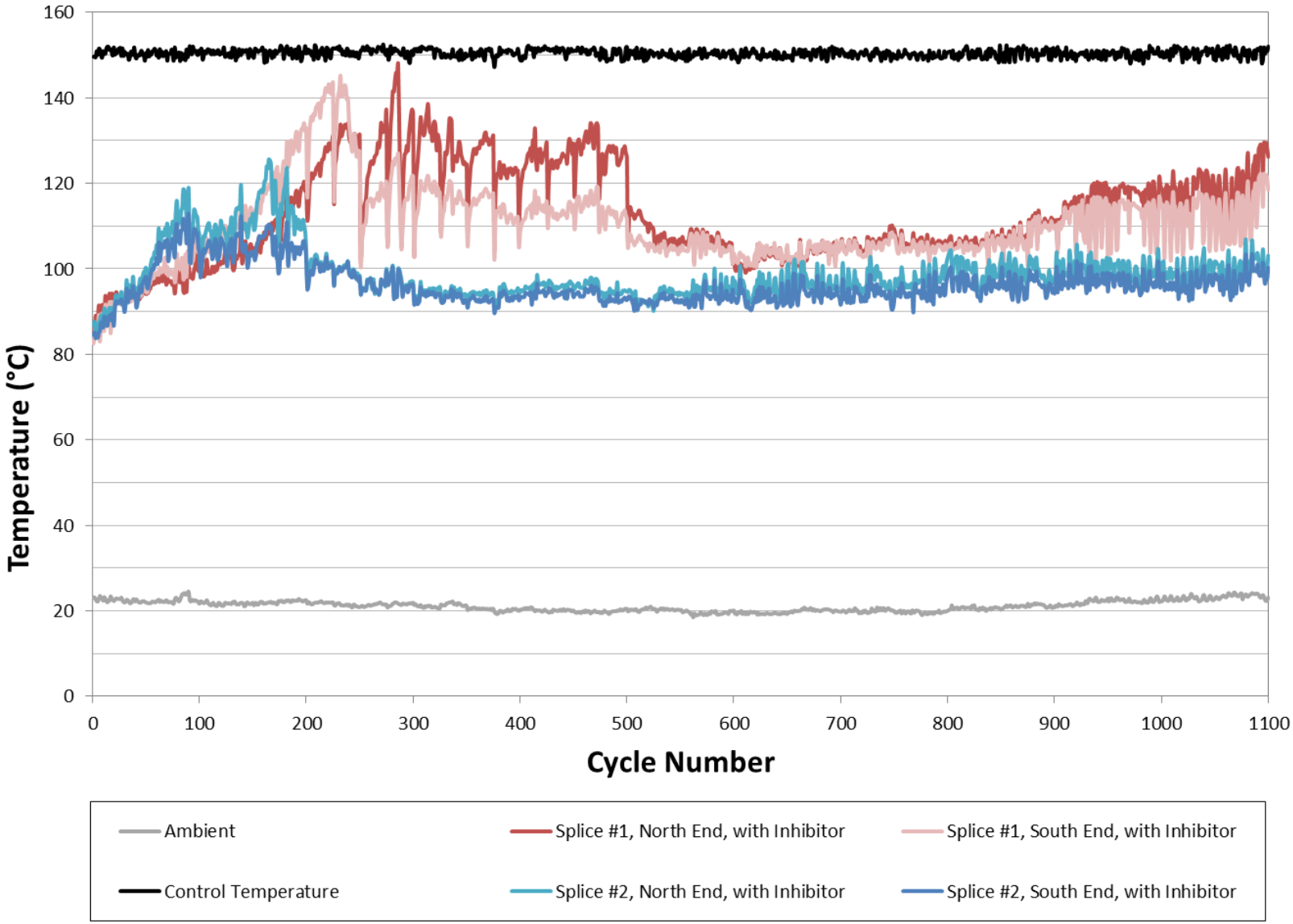
Temperature profile of Deadends *with and without* inhibitor



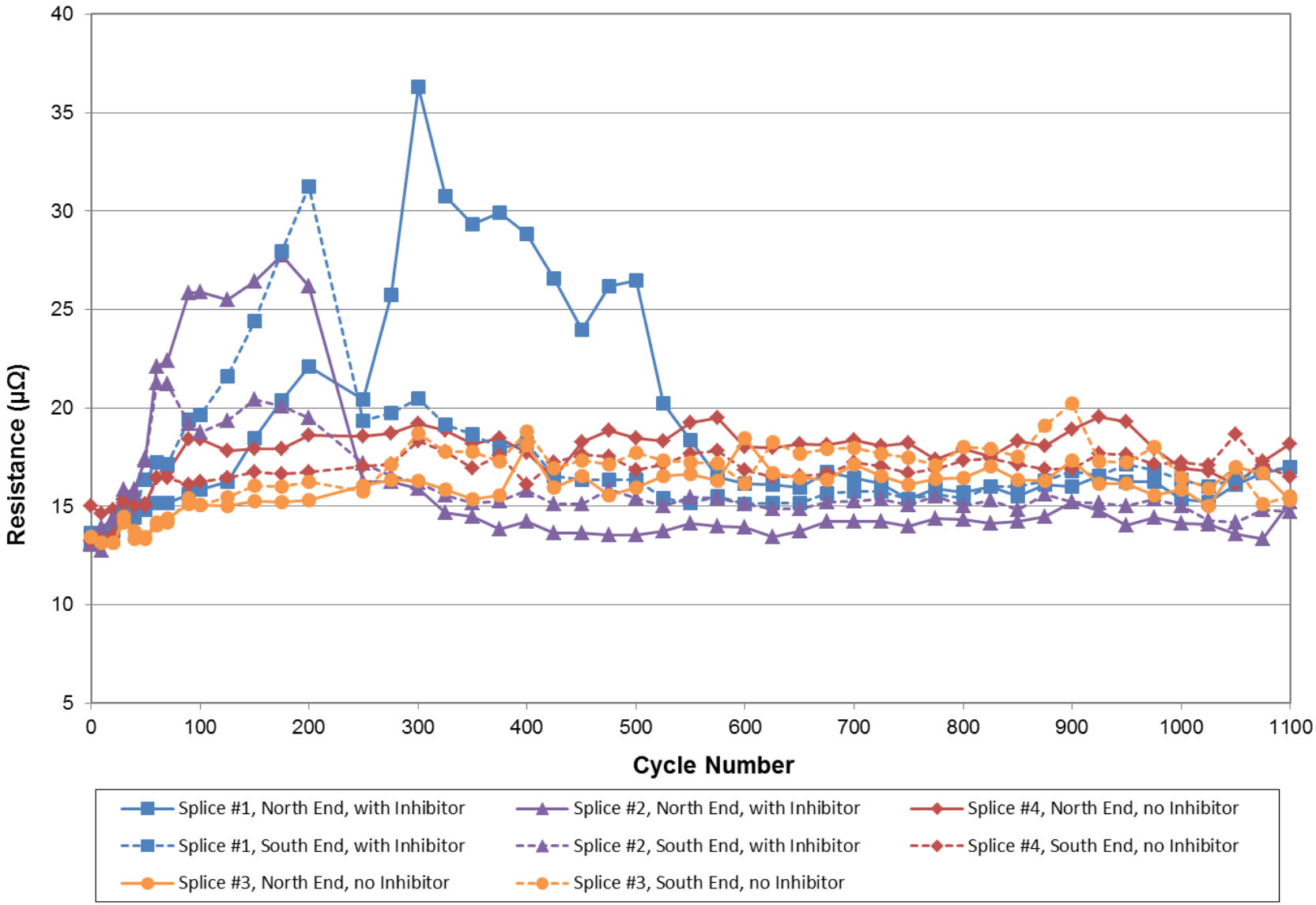
Resistance profile of Deadends *with and without* inhibitor



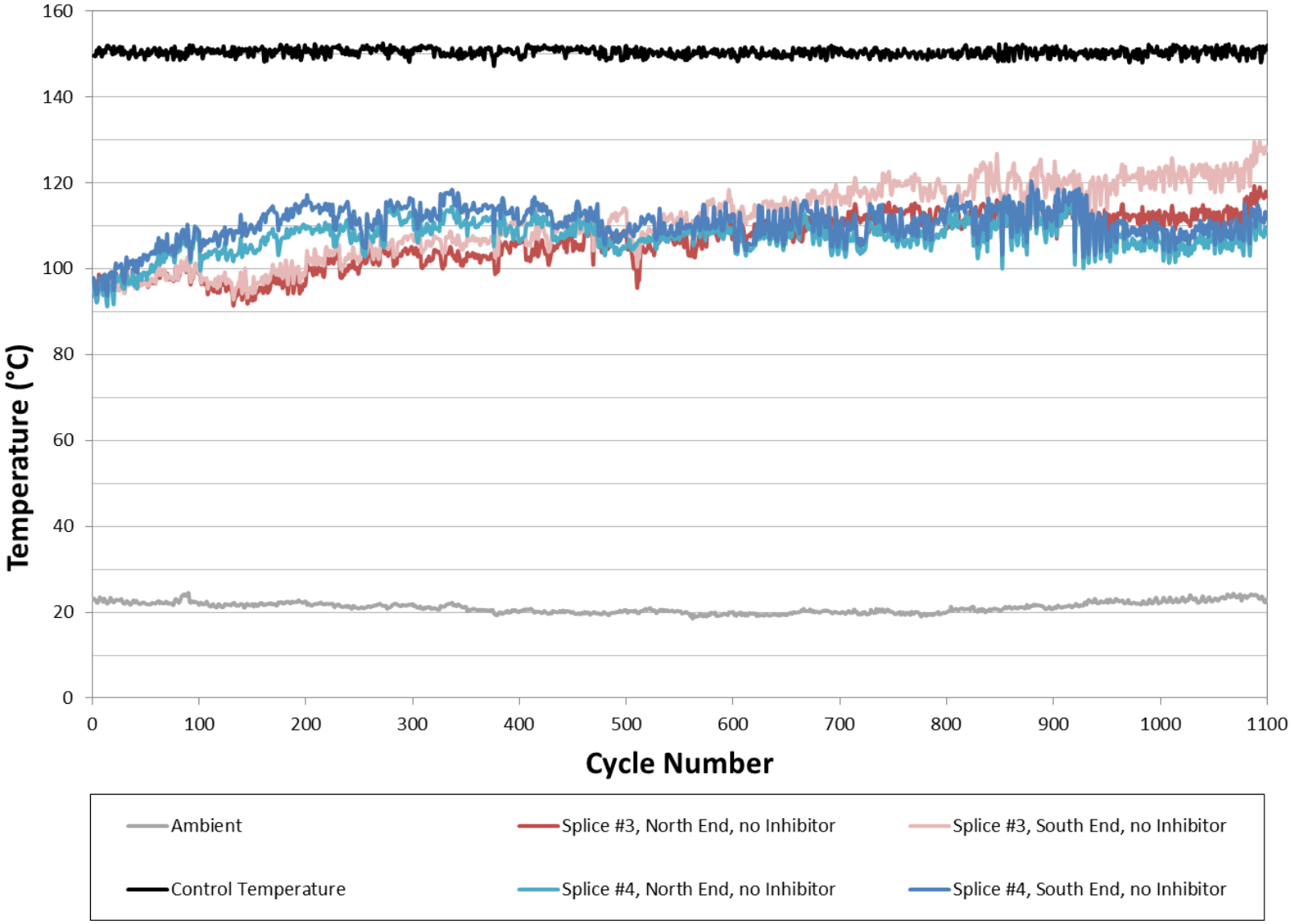
Temperature profile of Splices *with* inhibitor



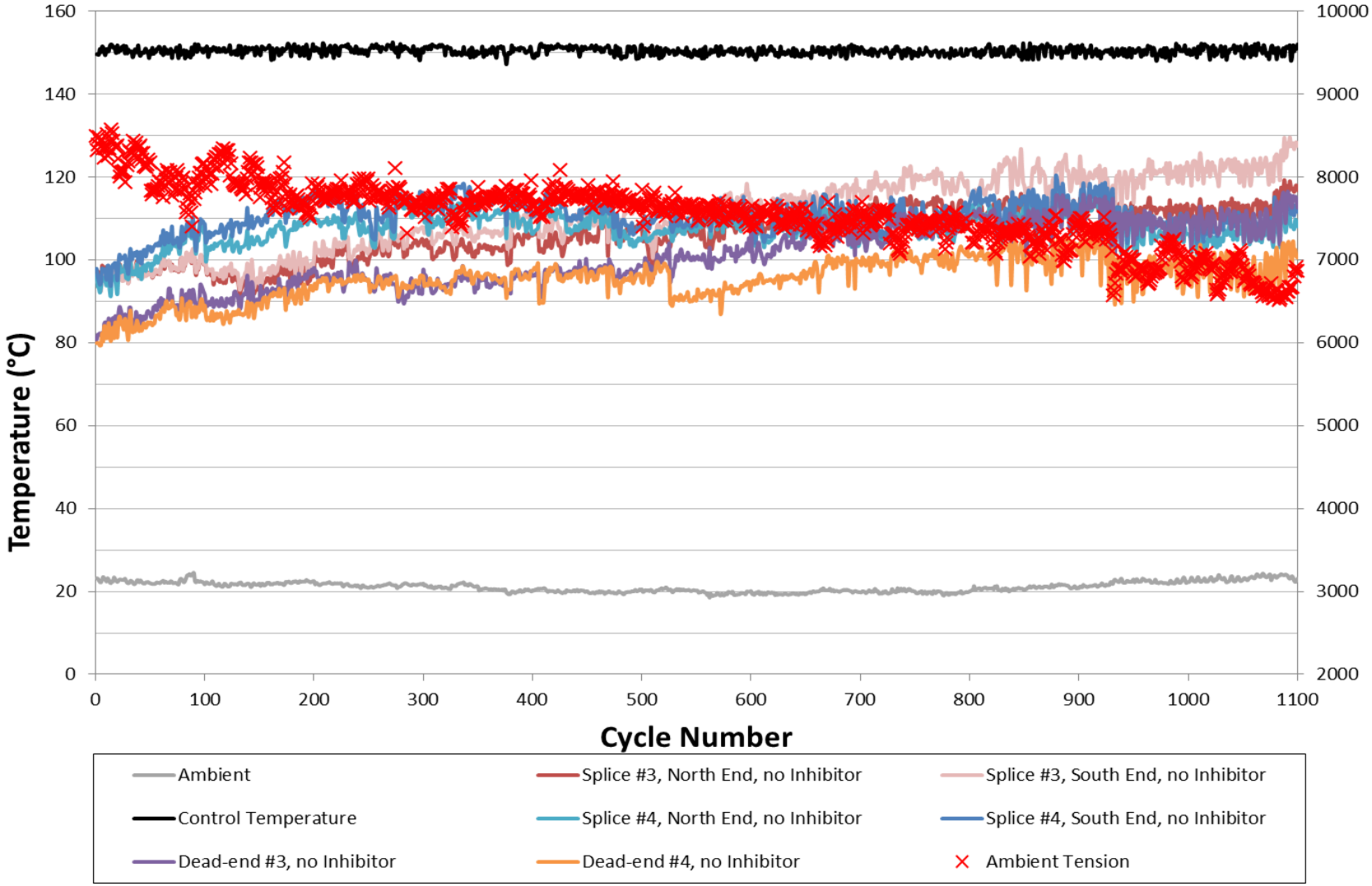
Resistance profile of Splices *with and without* inhibitor



Temperature profile of Splice *without* inhibitor

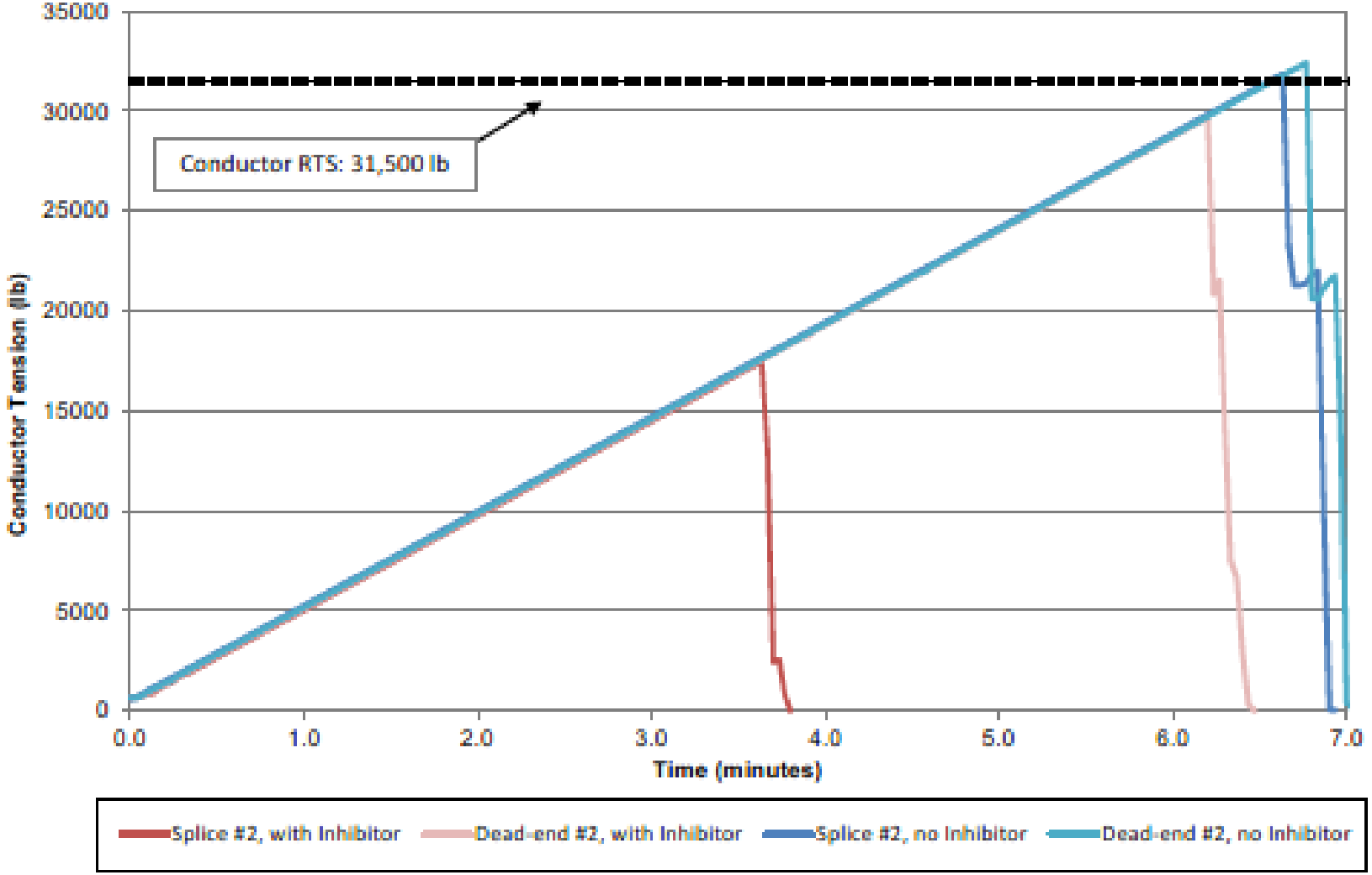


Tension profile on Splice and Dead-end without inhibitor shows some creep and relaxation due to high temperature and tension

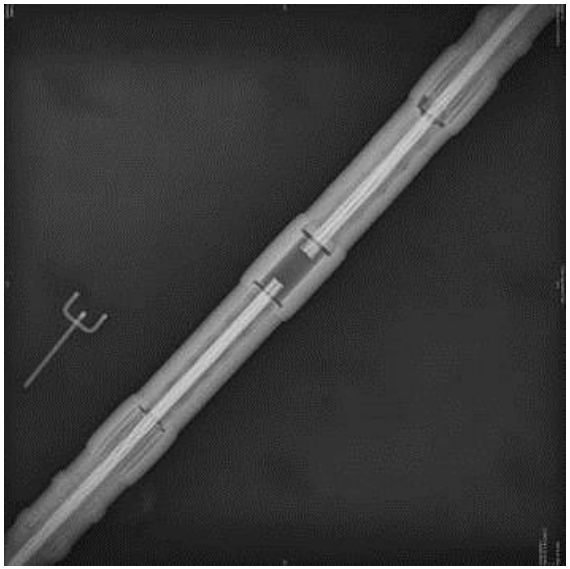


DMCPOWER KINECTRICS

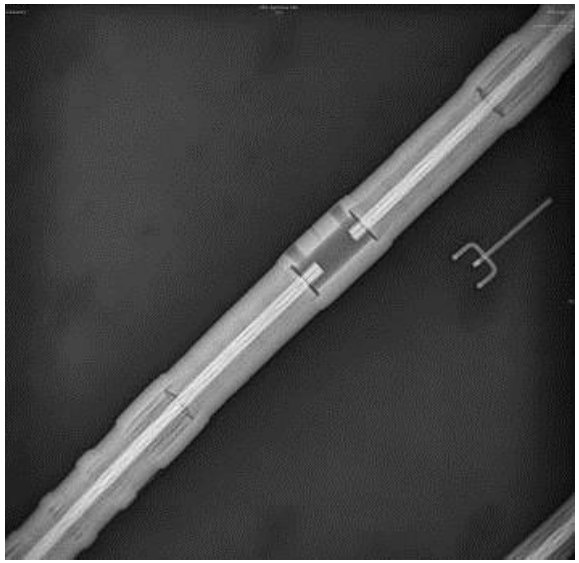
Post thermal aging samples with inhibitor and samples without inhibitor were mechanically tensioned until failure



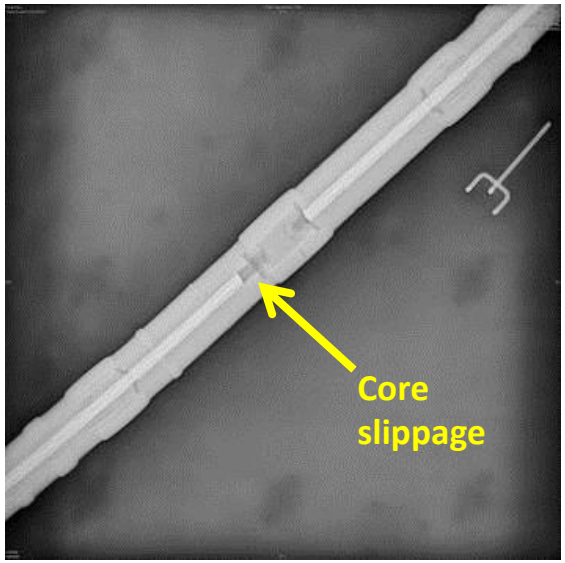
Digital Radiography Imaging



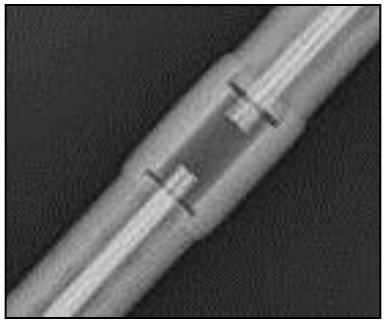
Splice As New

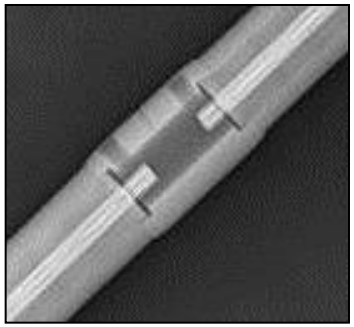


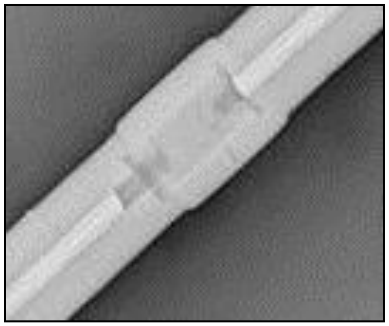
Splice after Cycling,
NO Inhibitor



Splice after Cycling,
WITH Inhibitor







Inhibitor Compound
"DMC" DFTC-1LB for application on conductors rated at 93°C and below.

- Urethane Polymer Base
- Operating Rage -40 F - +350 F
- Electrolytic Nickel-Aluminum Alloy
- Zinc Dust

Chemical analysis of Inhibitor Compound samples show significant decrease in base materials

Parameter	As-New Inhibitor [A]	Aged Inhibitor [B]	Percentage Difference [(B-A)/A]
¼ Worked Penetration	293	279	-4.80%
Aluminum Content [ppm]	150,000	11,400	-92.40%
Nickel Content [ppm]	151,000	63.2	-99.90%
Silicon Content [ppm]	26,500	356	-98.70%
Iron Content [ppm]	169	1,280	657.40%

Corrosion Test Performed on Swage Technology SSC
Performed to ASTM B117 for 1000 hours

Table 1 Summary of DC Resistance Measurements

Measure-ment Points	Hours Exposed to Salt Fog (hour)	Ambient (C)	Group A: Without filler compound				Group B: With filler compound			
			Al-TT	A2	A3	A4	Dl-TT	D2	D3	D4
			Micro Ohms				Micro Ohms			
1	0	223	65.1	64.7	65.5	64.5	65.2	65.3	64.0	65.8
2	690	206	65.4	64.8	65.6	65.6	65.4	67.9	64.2	65.6
3	1000	236	65.7	64.9	65.9	67.5	65.9	69.0	64.3	66.0
Average Resistance			65.4	64.8	65.7	65.9	65.5	67.4	64.2	65.8
Resistance Increase			0.6	0.2	0.4	3.0	0.7	3.7	0.3	0.2
Resistance Increase (%)			0.9	0.2	0.5	4.7	1.0	5.7	0.4	0.2

One sample of each showed slight increase in resistance, however no discernable difference between samples with and without inhibitor could be drawn

Conclusions:

- Single Stage Swaged connectors were subjected to 2,200 hours of emergency operating conditions (150°C)
- Single Stage Swaged connectors without inhibitor compound performed better
  - Thermally
  - Electrically
  - Mechanically

Based on the results of testing, DMC is rating Single Stage Full Tension Swage Connectors for 125°C continuous operating temperature!

Meets the highest NERC Reliability Standard **FAC-008-3 - Facility Ratings**

DMC POWER

KINECTRICS

DMC Power

Kinectrics